Locomotion in Domestic Fowls: Influence of Environmental, Social and Genetic Factors and Implications for Motivation

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Declaration

I declare that all the work presented in this thesis is of my own composition, and has not been presented in any other thesis.

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Abstract

The principal objective of this thesis is to investigate factors relevant to locomotion in the domestic fowl. Experiments concentrated on the influence of environmental (rearing condition, resource distribution, space, and restraint), social (presence and familiarity of companions), and genetic (age and breed) factors.

The general methods used throughout the thesis were adapted and modified from techniques used in the open-field test and the 'taut string' approach. Locomotion was quantitatively estimated by recording change of location within 10 second intervals throughout an observation, and then converted into the distance moved using an equation to measure distance between two co-ordinates. The inter-individual distance between two birds was also calculated using the co-ordinate locations at 10 second intervals and the same equation. Use of space was examined by demarcating the whole space area into equal quadrats, and then recording the number of sightings of birds for each quadrat.

Birds reared in a larger space or at a lower stocking density were more active and moved further than those reared in a small space or at high density. The frequency of walking and distance moved declined when the rearing space decreased. Exposure to space may be an extrinsic visual stimulus to induce motivation for locomotion. Cage-reared birds walked more and showed a higher level of motivation for locomotion when they were moved to a larger space, and were also less sensitive to restraint compared to pen-reared birds. Restraint in a small cage induced more locomotion. Although birds remained near to the resources (food, water, perches and nest boxes) and used the space unevenly, birds walked more when resource distribution was grouped than when resource distribution was more separate, which suggests that birds moved further for reason other than to reach the resources. One reason could be that feeding behaviour is usually accompanied by movement. Close proximity of resources may cause higher social tension and more aggression within a flock.

A familiar bird, an unknown bird, and an empty cage were used to investigate the effect of familiarity and companionship on birds' locomotion. It was found that isolation may cause a fear reaction, isolated birds were more nervous and less active, and remained motionless for a longer period of time, they performed more behaviour patterns with social content such as preening and foraging. Familiarity between birds increased locomotion: birds walked more and were less aggressive when the companion birds were familiar. The presence of companions and familiarity with flock mates may produce a situation where birds feel more secure and relaxed to explore. Familiarity and companionship of another bird had no effect on inter-individual distance.

When broilers, layers and a dual-purpose breed (Taiwan Country chickens) were compared, laying hens were the most nervous and active breed, while the broilers were the least active. The meat type broiler breed ground-pecked less, but still grew fastest. Broilers fed efficiently without spending much time on foraging activity such as ground-pecking/ scratching. This suggests that genetic selection has changed behaviour repertoires, even those essential for survival. Age had little influence on locomotion.

The findings show that in domestic fowls locomotion is motivated, and its expression influenced by a wide range of factors, and there are possible implications for welfare: the present battery cage system may not be appropriate for such motivation to be expressed. The design of housing system should take into account the layout of the equipment, that resources should be carefully distributed to prevent intense competition between birds.

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Chapter 1 General Introduction

1-1. Locomotion

Compared with research on restriction of small-scale body movements, whole body movement patterns of domesticated chickens have received little attention. The little information available on movement of poultry around their environment highlights the need for a better understanding of the motivation for locomotion; those factors that affect the motivation for locomotion are still little understood.

Locomotion is 'movement from place to place'; 'the action or power of moving from place to place; progressive motion of an animal'; 'passage', is change of place by a freely moving organism by its own power, as by crawling, running, climbing, swimming, or flying. The motor patterns used for locomotion vary widely among different kinds of animals, and even for a particular animal the patterns may vary with speed (Chambers English Dictionary; Immelmann and Beer, 1992; The Shorter Oxford English Dictionary).

Locomotion can be determined by three basic components: a genetic component; an environmental component; and the genotype-environment interaction (Bessei, 1980), and can arise from a number of motivational states (Lawrence and Rushen, 1993). A genetic component is characterised as spontaneous activity which appears without any environmental influence or stimulation. An environmental component acts through the environmentally determined excitability. The genetic-environment interaction exerts its influence via a genetically-determined excitability. However, although existence of spontaneous activity has been demonstrated in physiological experiments (Hamburger, 1963; von Holst, 1969; Bessei, 1979; Saleh and Bessei, 1981) and has been considered as a motivational factor in ethological studies, it is impossible to avoid entirely any environmental stimulation in order to measure spontaneous activity. The experiments in this thesis focus on three main factors according to Bessei's category:

environmental, social and genetic effects on locomotion, and their motivational implications.

1-2. Factors Influencing Locomotion

1-2-1. Environmental Factors

Exploration

For species in the wild, exploration is a way for animals to familiarise themselves with their environment. Exploration usually will increase the chance for animals to encounter resources (Archer and Birke, 1983). Even in familiar territories, animals maintain a regular level of patrolling in order to monitor their environments. Aversive environments can give rise to locomotory escape attempts (Lawrence and Rushen, 1993).

Rearing Condition

In comparative studies of floor- and cage-housed laying hens, it has been demonstrated that the birds on the floor were more active than those in cages (Black and Hughes, 1974; Bareham, 1972), the activity of floor hens, which was originally higher than the activity of caged hens, remained at a relatively high level when the birds were transferred from floor to cages, which may be a rebound resulting from an increase in motivational tendency during the period of spatial restriction, or from a response to an increase in novelty (Nicol, 1987). It has been found that the marked differences in the ethograms of birds housed on litter or in cages are mainly quantitative, though there are also some qualitative differences (Bareham, 1972; Black and Hughes, 1974; Hughes and Black, 1974).

Access to Resources

Deprivation of both food and dust-bathing has been found to increase exploratory locomotion in poultry (Nicol and Guilford, 1991), which suggests that animals locomote to search for resources. However, there is evidence that birds moved further than was necessary simply to reach food and water (Preston and Murphy, 1989). In domestic fowls, it has been observed that hens kept in pens spend more time working through the litter for food rather than eating the food ad libitum from a hopper, which indicates that they still work for food even when there are free food available (Duncan and Hughes, 1972; Inglis and Ferguson, 1986).

Space

Where space is limited by some external factor, the space available will affect the behaviour. However, there is often not a rigid distinction between spatial and behavioural factors and there will be many cases where behaviour affects space and space in turn affects behaviour. The distance or space between animals can be measured objectively, but whether that space is determined by the behaviour of the animal or by external factors in the environment is something that has to be investigated (Dawkins, 1985). Increased space allowance has been found to reduce stereotypic behaviour in many species (Keiper, 1969; Krzak et al., 1991; Terlouw et al., 1991) and increase activity (Hughes and Black, 1974).

1-2-2. Social Factors

Social Interaction and Familiarity

There has been sufficient evidence to accept the idea that social interactions may influence behaviour and physiology. It has been suggested that animals behave more calmly and less emotionally when there are companions present. Social contact can reduce the emotional behaviour of isolated animals (Tolman, 1965); isolation can increase metabolic rate and affect digestion, cause more body heat lose and more activities in chicks, especially when they are under stress (Notermans and Kampelmacher, 1975). Familiar birds have been found more preferred when birds had to choose between an unfamiliar flock and a familiar flock (Hughes, 1977).

It has been observed that excessive housing densities (less than 450 cm^2/bird) and low social status are associated with behavioural and physiological symptoms of stress in laboratory and farm animals. It has been suggested that increased incidence of movement represents competition and frustration, whereas reduction of motor activity may reflect reduced levels of disturbance (Hughes, 1983). It has been suggested that chickens in large flocks would generally restrict their movements to small areas in which they could recognise other individuals (McBride et al., 1963; 1969). On the other hand, some researchers have found that birds generally did not confine their movements to a particular site in the shed which could be equated with home ranges, and they suggested that social factors did not restrict movement (Hughes et al., 1974; Preston and Murphy, 1989). Research on whether activity would increase with greater social interaction is still inconsistent: Hughes and Black (1974) observed in laying hens that, activity increased when there were more birds in a pen (2 birds vs. 4 birds). Yet, Bessei (1979) found a contrasting result in Japanese quail that individually housed birds were more active than birds reared in group of three in pens. This inconsistent result may be due to the social isolation of individual housing in single birds, rather than the number of birds. The effect of isolation and companionship is investigated in Chapter 5 of this thesis.

1-2-3. Genetic Factors

Breed and Age

Comparison between the commercial medium hybrid laying strain and the more primitive bantam type has found that body size may be important in influencing the distances between individuals, as the commercial medium hybrid laying strain was larger than the more primitive bantam type and so could perhaps maintain contact at greater inter-individual distances. It is suggested that there may be some behavioural difference between the two strains which influences the spacing. The two strains were very different in their spacing behaviour but both strains showed the same general patterns of spacing which were related to particular activities (Keeling and Duncan, 1985).

In terms of age, in the young chicks, significant developmental changes during the first week after hatching occur in stimulus preferences and a decrease in the liability to move with age has been found (Zolman and McDougall, 1983). It has been observed in broilers that increasing age is associated with increased difficulty in walking (Newberry et al., 1986), a decrease in frolicking behaviour (Dawson and Siegel, 1967), and a decline in home range, walking time and distance moved (Newberry and Hall, 1990). The increased body mass along with advancing age may act as a physical barrier to walk from one location to another among individuals (Newberry and Hall, 1990). It has been suggested that circadian changes in behaviour must be taken into account (Bessei et al., 1979).

1-3. Relevance of Motivation for Animal Welfare (Influence of the Present Housing Systems and Genetic Selection)

Unlike wild animals which have evolved to use their time efficiently in their natural environments, intensively housed birds do not have the problem of fitting a number of competing tendencies into a limited time in artificial environments, but rather need to fill the time available from a relatively limited number of behaviour patterns open to them, therefore not having enough to do may itself be stressful (Dawkins, 1983; Hughes and Duncan, 1988). Concern over the welfare of laying hens, particularly those kept in intensive systems such as battery cages, has led to the suggestion that the 'natural' behaviour of the species should be used to assess the welfare of intensively kept birds (Thorpe, 1965; Farm Animal Welfare Council, 1986). Although battery cages prevent both the sensory and locomotory components of exploratory behaviour, the possible occurrence of boredom in laying hens has not been investigated in this manner (Nicol, 1986). It is well known that a number of behaviour patterns such as wing flapping, jumping, running, flying and exploring unfamiliar territory cannot be expressed in battery cages, other movements on a smaller scale such as ground scratching, dust bathing, nest building and walking can be performed only in vacuum or severely constrained form (Appleby et al., 1989). When assessing the welfare status of animals, appropriate matching of this sort between environment and behaviour is one of the factors which must be taken into account. If future research agrees that these behaviour patterns are essential to health, or are behavioural needs, birds may have to be given access to much larger, relatively unconfined spaces.

There is another way in which man has interfered with some species to the detriment of animals' welfare and that is by changing them genetically. It appears that sometimes intensive selection pressure for a particular trait can result in an animal for which a satisfactory environment cannot be designed. For example, the breeding stock for fattening broiler chickens have to be kept constantly hungry in order to prevent them from becoming too obese to breed or susceptible to diseases (Nir et al., 1978; Siegel, 1989). Selection for weight gain in broiler chickens has resulted in a huge increase in the incidence of various painful orthopaedic diseases such as twisted leg, kinky back and tibial dyschondroplasia (Duff and Hocking, 1986; MAFF, 1986).

1-4. Theories of Motivation

The study of motivation has been pursued not only by ethologists working within a zoological framework but also psychologists. A problem in motivation research is the number of the possible causal factors should be considered and the dimensions of multidimensional state space needed to describe motivational state (Broom, 1981). Motivation is always a controversial field. Many researchers have argued about its accurate and proper definition for a few decades, and different methods to measure it have been suggested by various schools. Nevertheless, the subject is still a mystery even in the field of human psychology (Krebs et al., 1978; Fölsch, 1980; McFarland, 1985; Appleby et al., 1992). Motivation has been used as a generic term for specific behaviour, such as hunger, thirst, sex, exploration etc., but there is no consistency in general theories (Toates, 1986). By using motivational approach, ethologists can understand the causations of behaviour, and imply the findings on welfare such as housing designs and husbandry practices.

In behaviouristic terms, motivation is related to goal-directed behaviour that may be determined by one or more of the following variables: some specific internal state that contributes to 'drive'; specific patterns of sensory stimulation, such as innate sign stimuli or learnt discriminative stimuli, that may function as incentives and arouse drives or may function as goals or rewards, and direct and shape behaviour; and learning or experience, which may provide the basis for acquired 'drive' and conditioned satiation as well as new appetitive and even new consummatory behaviours (Stellar and Stellar, 1985).

The traditional Lorenzian 'psychohydraulic model' emphasises more on internal sources of motivation, while newer models place greater emphasis on external sources (Wood-Gush, 1973). Lorenz's model fails to encompass the importance of feedback from the environment as a result of earlier actions (e.g., feeding, drinking and nest-building are some of the behaviours that are affected by what the animal has done earlier). To incorporate such feedback effects, a number of motivational models under the general heading of 'homeostatic models' assumes that there is an ideal state or set point for the animal, and motivation is then stimulated by the discrepancy between the set point and the actual motivational state. The discrepancy leads to 'feedback' reaction into the system and stimulates the behaviour or physiological response to operate until the discrepancy itself is reduced (McFarland, 1971; Toates, 1986). Some research on motivation has emphasised internal sources, and the increase in motivation if the opportunity to perform the behaviour is unavailable (i.e., motivation for these behaviours increases during deprivation) (Hughes, 1980; Gonyou, 1994; Keeling, 1994). However, homeostasis is in practice much more complicated and fails to explain all aspects of specific behaviours such as feeding and drinking behaviours (Rolls and Rolls, 1982). All of the models mentioned above are simplifications and have their deficiencies. Nevertheless, the attempt to identify certain principles in motivational state still can be used as a stepping stone in understanding some aspects of animal behaviour, even if there may be no complete explanation and perfect model for motivational mechanism in the next few decades.

Due to the argument between internal and external effects in contemporary motivational models, and the fact that motivation is intricately stimulated by both internal factors and external factors (Hull, 1952; Spence, 1956), the concept adapted in this thesis is not the common 'external-internal factors' approach. As it has been pointed out by Jensen and Toates (1993), most motivational states are both externally and internally induced and influenced by the interaction of both. They argued that it is conceptually wrong to dichotomise and rank the motivational effects of internal and external factors. Therefore, it is impractical to divide behaviour into dualistic terms: external or internal. The experiments in the thesis will only use the general view of various factors influencing motivational states to investigate motivation for locomotion.

1-5. Review of the Present Methods for Assessment of Motivation

The measurement of motivation is the measurement of the intensity (latency, magnitude, frequency, or probability) of behaviour and its duration and persistence. Intensity and duration measures apply to the expression of behaviour that is largely unlearned. When it is modified by learning, animals make a choice, in situations which some arbitrary act or behavioural sequence is learned and performed, and in the measurement of affective displays (Stellar and Stellar, 1985). For example, Fölsch (1980) used a quantitative ethogram for each system, registering the protocol of the positions of behaviour with the multi-moment technique four times per hour. The problem is that the quantified units can only give correct information when the quality of the environment and of the behaviour of the birds are properly described.

Preference tests are widely-used in contemporary motivational research (Hughes and Black, 1973; Dawkins, 1982; Appleby et al., 1984; Appleby and McRae, 1986). In a preference test, the animal is given a choice of certain aspects of its environment and it is assumed that it will choose according to how it feels, i.e., in the best interests of its welfare. The traditional preference test allows the animal to choose between two conditions, both of which are conducive to the same behaviour (Gonyou, 1994). Two new concepts were introduced by Dawkins (1983) to the use of preference tests in welfare related research: (1) To examine motivation, as opposed to choice. In such a test the animal is given access to two situations that are suitable for different behaviours. (2) The measurement of the strength of a motivation. Using 'consumer demand theory', by increasing the cost of obtaining access to a condition in which a behaviour was possible, the strength of the relevant motivation could be measured. The results of preference tests (choices) are affected by both the nature of the stimulus and the internal state. If the treatments of the preference test allows the animal to perform the consummatory act, then the choice is altered by the feedback from consummatory behaviour. Therefore, the method of testing can influence the choice of preference tests (Stellar and Stellar, 1985; Duncan, 1992).

Different measures of preference have been suggested by researchers:

(1) The number of animals in the experimental group choosing a particular alternative (Dawkins, 1978, 1980).

(2) The number of occasions on which individual animals choose a particular alternative (Hughes, 1975, 1977).

(3) The number of reinforcements obtained on an operant schedule (Baldwin and Meese, 1977; Bailey et al., 1983).

(4) The total time spent with each alternative during the course of the experiment (Hughes and Black, 1973; Dawkins, 1981, 1982).

In additional, three main manipulations on preference tests were proposed by Duncan (1992) to measure the strength of preferences:

(1) Limiting available time: the time that an animal has available to perform all

activities is regarded as " income". It is assumed, by decreasing the "income", that the "luxury" activities will drop out when there is insufficient time for the animal to perform its full repertoire of behaviour (Nicol, 1986), also seen as 'time budgets' (Dawkins, 1989).

(2) Operant Conditioning: this is a type of learning in which an animal learns to make a response in order to gain a reward or avoid a punishment, such as key-pecking (Savory and Duncan, 1982; Dawkins and Beardsley, 1986), lever pressing (Matthews et al., 1994), and wheel-running (Haddad et al., 1994).

(3) Obstructive techniques: In these techniques the animal simply walks towards the putative reward. There are varieties of obstructions such as a pool, a runway (Petherick et al., 1990a), a feather duster (Petherick et al., 1992), a narrow door (Cooper and Appleby, 1994), an air current, or a weighted push-door (Petherick et al., 1990a).

Although preference tests are very useful in studying motivation, it seems that preference tests often put the wrong question to the animal and have limitations (Dawkins, 1977; Duncan, 1974; 1978; Faure, 1994; Hughes, 1977). It has been suggested that preference tests can only be taken as a point sample taken at a time when an animal's different motivational systems are variously stimulated. Since most of the tests used were very short, the choice therefore could be strongly influenced not by the environment itself but by its novelty (exploration or neophobia) (Faure, 1994), and also by previous experience. Preference tests only give information on the current feelings of animals, yet short-term preference may conflict with long-term welfare, so preference tests do not necessarily indicate the long-term welfare of animals. In such case, animals can be fooled by the present choices (Duncan, 1978; 1992). Preference tests also do not measure strength of motivation because several motivational systems are simultaneously aroused. The conflicting motivations should not be tested simultaneously, and it is important to test the relationships between the two conflicting motivations by multiple tests with both motivational variables under experimental control and at different levels (Hutson, 1984). Besides, it is also important to investigate how much of the behaviour is due to the unfamiliarity of the environments and to plot the time course of adjustment to the new environment. As the trials progress, the animal will gradually accumulate experience of being confined in the environment and of making the choice repeatedly (Dawkins, 1977). Preferences have usually been measured for one animal at a time without any social influence, but the social context may actually play a marked role: the preference of a group should not be excluded from the sum of individual preferences (Faure, 1994). Moreover, there may be occasions when minority choice also reflects preference and is important to the animal's welfare (Duncan, 1978), but whatever the measure of preference used, the majority choice is generally taken to indicate preference whilst the minority choice is ignored. Preference tests only give gross information about the relative properties of the choices given, which makes the results not absolute and difficult to interpret (Duncan, 1992).

Interpretation must be cautious because these preferences are relative rather than absolute, are strongly influenced by the previous experience of the bird, and are affected by testing method (Hughes, 1980). Difficulties of interpretation are intensified by the absence of reliable physiological or biochemical measures for assessing long-term stress.

Despite difficulties of interpretation, preference tests remain important in providing us with information obtained from the animals' point of view. Nonetheless, efforts directed towards the provision of unambiguous alternatives in preference tests would allow clearer inferences to be drawn about the feelings of animals towards their environment (Nicol, 1986).

Since domestic animals are exposed to a variety of potentially stressful husbandry procedures, there is a need to determine how unpleasant or aversive the animals find such procedures (Rushen, 1986). The indicators for measuring aversiveness include escape, passive avoidance, and active avoidance (Rutter and Duncan, 1989, 1991). It has been recommended that passive avoidance is a more suitable indicator of aversion than active avoidance (Rutter and Duncan, 1992). Domestic fowl either fail or are very slow to learn active avoidance tasks such as shuttle or one-way avoidance (Rutter and Duncan, 1991), conversely, passive avoidance tasks are believed to be learnt more readily (Rushen, 1986). It has been proposed that techniques used to assess aversiveness should meet three main criteria: (1) the task should be able to be learnt by the majority of animals tested for the levels of aversion to be representative of the population as a whole; (2) the task should be learnt with minimal number of exposures to the aversive stimulus, to minimise the likelihood that habituation confounds the experimental design (specific stimulus); (3) the chosen technique should be tested with various treatments believed to vary in their aversive properties (Rutter, 1989; Rutter and Duncan, 1989).

Operant conditioning technique is another extension from preference tests. Moderate repetition of training activities is needed for efficient learning to carry out operant conditioning tests (McCall et al., 1993). Repetition is important in training: extensive training of the animals is often needed for them to make the correct response (Petherick and Rutter, 1990), but massing trials (prolonged practice) can result in inefficient learning. The more reinforced responses (training) an animal receives, the more slowly extinction occurs when reinforcements are terminated (Williams, 1938; Wilson, 1964). The shortcomings of operant techniques were pointed out by Dawkins and Beardsley (1986) that: (1) the task that the animal has to perform (pecking a switch, depressing a lever, pushing a pad) may not always be appropriate for the reward it is receiving; (2) details of the spatial arrangements of the manipulanda and the temporal arrangements of the reinforcement schedule may not be appropriate for the response the animal is supposed to make; (3) Some behaviour may be less conditionable than other kinds; (4) An animal may not always be able to learn an operant response although it may be highly motivated to gain the reward (Dawkins and Beardsley, 1986). Increasing the cost has often been accomplished by increasing the reinforcement ratio in operant conditioning studies (Gonyou, 1994).

In operant conditioning procedures, minimising the trials needed for response acquisition is a more humane approach to learning research using primary negative reinforcers (such as electric shock and water mazes) than setting an arbitrary number of trials per training session. This can be achieved by varying number of trials per training session to study learning response, combined with information about time intervals between the training sessions. This could enable animal learning researchers to gain useful information in fewer training sessions, and to decrease the time needed to collect meaningful data and the problems associated with boredom of the animal and stimulus habituation. Hence, distress to the animal and anxiety to human observers could be minimised. It might serve as a method of quantifying the animal's progress toward a specific task.

Another approach is the cognitive approach. Cognitivism focuses on the internal representation of knowledge, and insists that theoretical concepts such as attention, expectancies, intentions, images, goals, plans, and templates are essential for the understanding of behavioural patterning (Colgan, 1989). A cognitive representation is an appreciation of an object or an event which is not directly detectable or is not actually occurring at the moment. An animal which is working towards a goal is utilising cognitive processes in its behaviour control (Fraser and Broom, 1990). It has recently been argued that not only should animal feelings be included in considerations about welfare, but that welfare is entirely a question of the animal's mental, psychological, and cognitive needs. Operant conditioning (push-door, Y-maze) is commonly used to investigate animals' cognitive abilities (Petherick and Duncan, 1989; Petherick et al., 1990b). This approach assumes that if the cognitive needs are met, animals' physical needs will usually be covered as well, although, in some cases, it does not necessarily indicate poor welfare when the cognitive needs do not cover the physical needs. For example, welfare is only adversely affected when people feel ill or when they know that they are ill, both are cognitive processes. There may be cases in which the animal is not in the best physical health, but feels all right. Then it may be concluded that its welfare is all right (Duncan and Petherick, 1989; 1991).

The most obvious and controversial criticism of cognitive approach is that, unless mental concepts are clarified and their need justified by convincing data, it has been regarded as being outside the realm of scientific investigation, and not more advanced than anecdotalism or anthropomorphism (Colgan, 1989). Some research suggests that hens are not capable of true cognitive anticipation, but rely on internal and external cues associated with a circadian rhythm (for example, the time of day) as a predictive cue (Duncan and Petherick, 1991).

1-6. Behavioural Approach as Complement to Preference Tests

Not all measures of motivation agree with each other; this presents both problems for measurement and opportunities for analysis. Appetitive measures may differ from consummatory measures. In some instances, performance (skill, work capacity) may be at stake (bar-pressing, key-pecking), experimental manipulations (drugs) may also interfere with motor performance as much as with motivation (Stellar and Stellar, 1985).

Despite difficulties of interpretation, preference tests remain important in providing us with information obtained from the animals' point of view. Preference tests afford a valid insight into the way animals perceive their environment, and permit an estimation of which features the bird is likely to regard as important. When a particular feature has been identified as important, all available indicators of stress should be examined in situations in which the environment is likely to be inadequate (Hughes, 1975). The provision of unambiguous alternatives in preference tests would allow clearer inferences to be drawn about the feelings of domestic animals towards the environments in which we intend to house them. To improve the shortcomings of preference tests, the interpretation of results from preference tests can be aided by observing the behaviour of the birds during the tests (Duncan, 1992).

The advantages of using behaviour as an indicator of motivation include the fact that it can be observed without invasive techniques and be recorded without complicated equipment. Disturbed behaviour may indicate more subtly and more quickly when the motivation of an animal is adversely affected. It has been suggested that the suffering animal shows a depletion of the behavioural repertoire characteristic of the normal behaviour, and that loss of maintenance priorities through changes in motivational time-budget appears to be the essential criteria of poor welfare. It is suggested that a decreased frequency of certain maintenance behaviour and increased frequency of anomalous behaviour may indicate depression (Schmidt, 1982). Several different approaches have used behaviour to assess motivation and to investigate welfare:

(1) To study how animals behave in various states of suffering such as frustration, fear and pain (tonic immobility: Sanberg et al., 1981).

(2) To study preferences of animals by giving the animal a choice of various aspects of its environment (social condition: Appleby et al., 1984; Bradshaw, 1992; nesting behaviour: Appleby et al., 1986; Duncan and Kite, 1989; Hughes, 1993; floor type: Hughes, 1976; Hughes and Black, 1973; cage size: Dawkins, 1981; 1983; space: Nicol, 1986; Hughes, 1975; Faure, 1994; group size: Dawkins, 1982; Lighting: Widowski et al., 1992).

(3) To use operant conditioning techniques to see how hard animals will work to obtain, or to avoid, some aspect of their environment (floor type and cage size: Lagadic and Faure, 1987; feeding behaviour: Clifton, 1979; Faure, 1986; lighting: Savory and Duncan, 1982; thermal environment: Morrison et al., 1987).

(4) In order to overcome the problems associated with operant conditioning methods, a technique has been developed in which the animal simply walks towards the reward (or away from the aversive stimulus or punishment) in a runway or simple maze. Its motivation to reach the reward (or to avoid the punishment) can be measured by placing various obstacles in the runway which it has to overcome to reach the reward (or to avoid the punishment) (transportation: Alami, 1993; sounds: McAdie et al., 1993; food: Petherick et al., 1992).

(5) An extension of the (4) method is to see if animals will learn to walk through a maze following certain cues, such as coloured doorways or windows etc., in order to reach a reward (e.g. food) (Black, 1978; Petherick et al., 1990b).

However, there are some problems in using a behavioural approach, which have been reviewed by Monaghan and Wood-Gush (1990):

(1) Difficulties in deciding what is an 'ideal environment' for a domesticated species.

(2) This method provides results which are very difficult to interpret.

(3) The interpretation of results from this method is particularly problematical when a behaviour pattern is missing in the test environment.

(4) In interpreting behaviour patterns that occur in the test environment but in a

vacuum (in the apparent absence of the external stimuli normally eliciting them).

To overcome these disadvantages of behavioural approach, the experiment in Chapter 3 was designed to investigate a modified approach which combines preference tests and behavioural approach. To overcome the common problem in usage of short-term preference tests, the observations in Chapter 3 were carried out in the animals' home environment for a period of 11 weeks allowing the animals to perform their behavioural repertoire in different treatments, where their preference for certain behaviour patterns (i.e. priorities of performing these behaviour patterns) will be considered as indicators of their motivational state. Therefore, preference test was complemented with behavioural indicators to investigate the effect of the treatments. Also to the other problem in behavioural approach, video play-back technique was used to improve the shortage of real-time recording in this thesis.

There are limitations of real-time recording of behaviour:
(1) there is no permanent record or complete registration of the scene, including sounds, movements, gestures etc. Only the relevant behaviour patterns are interpreted, classified and registered. Therefore, it is impossible to test the reliability of interpretation within the observer (intra-observer agreement), and the agreement between observers (inter-observer agreement); and rectify and interpretation or data-entry error.
(2) interference: the observer may influence the behaviour of the subject of interest.
(3) the observer's body and mind have limited physical capacities, which causes: restrictions on the number of subjects or classes of interest one observer can register; limitation on the speed of entering data; and limitation on the frequency of transitions of behavioural elements that can be recognised and/or interpreted.
(4) Not all subjects are always that dynamic; observing them during periods of inactivity can be tiresome and boring. Observer fatigue can lead to reduced accuracy and reliability. Live collection of observational data may be very inefficient when only a certain part of the behaviour is needed, and it may have a low rate of occurrence.

Due to the limitations and disadvantages of real-time recording, the observations in this thesis were recorded and analysed by video tape play-back technique. The observer was hidden from the animals in order to minimise the disturbance to their behaviour. Video play-back technique provides solutions to the (1), (3) and (4) mentioned above.

1-7. Thesis Plan

The principal objectives of this thesis are to investigate environmental, social, and genetic factors relevant to motivation for locomotion in domestic fowls; the strength of motivation will be assessed by calculating distance moved as a quantitative approach in order to get a more objective interpretation. The outline of the chapters in this thesis is as follows:

* To investigate the original recording procedures and assessment techniques of previous researchers (quadrats in 'open-field' study and 'taut string' approach), and then to develop the general methods used for recording movements and assessing motivation in this thesis. Behaviour patterns as complementary indicators of birds' motivational states are assessed (Chapter 2).

* The effect of environmental factors: space, distribution of resources and age were investigated (Chapter 3).

* Two hypotheses are examined: (1) if a larger space induces motivation for locomotion then hens will locomote more than in a smaller space; and (2) if a larger space is visible but unapproachable hens will show evidence of higher arousal and be more active (Chapter 4).

* The influence of a companion bird (present or absent, and unknown or familiar) on behaviour, moving distance and inter-individual distance is investigated (Chapter 5).

* Willingness to push through wide and narrow gaps is examined as an indication of

motivation for locomotion in cage- or pen-rearing systems. Measurements were made of behaviour patterns, the number of gap passages, the time spent outside the cage, and the mean walking distance (Chapter 6).

* (1) to compare locomotion among genetically different domestic fowls on a diurnal basis by studying the use of pen space, behaviour and movement; (2) to compare the effect of rearing conditions (flock size and flock density) on behaviour and movements; and (3) to investigate the effect of restraint on locomotion and other behaviour patterns (Chapter 7).

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Chapter 2 Pilot Studies on General Methods Used in the Thesis

Abstract

Two separate studies were carried out on ISA Brown laying hens and broilers, some measurements adapted from previous research for recording movement and use of space were used and investigated to develop proficiency in the general methods used in this thesis.

The first study investigated whether rank is related to locomotion and vocalisation. Fifteen ISA Brown laying hens were used at the age of 50 weeks old. Effects of spatial restriction on vocalisation and locomotion were also observed. The method of total squares entered (total number of quadrats passed in a square room) was adapted from 'open-field' test and used as a quantitative estimate of locomotion. The results showed that the high ranking bird vocalised more but moved less than low ranking birds (the ranks were 'high', 'intermediate', and 'low' in a group of three birds). No significant influence was found on vocalisation nor on locomotion by spatial restriction. Increasing the sample size by replication or increasing observation time would improve the accuracy and reliability of experimental results.

In the second study, the 'taut string' approach was introduced to study the behaviour and movement of broilers from 15 to 36 days of age in a flock of mixed sexes. Observations of individual birds in one house showed that they generally moved very slowly, but that over the 21 d period marked birds ranged over areas of at least 10% of the available area, and the average range was about one third of this area.

In conclusion, the observation techniques used in both studies proved suitable for applying to subsequent experiments. Some precautions and modifications are needed to improve the shortcomings exposed by these two studies.

2-1. Introduction

In a natural habitat, a flock of chickens is constructed with a dominant male, females and their offspring, and some subordinate males on the outskirts of the group (McBride et al., 1969). The dominant male usually plays the role of signal sender to direct movement and activity of the flock, and gives alarm calls to indicate the presence of predators. This inspired the first objective of the first study: Will high ranking birds vocalise more? The other objective of the first study was to investigate if there is a connection between rank and locomotion. It has been observed in domestic fowls that, both in males and females, birds of high social rank have smaller ranges than those of low rank (van Enckevort, 1965; Pamment et al., 1983).

Although both vocalisation and locomotory activity are crucial to animal communication and social organisation, there is little information about the locomotory responses of domestic fowl to spatial deprivation, and how locomotory activity by hens might be performed in an unnatural or confined environment. The objective of the first study was to investigate the relationship between vocalisation and rank, locomotion and rank, and the correlation between vocalisation and locomotion. The effect of physical restriction on vocalisation and locomotion was also studied.

The objective of the second study was to observe the behaviour and movement of broilers throughout the lifetime of a flock, and to evaluate the 'taut string' method for further experiments.

STUDY I

2-2-I. Animals, Materials, and Methods

The first study was carried out in June, 1993 at Easter Howgate farm in Bush Estate, Edinburgh. A 3.48 × 2.92 m room was divided into 4 × 4 equal quadrats by drawing lines on the ground. Each quadrat was therefore an area of approximately 0.87 × 0.73 m. Fifteen ISA Brown laying hens were randomly divided into five groups, and kept in five 0.60 × 0.47 m modified cages, each fitted with a 0.38 × 0.32 m nest box; three hens in each cage, with food and water ad libitum. Three treatments were introduced to investigate the influence of restraint on behaviour: a home cage (treatment C); a 0.28 × 0.18 m small cage (treatment S); and a 0.48 × 0.36 m large cage (treatment L). The birds were originally reared in individual cages until the age of 50 week old, and then randomly assigned into the new cages in groups of three, observed from the age of 50 week old for a week. Fighting was seen in the early days after mixing. There is an impression that the formation of rank was due to the mixture of birds from different cages. Three birds from the same cage were then divided into 'high', 'intermediate' and 'low' ranking birds (Appleby, 1983). The rank among a group of three birds in each home cage was decided by direct eye observations on aggression and competition in front of the cages during feeding time. There was no impression that the birds were influenced by the observation when the observations were taking place.

Three hens from the same home cage were randomly placed in the three treatments for 24 hours before observations. A randomised block design ensured that each bird was tested once under each treatment. After the 1-day restraint, the birds from the same treatment cage were then moved to the 3.48 × 2.92 m room and were observed for 10 minutes individually in turn. The observer was in a small room next to the test room, with an opaque wooden wall as a barrier to prevent the objects seeing the observer. This is to minimise the disturbance from the observer.

Locomotion was investigated by counting the number of passing quadrats entered. The number of quadrats entered was counted as one when half the body of the bird crossed from one quadrat to another. The total number of quadrats entered was used for an approximate quantitative estimate of locomotion. Behaviour (body-shaking, excreting, flying, ground-pecking, ground-scratching, head-shaking, running, tail-wagging, wall-pecking, wing-flapping, wing-shaking, and wing-stretching); and bouts of vocalisation were recorded by continuous sampling for each individual bird throughout the 10 minute observation. All records were made by direct observation throughout the test. The test pen was not cleaned out between tests; therefore, the order of testing was randomised to preclude any treatment bias created by olfactory cues. All tests were carried out between 09:00 and 12:00 h.

The method of using frequency of visits to individual squares (equal quadrats) in an open field test pen seems to be an useful way of quantifying locomotion. A similar method has been used in other experiments (Beattie et al., 1995).

To examine the relationship between rank and locomotion, rank and vocalisation, and locomotion and vocalisation the non-parametric data of five groups were pooled and analysed by Spearman rank correlation. The effect of treatments on locomotion, vocalisation, and comfort behaviour were analysed by Chi-square.

2-3-I. Results and Discussion

The rank of birds did not significantly influence vocalisation in any of the treatments, but had an effect on locomotion (Table 2-1), and the overall correlation between rank and locomotion was strongly negative (rs=-0.462, p<0.01, Spearman rank correlation), however, this was only significant in treatment C (p<0.05). In all five groups, each consisting of three birds identified as 'high'; 'intermediate'; and 'low' ranking, the high ranking bird moved less but vocalised more than the low ranking bird (Table 2-2). This finding is consistent with previous research (van Enckevort, 1965; Pamment et al., 1983). Although locomotion in treatment L was not significantly affected by rank, the tendency (rs=-0.37) was in the same direction as the other two treatments (rs=-0.51 in treatment C and rs=-0.48 in treatment S). The number of animals might not be sufficient to identify a significant effect for treatment L.

There was a negative correlation between locomotion and vocalisation (rs=-0.26), suggesting that birds which moved more vocalised less frequently, nevertheless, the result was not significant (p=0.08, Spearman rank correlation).

Restraint had no influence on vocalisation ($p>0.78$, Chi-square test), nor on locomotion ($p>0.17$, Chi-square test). A significant influence of restraint on behaviour was only seen in body-shaking ($p<0.05$, Chi-square test), indicating that birds kept in the small cage tended to shake their bodies more often than birds from the large cage after they were released from the restraint cage (Table 2-3). It has been suggested that behaviours rebound when restrictions are removed (Hughes, 1980; Nicol, 1987); this is consistent with the finding, that the small cage is more restrictive than the large cage. The birds from the more restrictive cage reacted more actively once they were released.

In a novel experimental apparatus, the absence of escape or freezing reactions (tonic immobility) may indicate higher fear levels than more active responses (Arnold, 1945; Miller, 1948). It has also been found that more fearful birds may be more reluctant to move around (Nicol and Guilford, 1991). Rank was found inversely proportional to fearfulness, while duration of tonic immobility (one indicator of fear) was shorter for high peck-order birds than low peck-order birds (Crawford, 1977). The results of the present study are thus consistent with previous research as mentioned above. Low ranking birds walked a shorter distance, they tended to get disturbed and nervous easily. It may be reasonable to describe such movements as being fear-motivated that the low ranking birds were too fearful to move, and it might be possible to correlate the strength of these movements with some other independent index of fear such as freezing and particular vocalisations (Murphy, 1978; Russell, 1983).

In the present study, the use of competitive feeding trials for deciding dominance relationships is not reliable, as it actually measures the degree of hunger rather than the rank. It has been found that with very hungry cockerels and feed available for only one individual at a time, there was a high incidence of peck-order violations, which would have confused an observer trying to determine dominance relationships (King, 1965). However, the relationship between ranking and locomotion is still interesting. Further investigation can be carried out to understand the role of rank in locomotion among a flock, which may be an interesting subject in sociobiology.

STUDY II

2-2-II. Animals, Materials, and Methods

The study was carried out on a commercial flock of broilers at Marshall's Sunnyside farm from 3rd March 1993 (when the birds were 15 days old) to 24th March 1993 (when they were 36 days old). It involved four chicken houses, each 14 × 64 m and stocked with 18,600 Cobb and/or Ross broilers (as hatched) at approximately 0.05 m^2/bird. Temperature in the houses was initially 32°C; it was brought down gradually to 21°C at 32 days old. The broiler flocks were transferred batch by batch to the company-owned slaughter house from the age of 6 week old, so the study ended before then.

Behavioural Studies

Behaviour was studied in one house containing Cobb broilers. Eighty one birds were marked for individual identification using red, blue and green Stockmarker sprays on the wing, head and tail. Most of these marks lasted throughout the 21 d period, but some did not. Observations were carried out on 10 days over the period, generally on the Monday, Wednesday and Friday of each week.

Once on each observation day, the observer walked slowly through the house, recording locations of as many marked birds as possible on a plan of the house. The plan of the house divided the area into 126 quadrats (Fig. 2-1): 6 across the width of the house (demarcated by the drinker and feeder lines) by 21 along its length (demarcated by the 20 posts). Ranges were calculated for the 36 birds recorded on at least 8 observation days. First, a bird's sightings were plotted on the plan and a line was drawn round the simplest convex area which enclosed all these sightings. Second, the number of quadrats and the actual area within this line were calculated with the 'taut string' approach: for each individual, a minimum estimate of total area used was obtained by the definition that the smallest area of adjacent squares without indentations that would include all records of the positions of the individual (Appleby et al., 1985, Fig. 2-2).

Three times on each observation day, a marked bird was chosen and followed for 1 hour, while the observer was stationary without any movement. A record was made of its behaviour once each minute, and its movements were plotted on a plan of the house so that an estimate could be made of the distance which it moved. In addition, a record was made of any movements likely to result in the bird being scratched or scratching another bird, and of any aggressive interactions between birds. A different bird was chosen each time, making 30 in all.

2-3-II. Results

Use of Area

Use of area, as indicated by the recorded positions of the marked birds, was generally very even. There was a slight tendency for the far end of the house (away from the gate) to be used more than the rest of the area: 35% of records were made in 29% of the area (the last 6 of the 21 divisions along the length of the house). And there was a slight tendency for one side of the house to be used more than the rest (Table 2-4). However, these tendencies were not marked.

Among the 36 birds observed frequently enough to calculate their ranges, the 'taut string' approach suggested that ranges varied from 14 to 71 quadrats with a mean of 34 (out of a potential 126). These corresponded to actual areas which varied from 96 m^2 (11% of the available area) to 723 m^2 (81%) with a mean of 283 m^2 (31%). In other words, a typical bird moved through an area of about one third of the house during the observation period.

Behaviour of Individual Birds

The average distance moved in one hour by the 30 birds observed was 10.6 m. During the hour, they were lying, feeding or drinking for an average of 51.9 minutes, so all movement occurred during the remaining 8.1 minutes and for this time their average rate of movement was 1.3 m/min. Average distance moved on different observation days varied from 5.1 to 18.4 m, but there was no apparent trend for increased or decreased movement with age.

During observations of individual birds, aggressive interactions were rarely recorded, although it was noticed that they did occur among other birds in the flock throughout the observation period.

2-4-II. Discussion

The results of this study show that while growing broilers generally moved slowly, they moved over large areas during the growing period. All ranges analysed were more than 10% of the area available and the average range was approximately one third of that area. This supports the research of Preston and Murphy (1989) which showed that broilers moved further than was necessary simply to reach food and water, and they were not generally attached to a particular site in the shed. In their study they did not observe any aggressive interactions, so they concluded that the extensive movements were partly because social factors did not restrict movement. However, in present study, occasional aggressive interactions were observed as early as 15 days old, and continued until the end of the growing period (36 days old).

Visual and auditory cues have been recognised as main cues for discrimination of a familiar bird from others, and visual cues were thought to be the more important (Marler and Vandenbergh, 1979). Therefore, due to the continuously changing appearance of rapidly growing birds, the likelihood of home range being defined on the basis of social recognition is minimal.

The marks applied on the plumage may have stimulated other birds to peck at those coloured spots, and therefore cause disturbance to the marked birds and consequently influenced their behaviour. However, there is still no solution to substitute bird marking while carrying out observations on certain individuals in a large flock. High-technological method such as radio tracking (White and Garrott, 1990) is possible to track individual animal's movement, which has been widely applied on field studies in wild animals, but it is far too cosy for the present study and so it is not practical.

Although the birds may be influenced by the observer's movement and shift their positions, such shift was not significant and should not influence the accuracy of position recordings. Moreover, positions of the birds were observed from a distance as far as possible, in order to record their genuine staying areas.

In general, movements were similar to those described by Preston and Murphy (1989). It was observed in the present study that the birds tended to gather into a closely packed flock, even if there was still other space available to recline or move. In fact, this phenomenon actually resulted in the availability of free space. This finding is constant with previous research (Preston and Murphy, 1989). 'Taut string' approach is a useful method to measure areas occupied by individual birds, but its accuracy will depend on the size of each quadrat, the accuracy increases as the size of the quadrat decreases. The physical dimension of the bird may be the appropriate size to measure distance moved, but larger dimension may be more suitable for home range measurement, as the bird will more around an area much larger than its physical dimension. An over-sized quadrat may over-estimate the actual home range, while one similar to the animal's physical dimension may be impractical when tracking the animal in a large flock within a huge house due to difficulty in orientating the position. However, the optimum size for quadrat is influenced by many potential factors such as race (active or inactive) and stocking density (crowding may obstruct some movements), etc. Therefore, the quadrat should be designed more cautiously according to these factors.

2-5. Conclusion

In conclusion, the observation techniques used here were suitable for applying in subsequent experiments, however, some precautions and modifications are needed to improve the shortcomings exposed by these two studies. Firstly, according to the outcome of study I, the sample size needs to be increased by replication or increasing observation time, in order to improve the accuracy and reliability of the experimental findings. Secondly, study II shows that using equal quadrats would be more convenient and appropriate for estimating locomotion, but the size of quadrats should be decided by the average moving distance and the flocking density of the object to increase the accuracy. The methods for recording movement (the number of squares entered in study I) and use of space (the percentage of individual birds sighted in specific areas adapted from 'taut string' in study II) were shown to be useful techniques for quantifying locomotion.

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Fig. 2-1

The plan view and demarcation of the broiler house. The house was divided into 6 across the width (A to F) by 21 along the length (from 1 to 21).

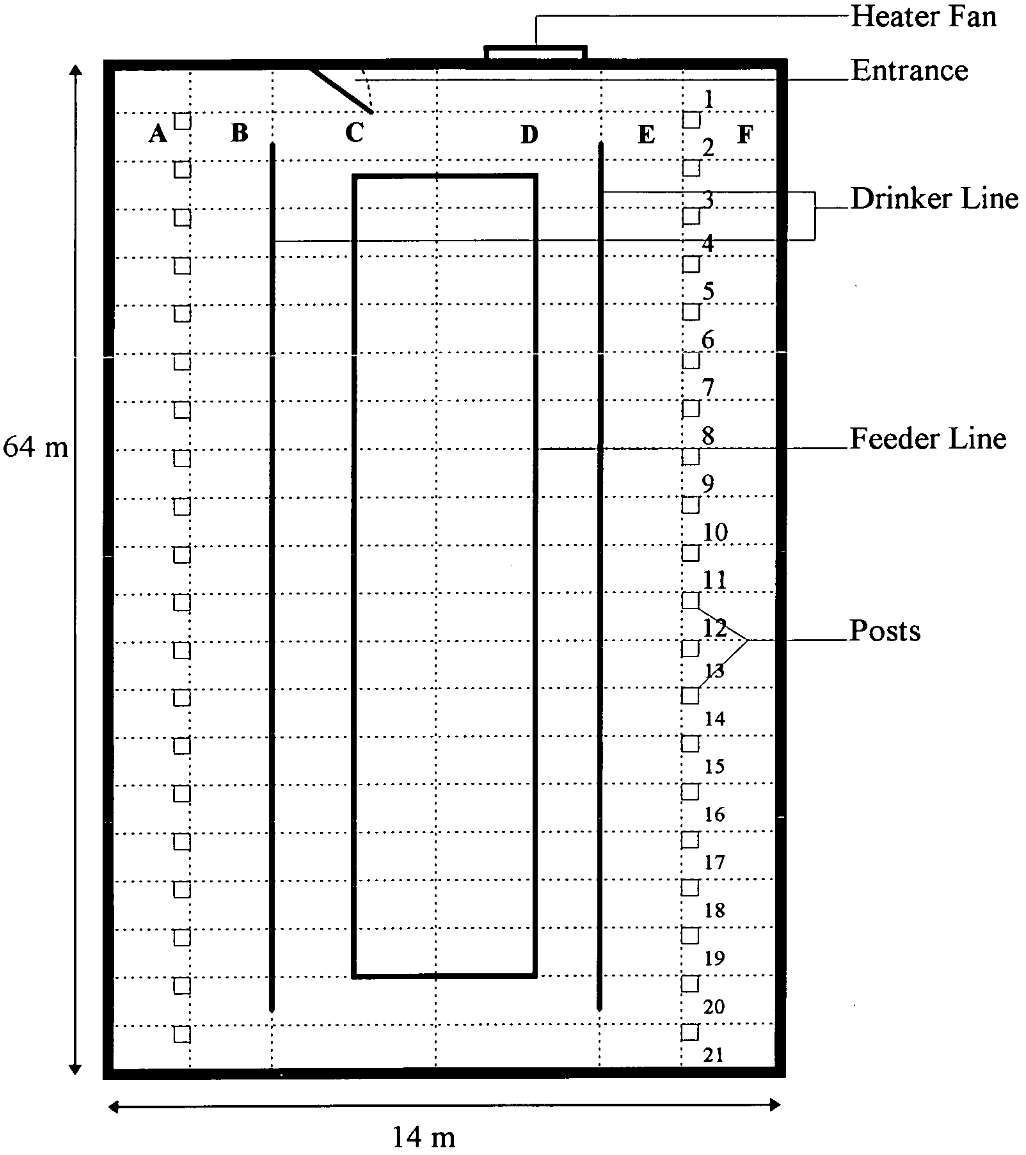

Fig. 2-2

The 'taut string' approach for recording movement (approximate home range for each individual). 'x' represents the location of the individual bird. For example, in this diagram, the approximate home range of this bird is within the dark area. The total moving area is: A×5+B×11+C×7+D×4+E×8+F×10.

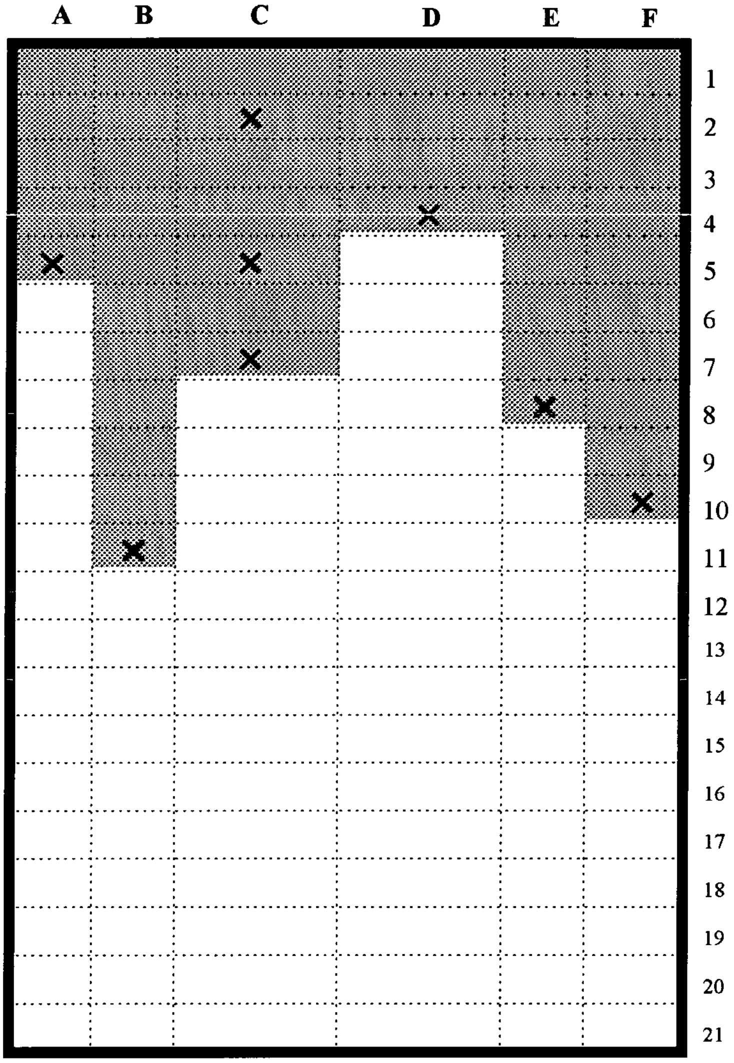

Table 2-1
The influence of rank on vocalisation and locomotion in the pen after different treatments had been applied. Spearman rank correlation coefficients.

Rank	Vocalisation	Locomotion
Treatment C	-0.12	-0.51*
Treatment L	0.38	-0.37
Treatment S	0.38	-0.48
Overall	0.22	-0.46***

***=p<0.001, *=p<0.05

Table 2-2
The total numbers of quadrats entered and total bouts of vocalisation of different ranking birds from three treatments in 10 minute observations.

Rank	Quadrats (No/Bird)			Vocalisation (Bouts/Bird)		
	C	L	S	C	L	S
1	22.0	27.2	11.8	40.2	44.8	33.4
2	13.0	16.0	8.0	68.4	35.0	30.0
3	3.8	11.8	6.2	52.4	92.6	55.8

Table 2-3
The frequency of body-shaking of different ranking birds from three treatments (bouts/bird/min).

	Rank		
Treatment	1	2	3
C	0.6	0.6	0.4
L	0.8	1.0	0.6
S	1.2	1.8	0.8

Table 2-4
Use of area across the width of the house.

Area		% of area	% of observations
A	Wall to drinker line	14	16
B	Drinker line to feeder	12	10
C	Feeder to middle	22	20
D	Middle to feeder	23	22
E	Feeder to drinker line	13	11
F	Drinker line to wall	15	21

Table 2-5
The number and position of scratches at different ages (N=150).

Age(day)	Birds with Scratches	No. of Scratches			Total	Scratches per Bird
		Thigh	Back	Breast		
17	25(17%)	28	1	1	30	0.20
24	84(56%)	94	131	14	239	1.59
32	83(55%)	147	9	17	173	1.16
38	92(61%)	179	0	18	197	1.31
Total Records		448 (70%)	141 (22%)	50 (8%)	639	

Chapter 3 Locomotion in Laying Hens: Effects of Space, Distribution of Resources and Age on Behaviour and Motivation

Abstract

This chapter investigates whether motivation for locomotion is influenced by space, stocking density, distribution of resources and age. The ways in which distance moved and patterns of behaviour shown are affected by these factors may be used as indicators.

Sixty ISA Brown laying pullets were studied from 12 to 22 weeks of age. They were randomly assigned into three treatments, and each treatment had 4 replicates. Treatment C (control) was a 0.7 × 0.7 m wire-floor pen with 4 resources (food, water, perches and litter-box). Treatments G and S were 2 × 2m wire-floor pens either with the same four resources gathered within a 0.7 × 0.7 m area, or separated at four corners of the cage, respectively. The treatments were available space (C vs. G), stocking density (C vs. S), and distribution of resources (G vs. S). In each replicate, 5 birds were raised with food and water ad libitum. Moving distance and behaviour patterns (locomotive, non-locomotive, comfort, feeding, and aggressive behaviours) were recorded once a week.

The results indicated that the birds raised in C had the least moving distance and locomotive behaviour among the three treatments. There was no significant difference in locomotive behaviour between G and S, although birds in G moved further than in S. For non-locomotive and feeding behaviour patterns, the sequence is G>C>S and S=C>G. Floor space and resource distribution affected locomotion. Age did not have much influence on locomotion. Behaviour patterns are useful to interpret results. Distance moved and walking frequency could be used as quantitative measures for locomotion.

3-1. Introduction

Restricted space and rearing environment for domestic fowls have often been criticised by animal welfare organisations. They claim that the poultry industry does not supply poultry with enough space to walk around freely and express other normal behaviours they can perform in the natural environment. For example, it has been reported that behaviour of pullets will differ in a variety of ways if they have previously been kept in low-density floor pens rather than in high-density rearing cages. Pen-reared birds had significantly more aggressive behaviour after transfer to laying-house cages than cage-reared birds (Craig et al., 1988). However, from a scientific point of view, conclusions on whether housing space is adequate or too small for animals should depend on objective evidence on the motivational state of the animals.

In laying hens, we can ask whether motivation for locomotion has become established during evolution, and if so, whether the need for locomotor activity is frustrated under restricted conditions such as cages. Bessei (1979) defined motivation for locomotion as a quantitative trait which is determined by 3 basic components: a genetic component; an environmental component; and the genotype-environment interaction. The genetic component is also characterised as spontaneous activity; its existence has been demonstrated in physiological experiments (Hamburger, 1963; von Holst, 1969) and is considered as a motivational factor in ethological studies, but it can not be measured separately due to the impossibility of avoiding environmental stimulation completely. This is also true for the pure environmental component of behaviour, because responses are partly due to genetic predisposition. Therefore, there is a contribution from the genotype-environment interaction in all cases. Thus, in ethological experiments, measuring either pure genetic or pure environmental components will be impractical because the genotype-environmental interaction in most cases will be involved in the expression of the phenotypic behaviour. This is a problem in drawing conclusion for the welfare of hens, because if the tendency to show locomotion is fixed genetically, adaptation to restricted conditions would not be possible and, therefore, they would cause permanent frustration (Bessei, 1980).

As mentioned earlier, existence of motivation for locomotion has been demonstrated. Motivation has been investigated using preference tests, tests of aversion, operant conditioning and deprivation choice tests. However, these measurements of motivation do not always agree with each other. Appetitive measures may differ from consummatory measures. Hence, none of these can give a complete picture on its own (Dawkins, 1976, 1983; Hutson, 1984; Vestergaard, 1988; Hughes, 1975, 1992; Duncan, 1992; Fraser, 1993). Therefore, it is reasonable to seek for a combination of the above methods to measure the strength of motivation.

This study was designed to use distance moved and frequency of locomotive behaviour as potential indicators to investigate the influence of housing and age on motivation for locomotion, as well as other behaviour patterns which may account for the possible causation for the difference. The objective was to gain better understanding of how rearing conditions, distribution of resources, and age can affect locomotion, and the potential usage of behaviour patterns as indicators of motivation for locomotion.

3-2. Animals, Materials, and Methods

Sixty 9 week old ISA Brown pullets were randomly assigned to three treatments, twenty birds for each treatment. They were (C) 0.7 × 0.7 m wire-floor wooden-wall pen with resources (food, water, perches and litter-box) set at four corners; (G) 2 × 2 m wire-floor wooden-wall pen in which the resources were arranged in similar positions as in C (i.e. within a 0.7 × 0.7 m square at a corner of the pen); and (S) 2 × 2 m wire-floor wooden-wall pen with the same resources located in the four corners of the square pen (Fig. 3-1). The pens were non-roofed and were built inside an individual wire-wall floor-pen. The birds on each treatment were randomly allocated to four replicates, i.e. five birds per replicate. Individual birds were identified by coloured wing badges (blue, green, yellow, red, and orange). The densities of housing in each treatment per bird were 980 cm^2 per bird in treatment C, and 8,000 cm^2 per bird in treatments G and S. The housing environment was controlled at 21 °C, 10-16 lux lighting, and on a 14 h light: 10 h dark lighting regime, with the lights coming on at 04.00 h, and off at 18.00 h.

All birds were allowed 3 weeks to become accustomed to their experimental environments. Food and water were given ad libitum by trough-feeder and automatic nipple-drinker. To minimise any disturbance to the birds, they were tested in their home environments without transporting to another testing arena.

3-2-1. Experimental Protocol

From 12 to 22 weeks of age, moving distance and other behaviour patterns of every pullet were recorded by video equipment for 30 minutes for each pen in each treatment weekly. The four replicates of each treatment were randomly assigned into four observation periods, i.e., 9.00-11.00, 11.00-13.00, 13.00-15.00 and 15.00-17.00 h. Fully randomised design was used to video-record movements of birds throughout each pen (Table 3-1). Four replicates were divided into four time blocks. Each replicate comprised of three treatments. The recording schedule was carried out once a week, and a rota ensured that each treatment was observed in turn within each block. Five birds in a group for each pen in each treatment were video-recorded at the same time, their individual location and behaviour were recorded by reviewing video tapes with instantaneous sampling method at 10 second intervals for 30 minute period per bird.

3-2-2. Moving Distance Measures

Pen space was divided into 4 equal quadrats in treatment C, or 16 equal quadrats in treatments G and S (Fig. 3-2). Locations of individual birds were recorded at 10 second intervals. Change of location between two scans at 10 second interval was used to estimate moving distance by calculating the straight distance between two co-ordinate locations as shown in Figure 3-2.

3-2-3. Behavioural Measures

Besides the location of the bird, behaviour patterns were also recorded at the same interval and over the same period of time. Behaviour patterns were allocated into five main categories: locomotive (run, and walk), non-locomotive (dust-bath, rest, and stand), comfort (body-shake, head-scratch, head-shake, preen, tail-wag, wing-flap, and wing-stretch), feeding (beak-peck, drink, eat, feather-peck, ground-scratch, ground-peck, litter-scratch, litter-peck, and wall-peck), and aggressive behaviours (threat).

3-2-4. Statistical Analyses

An analysis of variance (ANOVA) was carried out on the moving distance and behaviour event. The moving distance data were converted to m/min/bird, and behaviour events were converted to percentage (2 decimal places) to give appropriate normality and equality of variance, making it legitimate to use ANOVA without a more complex transformation. Linear regression technique was used to compare walking frequency and moving distance over age (SAS Institute Inc., 1988).

3-3. Results

3-3-1. Comparison of Moving Distance and Behaviours

Table 3-2 shows the mean moving distance and frequencies of the five behavioural categories for the three rearing conditions. Three comparisons were conducted to investigate the influence of (1) extra floor space (treatments C and G); (2) different distributions of resources (treatments G and S); and (3) different stocking densities (treatments C and S).

The distance moved was greater and more locomotive and comfort behaviours were observed when the floor space was more extensive and the stocking density was lower (G and S), compared to the opposite rearing condition (C), but feeding behaviour occurred more in C than in other two treatments. Non-locomotive behaviour was more in C than in S. The birds in G moved further and showed more non-locomotive and comfort behaviours than in S, and were the most aggressive among the three treatments.

Table 3-3 shows the details of the twenty-two separate behaviour patterns for the three rearing conditions. More walking (locomotive behaviour); standing (non-locomotive behaviour); preening, tail-wagging and wing-flapping (comfort behaviour); ground-pecking (feeding behaviour); and threatening (aggressive behaviour) were found in the birds in G than in C. In contrast, less running (locomotive-behaviour); resting (non-locomotive behaviour); wing-stretching (comfort behaviour); drinking, eating and litter-pecking (feeding behaviour) were found in G.

Birds reared in G showed more resting and standing (non-locomotive behaviour); preening and wing-flapping (comfort behaviour); beak-pecking, feather-pecking, ground-pecking, and wall-pecking (feeding behaviour); and threatening (aggressive behaviour), but less running (locomotive behaviour); wing-stretching (comfort behaviour); and drinking, eating, litter-scratching, and litter-pecking (feeding behaviour) than the birds in S.

Compared to C, birds in S showed more walking (locomotive behaviour); preening and tail-wagging (comfort behaviour); and litter-pecking (feeding behaviour). In contrast, birds from C had more running (locomotive behaviour); resting and standing (non-locomotive behaviour); and feather-pecking and wall-pecking (feeding behaviour), compared to S.

The results from separate behaviour patterns, in general, give a similar finding as when they were grouped and analysed as the five main behavioural categories. However, exceptions were found for some behaviour patterns. Firstly, running (locomotive behaviour) was more in C than in G and S, although total locomotive behaviour was more in G and S. Secondly, although feeding behaviour was more in G than in S, foraging activities such as drinking, eating, litter-scratching/pecking were more in S than in G. Thirdly, comfort behaviour was less in a more compact space (C) than in the pen with extra floor space (G), however, the opposite was found for wing-stretching which was more in C. Fourthly, feeding behaviour was more in the smaller space and in the higher stocking density (C) than in the pen with extra floor space and lower stocking density (G and S), but ground-pecking and litter-pecking were more frequent in C.

3-3-2. Comparison of Walking Frequency at Different Ages

Figure 3-3 shows that time spent in walking throughout the observations appeared to decline gradually over the period of eleven weeks, except that the last observation at week 22 increased. When linear regressions between walking frequency and age were calculated either including or excluding week 22, the decline was significant only in G. No significant effect was found either in C or S (Table 3-4).

3-3-3. Comparison of Moving Distance at Different Ages

Figure 3-4 shows that mean moving distance tended to decline over the eleven-week period. The linear regression for G matched this trend, the best model is $Y=5.03-0.45X+0.012X^2$ ($R^2 = 0.87$) when excluding the last observation at week 22. However, the decline was significant only in G (Table 3-5).

3-4. Discussion

The results demonstrated that the mean distance moved in treatments G (resources grouped) and S (resources separate) was significantly greater than in C (confined). In addition, more locomotive and comfort behaviours occurred in G and S than in C. In contrast, the birds in C performed more feeding behaviour than in G and S. Non-locomotive behaviour, especially resting and standing, was more when the stocking density was higher in C (980 cm^2/bird) compared to the lower stocking density rearing condition in S (8,000 cm^2/bird). In comparative studies of floor- and cage-housed laying hens, it had been demonstrated that birds in a larger space were more active than those in a smaller space (Bareham, 1972; Hughes and Black, 1974; Eskeland, 1976; Keeling, 1994), with the exception of Jezierski and Bessei (1978). They found the opposite result in White Leghorn hens. The cage birds showed a significantly higher activity than floor birds. The results from the present experiment support most of the earlier research, and suggest that birds reared in a larger space or a lower stocking density were more active than those reared in a smaller space or a higher stocking density. In Jezierski and Besseis' (1978) experiment, both floor and cage birds were originally reared in deep litter or in cages from one day old, and then transferred to single activity cages for observations. The floor birds were given 2 months adaptation time for the new single activity cages before the observations, thus the novelty should not be considered as the major factor to the lower activity in pen birds. It is suspected that, although the pen birds in Jezierski and Besseis' (1978) experiment have been given 2 months to adapt to the single activity cages, their earlier rearing experience may still have effects on their perception of the restrained environment of the cages, and also their motivation for locomotion.

There was a number of other interesting findings. Firstly, birds moved further in G, in which resources were grouped closely within a 0.7 × 0.7 m square located in a corner of a 2 × 2 m square pen, than in S, in which the resources were separately distributed in four corners of a 2 × 2 m square pen. It was predicted that the birds in S would move further in order to reach the four different resources (food, water, perches, and litter box) than the birds in G, where the resources were near to each other and the birds needed only to move around within the 0.7 m× 0.7 m square area to reach the same four resources. The results do not support the prediction. Moreover, while the birds in G moved further and were more active, they performed more non-locomotive behaviour, such as resting and standing, compared to S. The results may be explained by concluding that the birds reared in G moved further for reasons other than to reach the resources, one reason could be that more feeding behaviour in G contributed to greater distance moved, as ground-pecking of feeding behaviour is usually accompanied by movement.

This finding may imply that birds moved not only in search of food, water, perches and litter box, they moved further for other needs as well. In the present experiment, exploratory behaviour should only play a minor role in the causation of locomotion, because all observations were carried out in the home environment over a period of eleven weeks, so it is unlikely that there were any effects from the novelty of the environment.

Secondly, more aggression was found in G than in S and C. This may be explained by greater social tension among flock mates in G than in the other two treatments. Comparing G with S, although the floor space was the same in both G and S, the birds in G spent more time close together because they were utilising the grouped resources, whereas in S they spent more time spreading out across the pen. Therefore, in G the inter-individual distance between birds was closer when birds had to congregate within the 0.7 × 0.7 m square to utilise the resources, as a consequence, causing greater conflict, social tension and aggression in G than in S. Previous research has also demonstrated a correlation between aggressiveness and space (Nicol, 1989), and influence of rearing conditions on competitiveness (Broom and Leaver, 1978). Social spacing may play a crucial role in social behaviour such as aggression and communication (Keeling, 1994).

Although aggression usually accompanies locomotive activities such as walking and running, it seems that aggression did not contribute to the main causation in view of the higher percentage of locomotive behaviour in G than in S, because aggressive behaviour only occupied a minor part (0.33%), compared to the percentage of locomotive behaviour (14.55%).

More aggression was also found in G which had more space compared to the confined conditions in C. It is more difficult to explain why there was more aggression in G than in C, because in C the birds were obliged, because of the smaller enclosure, to spend even more time close together. However, it may be that it is not so much a small inter-individual distance which stimulates aggression as the entry by one bird into the 'personal space' of another (Hughes and Wood-Gush, 1977). In G it was more obvious to other birds in the flock when an individual was approaching the resources, and such behaviour stimulated the attention of other flock mates. As a result of social facilitation birds in G tended to congregate towards the small area where the resources were located, and the birds behaved aggressively and defensively to other birds approaching the square.

An informal observation should be noted here, that there was a specific bird which tended to fly over pen walls in three out of four pens from G. These birds were threatened by other flock mates especially while they were feeding. Their feeding bouts were shorter compare to other dominant birds. A bird in G died from cannibalism at the end of observations. Serious feather pecking was performed by a specific bird in the same pen during week 22. The bird pecked other flock mates by pulling their feathers which led to bleeding and attracted other birds to peck at the wounds.

Thirdly, comfort behaviour such as preening and tail-wagging occurred more in the larger floor space (G) and in the lower stocking density (S) than in the compact condition (C). Previous research (Hughes, 1983; Nicol, 1986, 1989) suggested that comfort behaviour is related to social status and spatial restrictions: less aggressive birds performed more preening and wing-flapping, and tail-wagging was more frequent when the social stimulus was stronger. Preening and body-shaking were higher when birds were in close proximity to their flock mates. The frequency of comfort behaviour decreased when physical space was insufficient (Keeling, 1994), but increased after prevention by spatial restriction (Nicol, 1986). The findings of the present experiment are inconsistent with the observation of Nicol (1989), that birds were stimulated to perform more comfort behaviour in a more compact housing environment when they had closer proximity to their flock mates, but are consistent with Keeling's (1994) observation that comfort behaviour declined when space was limited. According to the observations, the birds either in G or in S were close to each other, and gathered as a flock in a corner of the pen while they were preening. This supports the earlier research that preening was performed when birds were close to each other (Keeling, 1994; Keeling and Duncan, 1991). Such findings taken together with the present results suggest that the higher incidence of preening in the larger space (G and S) than in the smaller space (C) is produced by the social interaction of grouped birds (close approximately with each other while preening) rather than by caging itself. Moreover, higher frequencies of preening and wing-flapping were found in G than in S. This indicates that the social interaction in G was even higher than in S. The positive correlation between aggressiveness and comfort behaviour found in this experiment is inconsistent with previous research (Wennrich, 1975; Nicol, 1989). Both higher incidences of aggression and comfort behaviour were found in G in the present study. This may because most aggression in G occurred while the birds were feeding or using the grouped resources due to the higher social competition, but they did not exhibit aggressive behaviour while they were close to each other performing comfort behaviour. Thus the increased aggression did not affect the performance of comfort behaviour. These two behaviour patterns were performed at different times and different social contents.

Fourthly, feeding behaviour such as drinking, eating, and litter-pecking occurred more in C, but more ground-pecking was found in G. This is consistent with Keeling's (1994) observation that the frequency of ground-pecking decreased as pen size decreased. She also suggested that birds performed ground-pecking less often when the available space decreased rather than performing them at inappropriate inter-bird distance.

Lastly, although in C the space was smaller than G, and the stocking density was higher than S, the birds housed in such a compact environment still performed more running than those reared in other two treatments; this result is inconsistent with a previous finding that walking declined as the pen size decreased (Keeling, 1994). However, there may be other possible explanation for this inconsistent result. In cattle it has been observed that decreasing walking space caused increasing social pressure, and as a result, locomotion was induced by increasing social competition (Zeeb et al., 1990). In the present experiment, running behaviour in C appeared to be chasing behaviour among birds, it is possible that over-crowded environment in C caused greater social pressure which consequently increased locomotion.

In general, walking frequency and moving distance declined throughout the observations in all three treatments, but the trend was only significant in G. It is suggested that locomotive activity declined as physical development approached maturity. It is possible that space becomes less as birds get bigger, therefore less space available for locomotion. In Japanese quail, it has been found that the genetic correlation of activity with body weight was 0.45 (Bessei, 1979).

It is concluded that walking and distance moved are related to floor space, and decline when the space decreases. Distribution of resources also affects on locomotive behaviour. The birds moved for reasons other than purely using the resources provided. It is speculated that such finding may indicate there is motivation for locomotion in laying hens. The decline in walking frequency and moving distance with age was only significant in the 2 × 2m pen with grouped resources (G). The abnormal feather-pecking in G suggests that grouped resources may have increased the social tension and aggression among the flock. Behavioural problems can be evoked by poor layout of equipments, therefore, resources should be carefully distributed to prevent severe social competition and avoid impact on welfare. Other behaviour patterns such as comfort behaviour are useful to interpret the results, while walking frequency and moving distance could be used as quantitative indicators for locomotion.

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Fig. 3-1
Housing environments of three treatments: (C) control group; (G) resources grouped; (S) resources separated in four corners.

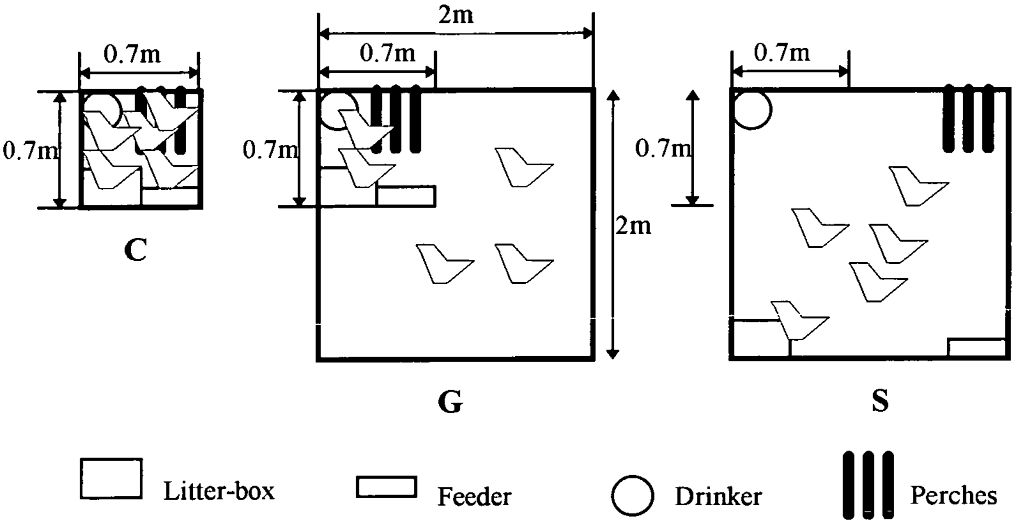

Fig. 3-2
Floor space of pens was divided into 4 (a, for treatment C) or 16 (b, for treatments G and S) grid squares to estimate moving distance of the birds.

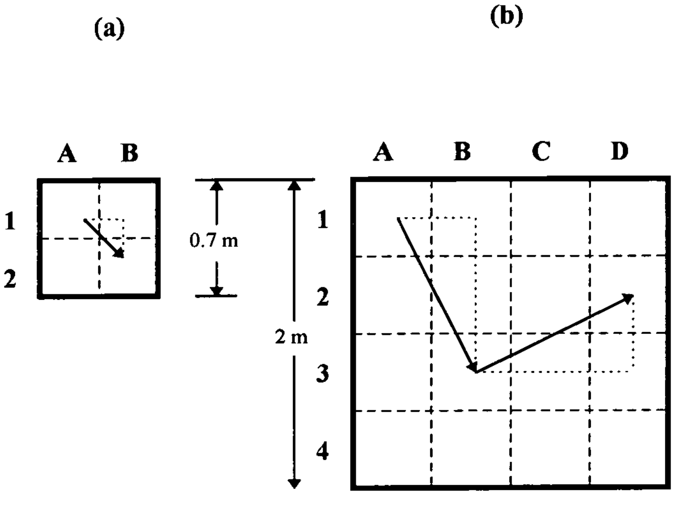

Table 3-1
Observations order of 3 treatments (C, G, and S), 4 replicates (Group 1-4) in 4 time blocks in a fully randomised design for video-recording periods. Each replicate group comprised of three treatments.

Period	Time	Replicate	Recording Sequence
Block 1	09:00-11:00	Group 1	Three treatments in random orders
Block 2	11:00-13:00	Group 2	ditto.
Block 3	13:00-15:00	Group 3	ditto.
Block 4	15:00-17:00	Group 4	ditto.

Table 3-2
Comparison of moving distance(m/min/bird) and categorised behaviour patterns (%) among rearing conditions.

Variable	Treatment C	Treatment G	Treatment S
Moving Distance (m/min/bird)	0.19 ± 0.023^{a}	0.89 ± 0.023^{c}	0.81 ± 0.023^{b}
Behaviour (%)			
Locomotive	8.15^{a}	14.55^{b}	15.23^{b}
Non-Locomotive	42.76^{a}	44.65^{a}	29.80^{b}
Comfort	1.00^{a}	1.67^{b}	1.49^{b}
Feeding	48.09^{a}	38.80^{b}	53.31^{c}
Aggressive	0.00^{a}	0.33^{b}	0.17^{a}

Among treatments, values are significantly different at least at $p<0.05$ level if followed by different letters

Table 3-3

Comparison of behavioural activities for three treatments (%).

Behaviours	Treatment C	Treatment G	Treatment S
Locomotive:			
Run	2.66^c	0.50^a	1.66^b
Walk	5.49^a	14.05^b	13.58^b
Non-Locomotive:			
Dust-Bath	0.67	0.33	3.31
Rest	28.79^c	24.75^b	18.87^a
Stand	13.31^b	19.57^c	10.60^a
Comfort:			
Body-Shake	0.17	0.17	0.17
Head-Scratch	0.17	0.17	0.17
Head-Shake	0.17	0.00	0.00
Preen	0.17^a	0.84^c	0.66^b
Tail-Wag	0.00^a	0.17^b	0.17^b
Wing-Flap	0.17^a	0.33^b	0.17^a
Wing-Stretch	0.17^b	0.00^a	0.17^b
Feeding:			
Beak-Peck	0.17^a	0.33^a	0.00^b
Drink	3.00^b	1.67^a	2.65^b
Eat	37.27^b	27.09^a	38.74^b
Feather-Peck	0.83^b	0.67^b	0.33^a
Ground-Peck	0.67^a	4.35^c	2.48^b
Ground-Scratch	0.33	0.50	0.66
Litter-Peck	5.49^b	3.85^a	8.11^c
Litter-Scratch	0.00^{ab}	0.00^a	0.17^b
Wall-Peck	0.33^b	0.33^b	0.17^a
Aggressive:			
Threat	0.00^a	0.33^b	0.17^a
Total	100.00	100.00	100.00

Table 3-4

Parameters for linear regressions between age (X) and walking frequency (Y) of three treatments, Y=a+bX (n=60).

Age	a	b	p	R^2
12 to 21 weeks				
Treatment C	0.41	-0.0047	ns	0.039
Treatment G	1.64	-0.0487	<0.05	0.683
Treatment S	1.00	-0.0116	ns	0.109
12 to 22 weeks				
Treatment C	0.3673	-0.0081	ns	0.077
Treatment G	1.4214	-0.0341	<0.05	0.443
Treatment S	0.8868	-0.0410	ns	0.016

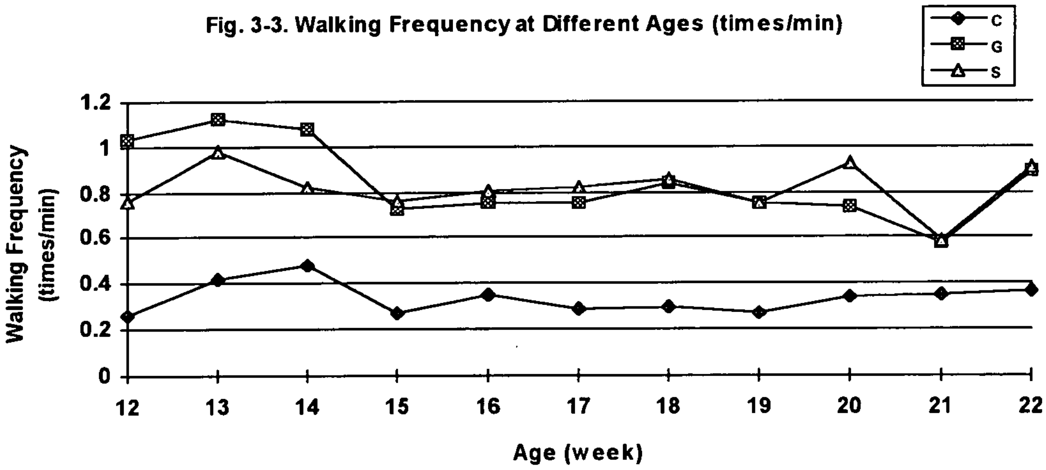

Table 3-5

Parameters for linear regressions between age (X) and moving distance (Y) of three treatments, $Y=a+bX$ ($n=60$).

Age	a	b	p	R^2
12 to 21 weeks				
Treatment C	0.238	-0.0031	ns	0.077
Treatment G	2.012	-0.0684	<0.0001	0.85
Treatment S	1.064	-0.0167	ns	0.34
12 to 22 weeks				
Treatment C	0.1971	-0.0004	ns	0.0012
Treatment G	1.7379	-0.0501	<0.005	0.61
Treatment S	0.8645	-0.0033	ns	0.01

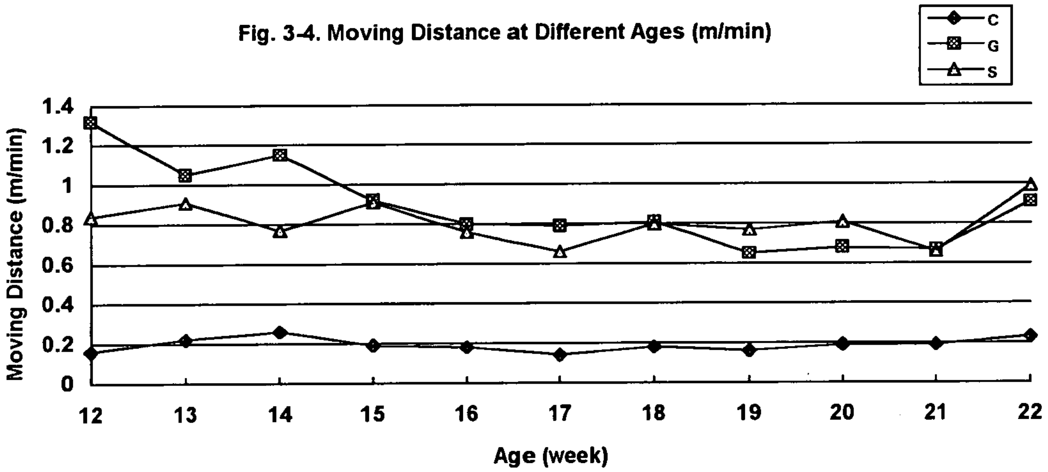

Fig. 3-4. Moving Distance at Different Ages (m/min)

Chapter 4 Effects of Exposure to Space on Motivation for Locomotion

Abstract

This experiment investigates the hypothesis that if a larger space induces motivation for locomotion then hens will move around more than in a smaller space, and that if a larger space is visible but unapproachable hens will show greater anxiety and be more active. The test arena was a 2×2 m wire-floor wooden pen without any object in it as the control (treatment C), or the hens were confined in one corner by a 1×1×1.5 m (L×W×H) opaque wooden wall (treatment N), or by a transparent wire wall of the same size (treatment T). Six pairs of ISA Brown laying hens from the confined rearing condition (treatment S in Chapter 3) were used at 26 weeks old. Paired birds were randomly chosen from a group of five birds in each pen, and assigned to the three treatments in balanced orders. The results indicate that locomotive, non-locomotive and aggressive behaviours occurred most frequently in treatment C, while the incidence of foraging and comfort behaviours were least in treatment C. Rebound of wing-flapping, running, and walking may represent a reaction of the animals released to a larger space (environmental changes). A larger space stimulated more locomotion, but the effect of visibility of space may not be as important as the effect of physical confinement. Results are discussed in terms of the potential benefits of relating behavioural activities to motivational states for studying the effects of visibility of space on motivation for locomotion.

4-1. Introduction

The Ministry of Agriculture's Codes of Recommendations for the Welfare of Livestock, Domestic Fowls (1987) state that all farm animals must have "freedom of movement" and the "opportunity to exercise most normal patterns of behaviour". However, the space provided in earlier studies is above the 450 cm^2/bird recommended as the minimum space allowance by current EC regulations (Bogner et al., 1979; Freeman, 1983; Dawkins and Hardie, 1989). One thing should be noted here is that these are measurements of area occupied by hens' bodies, not necessarily the space needed by them (Hughes, 1983), the values reported should be regarded as less than the minimum space needed, therefore, the space allowed by current EC regulation actually can not ensure adequate hen welfare (Dawkins and Hardie, 1989).

In terms of welfare in relationship to poultry production, one of the most important concerns is the physical and social restriction imposed by close and continuous confinement. It is usually assumed that the larger the cage, the better the welfare. It has been observed that confining chickens to relatively small cages for efficiency in husbandry and production has caused changes in their activities (Levy, 1944; Black and Hughes, 1974). However, some research found that hens do not necessarily prefer pens to cages (Dawkins, 1977), and some hens would work for larger cages whereas others would not (Faure, 1994). Therefore, whether hens feel better in a larger space or in a smaller cage is still unknown. It has been suggested that the preference for cage or pen will depend on hens' previous rearing experience, and it is important to consider the variability among individuals (Dawkins, 1977; Faure, 1994).

To tackle the argument between poultry practice and welfare concern, many studies have investigated the need for space (Nicol, 1986, 1987 a) and how hard birds will work to gain access to additional space (Faure, 1985; Faure and Mills, 1987). Two main approaches to determining a minimum space allowance for hens are based on physical dimensions (length and width) (Bogner et al., 1979; Freeman, 1983; Keeling, 1994) and on the space necessary to perform essential activities (Bogner et al, 1979;

Hughes, 1983; Dawkins and Hardie, 1989; Keeling and Duncan, 1991; Keeling, 1994; 1995). The latter approach is preferable but a lengthy process, and also requires more research and agreement on the behavioural activities that are primarily essential for hens. Age, reproductive state and other factors will all have to be considered when this approach is carried out. Body surface area (BSA) is also considered as a reference base for determining minimum space allowances for chickens (Hurnik and Lewis, 1991). The formula for BSA is based on body weight, which is an easily measured and well-established parameter. It has been suggested by Hurnik and Lewis (1991) that the minimum space requirement for poultry should be no less than the equivalent of 5-% of the bird's body surface area. Such recommendation was based on the principle that all birds in an enclosure should be able to rest simultaneously without contacting another bird or the walls of the enclosure.

The methods used for measuring the amount of space occupied or needed, include frame-by-frame and videotapes playback (Dawkins and Hardie, 1989); the use of operant conditioning (Lagadic and Faure, 1987; Lagadic, 1989; Faure, 1991); and choice tests (Hughes, 1975; 1977; Dawkins, 1976; 1977; 1981). The amount of space used by hens performing common behaviour patterns has been measured (Bogner et al., 1979) while turning (540-1006 cm^2), wing stretching (653-1118 cm^2), wing flapping (860-1980 cm^2), feather ruffling (676-1604 cm^2), preening (814-1270 cm^2) and ground scratching (540-1005 cm^2). Apparently, these behaviour patterns will be performed in a cramped or squashed way when less space is available, and the frequency will change consequently (Black and Hughes, 1974; Dawkins and Hardie, 1989; Tanaka and Hurnik, 1991; 1992). Previous experiments have shown that hens perform many activities at significantly different rates in accordance with spatial allowances (Black and Hughes, 1974; Bareham, 1976; Eskeland, 1977; Wennrich and Strauss, 1977; Keeling, 1995). In these studies, variation in spatial allowance has been confounded with group size (Eskeland, 1977), or else the comparison has been drawn between cages and pens. While such experiments may help in assessing spatial requirements in the short term, they do not add to our understanding of spacing behaviour per se. The underlying problem of spacing behaviour in laying hens and the locations of individuals and measuring inter-individual distances should be paid more attention (Keeling and Duncan, 1989). Studies of the stressful effects of high density should aim to determine the peaks of space requirements, and how the birds behave towards each other in these circumstances (McBride et al., 1969). Understanding variability with use of space is important not only in theory but also in practices as it might contribute to improving the adaptation of animals to space reduction and housing design.

Both perceptual factors (related to the perceived “barred character” of the obstacle, see Koehler, 1925; Tolman, 1932) and motivational factors (related to the degree of visibility of the goal, see Regolin et al., 1995) affect chicks’ performance in detour problems. In the absence of any local orienting cues emanating from the goal, chicks were still aware of the existence of an object that was no longer visible and could represent its spatial localisation in egocentric co-ordinates (Regolin et al., 1995). There were two main questions inspired by the above observations and investigated in this experiment: (1) Does visible space induce free movement and behavioural activities? (2) If there are more behavioural activities shown by the birds which can see the outside space but can not get access to it, does it represent frustration? In other words, visibility of space was used as the main factor to estimate the birds’ motivation for locomotion, and the hypothesis is that the visible space may stimulate the birds’ motivation for locomoting in the area outside the wire-cage, therefore, the birds restrained with transparent wire-walls would show more movement compared to when the same birds are restrained with opaque wooden walls so the space is invisible to them.

Behavioural activities such as pacing, displacement preening and feather raising are characterised as typical frustration responses in the domestic fowl (Duncan and Wood-Gush, 1972). In the present experiment, the incidence of movement will be considered as an indicator of the birds’ motivational state, moreover, the incidence of comfort behaviour among three treatments were compared to examine whether certain behaviour was built up to a higher level by the unapproachable space (deprivation of space).

4-2. Animals, Materials and Methods

Six pairs of ISA Brown laying hens from the small cage rearing condition (Chapter 3) were used when they reached 26 weeks old. Paired birds were randomly chosen from each group of five birds, and then allocated to three treatments in balanced orders. The test arena was a 2×2 m wire-floor wooden walled pen (no ceiling) as shown in Fig. 4-1. Three treatments were conducted to test the effect of sight of space on motivation for locomotion: the test arena (1) without any object in it as the control group (treatment C); (2) with a 1×1×1.5 m (L×W×H) opaque wooden walls placed in a corner (treatment N); and (3) with a transparent wire wall of the same size allocated in the same corner as treatment N (treatment T). No food, water, perches, or litter-box were provided during the tests. But all birds were neither hungry nor thirsty while they were tested in the empty experimental arena during the one hour observation, since they were fed before the three treatments were carried out, and were just moved from the home cage with water ad libitum, perches and litter-box provided.

Observations were recorded from 10.00 to 12.00 h by video equipment attached to the ceiling to give a plan view of the whole test arena. Twenty minute observations were carried out by instantaneous sampling at 10 second intervals for each pair/treatment in rota. Only 15 minutes observations were analysed as the data collected in the initial 5 minutes were excluded, during these 5 minutes the test birds were allowed to settle after the handling from their home cages to the test arena. Only a pair was observed for each day, and the pair was tested by all three experiments at the same day. Sequences of three treatments were randomly assigned to six pairs of birds in 6 days with a balanced order (Table 4-1).

The same method as in Chapter 3 was used to evaluate the approximate distance moved per minute (m/min) of individual birds. Behavioural activities were also recorded simultaneously. Fifteen activities were recorded and analysed separately, and then grouped into five categories: locomotive behaviour (run and walk); non-locomotive behaviour (stand and rest); comfort behaviour (body-shake, head-scratch, head-shake, preen, tail-wag and wing-flap); foraging behaviour (feather-peck, ground-peck and wall-peck); and aggressive behaviour (threat and fight). Data collected for two birds in each pair were analysed as a grouped value as they were dependent on each other. Analysis of variance (ANOVA) was used to compare the effect of treatments on the test birds' behavioural activities and moving distances.

4-3. Results

The effect of treatments on separate behavioural activities and categorised behaviours are shown in Table 4-2 and Table 4-3. The results show that treatments have significant influence on all categorised behaviours (locomotive, non-locomotive, comfort, foraging, and aggressive), and on some separate behavioural activities such as walking, running, standing, preening, wing-flapping, and wall-pecking.

The percentage of behavioural activities is shown in Table 4-4. Three comparisons were made by exposure to space (treatments T and N); restrain (treatments C and N); and the interaction of exposure to space and restrain (treatments C and T). Firstly, when considering the factor of exposure to space alone, more standing was found when the space was visible (T) than when it was opaque (N). Secondly, when considering the restrain effect alone, locomotive, non-locomotive, and aggressive behaviours occurred more in C than in N; but comfort behaviour and foraging behaviour were more in N than in C. Thirdly, when considering the interaction of two factors mentioned above, more locomotive and aggressive behaviours but less foraging behaviour were found in C than in T.

Walking, running, standing, wing-flapping, and threatening occurred more when birds were able to move around in the test arena (C) without being restrained by the wooden walls (N), on the other hand, preening and ground-pecking were more in N than in C. There was less walking, running, wing-flapping and threatening, and more wall-pecking when the birds were restrained by the transparent walls (T) than in C.

4-4. Discussion

Previous research on exploratory activity as a measure of motivation in deprived hens suggests that wall and ground pecking, and head stretching may reflect extrinsic exploratory activity (Nicol and Guilford, 1991). This earlier experiment showed that birds moved around the tunnel instead of simply entering and remaining stationary. In the present investigation when the space outside the walls was visible to test birds, the birds expressed more wall-pecking. The visible space may have induced motivation for locomotion and, combined with evidence of exploration, therefore, indicated that the birds were motivated to get to the outside space.

During informal observations, it was observed that the birds tested with T put their beaks through the wire-walls, and tried to squeeze their heads through the holes of the walls. It seems that they were trying to get into the space outside the enclosure. Exploration usually is an activity which goes with locomotion and foraging behaviour, and foraging behaviour itself usually accompanies locomotive behaviour: the more foraging behaviour was performed, the more locomotive behaviour was observed. (Berlyne, 1960; Hinde, 1970; Belzung and Pape, 1994). However, in the present experiment, more foraging behaviour did not accompany more locomotive behaviour. Previous research suggested that an increase in exploratory behaviour consequently leads to a decrease in other activities, such as drinking, feeding, wing-flapping, stretching, preening and perching (Nicol and Guilford, 1991). However, since there were no resources like food, water, perch and litter-box provided in the present experiment, behavioural activities such as feeding, drinking, and perching can be eliminated from those putative causations, indicating that if pecking on the wire-walls hints exploratory behaviour, then the increased locomotion may be mainly due to stronger motivation to explore in the open area outside the wire-walls.

Most noticeably, ground-pecking occurred more in the confined environment (N) than in the more extensive environments (C). The possible explanation for the higher incidence of ground-pecking behaviour in the more confined environment (N) than in the more extensive environment (C) may be, that the higher incidence of ground-pecking in N represented exploratory behaviour while in C exploratory behaviour was represented by the higher incidence of locomotion. A possible reason for such difference in expressing exploratory behaviour may be due to the discrepancy of space between N and C, because the birds in C had more sufficient space to perform locomotion, while the birds in N only had a quarter of the space as in C.

Frequency of comfort behaviour (preening) was higher when the birds were under confinement (N) than when they could have free movements (C) in a much larger space (1:4). 'Comfort behaviour' is a term with a number of activities of laying hens, on the assumption that their function is mainly to maintain plumage or stretch muscles. These activities are preening, wing-flapping, wing/leg-stretching, body-shaking, feather-raising, head-scratching (Black and Hughes, 1974), and tail-wagging (Kruijt, 1964). In N, the enclosure which was constructed with opaque wooden walls may have provided a secure environment for the birds, as the opaque wooden walls formed an enclosure more similar to the home environment of the cages where the birds were kept in. Therefore, the birds may feel more familiar with the set-up in N than the larger space in C, more preening may indicate that the birds were more relaxed in N. In the other hand, it may be due to the closer proximity between birds, which supports the previous research finding that close proximity between birds increased preening (Nicol, 1987 a), and preening was more frequent in cages than in pens (Black and Hughes, 1974). Since there was no significant difference in preening behaviour between N and T, it is suggested that preening was not influenced by the visible space outside the wire walls, but it was induced by the close proximity between paired birds, as a result of the confinement in the 1 × 1 m cage.

Wing-flapping, running and walking were observed significantly more in C than in other two treatments. This may be due to the variation between home environment (0.7 × 0.7 m) and the test arena (2 × 2 m). In C the space for each bird was more extensive than in other two treatments, in which the birds were physically confined within the 1 × 1m square enclosure. Therefore, they had adequate space for free movement and larger scale activities (such as locomotion and wing-flapping), and more interactions (for example, aggressive behaviour) between each other. Such increase in these larger scale activities may be seen as a reaction after being released to a larger enclosure. Nicol (1987a,b) found that wing stretching, feather raising, tail wagging, leg stretching and wing flapping rebound after the birds were transferred from a small home cage to the larger test cage, and suggested that such rebound may result either from an increase in motivational tendency during the period of spatial restriction, or as suggested by some researchers, that the rebound rates of activity performance are likely part of a response to general novelty, such as that of the experimental procedure (Hughes, 1980; Murphy and Wood-Gush, 1978). However, since all three treatments were preceded by the same experimental procedure, all pairs of birds were moved from their home cage to the test arena which may be novel to them while they were tested in three treatments, therefore, the effect of novelty can be counteracted when comparing among the three treatments themselves, so that novelty, in this case, would not be considered as a major contribution to the rebound of activities.

No significant difference in behaviour except standing was found between T and N, indicating that there was little influence caused by visibility of space on behaviour, although standing involves investigating and looking towards the outside space, which may represent attention to the outside. This suggests that actual access to space played a major role in motivating behaviour, not merely exposure to space.

Fighting was observed only in treatment C where birds could move freely without being confined inside the enclosure. It is likely that this result may be explained by the fact that there was not enough space to fight in treatment T and treatment N since fighting is a larger scale movement constituted by wing flapping, jumping, and running, which were unlikely to be performed in a compact space. In a compact space, the presence of one individual within the personal space of another may play a less important role in causation of aggression than the actions of approaching or entering into that space (Hughes and Wood-Gush, 1977).

In conclusion, a larger space stimulated the birds to locomote more, mainly due to accessibility to space more than merely visibility of space. Rebound of behaviour was affected more by the physical confinement in home environment than the visible space outside the wire walls. It is suggested that birds can perceive and be attracted by the visual stimulus of extra space, but the previous rearing experience and the accessibility to space have greater influence on motivation for locomotion. Gross body movements such as locomotion, aggression and wing-flapping may be suppressed if there is no enough space to perform these activities. Compact space provides close proximity between birds and therefore increases the incidence of preening.

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Fig. 4-1
Three main treatments: control group (treatment C), transparent walls (treatment T), and opaque walls (treatment N).

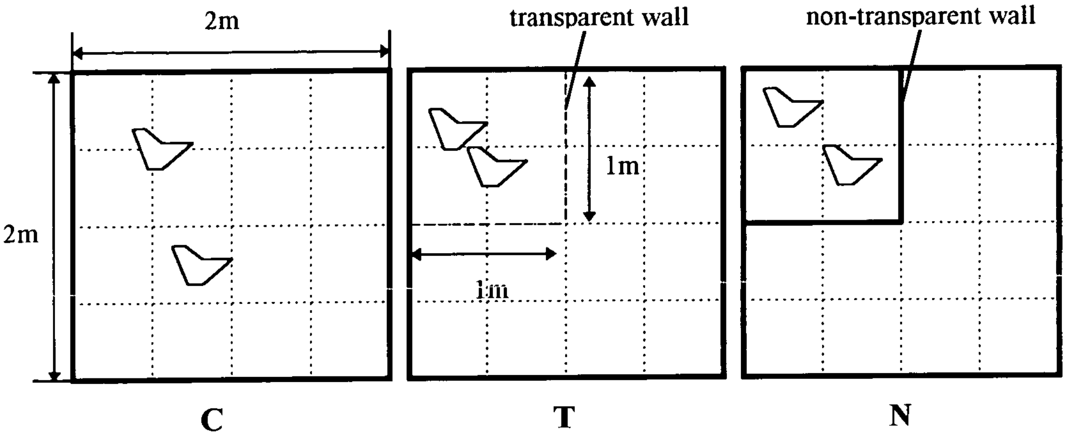

Table 4-1
Schedule of observations.

Day	Pair of Birds	Sequence of Treatments 1	 2	 3
1	A	T	C	U
2	B	U	C	T
3	C	T	U	C
4	D	U	T	C
5	E	C	U	T
6	F	C	T	U

Table 4-2
Analysis of variance of the mean cumulative totals of behavioural activities in three treatments.

	DF	Wall-Peck	Walk	Run	Preen	Wing-Flap	Stand
Treatments	2	8.86*	208.30***	0.54**	235.29**	12.03***	101.20*
Remainder	33	2.28	25.85	0.09	44.90	0.39	23.23

***=p<0.001, **=p<0.01, *=p<0.05

Table 4-3
Analysis of variance of the mean values of the 5 main behavioural categories in three treatments.

	DF	Locomotive	Non-locomotive	Comfort	Foraging	Aggressive
Treatments	2	229.32***	76.67*	151.63*	67.48**	0.22*
Remainder	33	26.08	23.84	44.70	13.89	0.05

***=p<0.001, **=p<0.01, *=p<0.05

Table 4-4
Effect of visibility of space on behavioural activities (%).

Behavioural Activities	Treatment C	Treatment T	Treatment N
Locomotive	37.13b	30.90a	15.94a
Run	0.97b	0.00a	0.00a
Walk	36.16.b	30.90a	15.94a
Non-locomotive	38.08b	52.61ab	26.80a
Rest	0.00	0.00	1.85
Stand	38.08b	52.61b	24.94a
Comfort	16.33a	32.19ab	36.27b
Body-Shake	0.89	0.51	0.28
Head-Scratch	0.47	0.90	0.36
Head-Shake	0.52	0.00	0.00
Preen	10.22a	30.51ab	35.17b
Tail-Wag	0.34	0.12	0.19
Wing-Flap	4.72b	0.12a	0.28a
Foraging	7.86a	24.73b	20.99b
Feather-Peck	0.45	4.20	3.78
Ground-Peck	6.55a	12.56ab	13.34b
Wall-Peck	0.86a	7.97b	3.87ab
Aggressive	0.60b	0.00a	0.00a
Fight	0.08	0.00	0.00
Threat	0.52b	0.00a	0.00a
Total	100.00	100.00	100.00

C (control group), T (transparent wall), and N (opaque wall).

Different letters represent the significant difference ($p<0.05$) among treatments within behaviour.

Chapter 5 Influence of Presence and Familiarity of a Companion Bird on Locomotion

Abstract

This experiment was conducted to examine the effect of another bird (unknown or familiar) on distance moved and inter-individual distance. Behaviour patterns of test birds were also recorded and used as complementary indicators of birds' motivational state. Ten ISA Brown laying hens from two 0.7 × 0.7 m wire-floor wooden-wall cages were used at 11 weeks old. Birds from the two cages were randomly assigned to three treatments. Each bird was tested individually. Observations were carried out in a 2 × 2 m wire-floor wooden-wall pen with: (1) an empty wire-cage (1 × 1 × 1.5 m: L × W × H) placed in the corner (treatment C); (2) a familiar bird in the wire-cage (treatment F); and (3) an unknown bird in the wire-cage (treatment U). Results indicated that birds performed more non-locomotive behaviour when alone; conversely, they showed more foraging and locomotive behaviours when there was another bird present, whether it was a familiar cage mate or an unknown stranger. The familiarity of the bird restrained in the wire-cage had effects on behaviour. More comfort behaviour was performed while there was a familiar cage mate present than when test birds were alone. Less locomotive behaviour occurred when the test bird was accompanied by an unknown bird, but frequency of aggression was higher compared to when there was a familiar cage mate present. It is assumed that motivation for locomotion is influenced by social factors (presence of another bird and familiarity with it).

5-1. Introduction

Investigating the effects of varying degrees of spatial restriction on behaviour has been one approach for studies on spacing (Al-Rawi and Craig, 1975; Zayan, 1985), while others have taken a different approach of looking at the effects of behavioural activity on spacing (Keeling and Duncan, 1991). It is well known that different activities are performed in different locations in free-ranging birds (Collias et al., 1966; McBride et al., 1969; Wood-Gush et al., 1978), but the extent of inter-individual distances between birds performing different behavioural activities is not well documented (Keeling and Duncan, 1991). Attempts to determine the size of either the personal space or individual distance in poultry have been inconclusive (Lill, 1969; Doyen and Zayan, 1984 a, b; Meunier-Salaün and Faure, 1984). Although these approaches are not directly applicable to commercial conditions, they may highlight the importance of behavioural activity and that this should be considered before spatial requirements under commercial conditions are assessed.

The idea of spacing behaviour is derived from Hediger's (1950) description which involves the concept of individual distance. McBride (1971) proposed that animals occupy both physical space and personal space. A similar notion was proposed by Waser and Wiley (1979) but they used a different term: 'isolation field' instead of 'personal space'. Physical space requirement is the actual amount of space the animal occupies (Baxter and Schwaller, 1983) and it varies according to the activity the animal is performing (Dawkins and Hardie, 1989). The space occupied by a group of animals is not simply the sum of the physical space requirements of each individual but includes the additional use of space in the social context which is termed the social space requirement. The results from previous research do not support the idea that there is a rigidly defended area around an individual in domestic fowl, and suggest there should be a more flexible mechanism which incorporates attraction as well as repulsion between individuals. Therefore, the dimensions of the personal space vary according to the activity of animals or to their orientation, so the concept of personal space becomes meaningless and assessing the spatial requirements of the animals involved will not be very helpful (Keeling and Duncan, 1989).

The spacing of animals is thought to be a balance between the tendency to approach and the tendency to withdraw from other individuals, which is influenced by many environmental factors, such as the risk of predation and the distribution of resources (Kummer, 1971; Zajonc, 1971; Bischoff, 1975; Krebs and Davies, 1981), and by the social rank of the individual (McBride et al., 1963, 1969; Keeling and Duncan, 1989). However, social factors are more important than environmental factors in the spatial organisation of domestic hens which are often housed under intensive conditions and at high stocking densities, especially, familiarity with flock mates is an important factor influencing the distribution of birds in a large flock (Keeling and Duncan, 1991).

When behavioural activity changes there is an adjustment in inter-individual distance which is reflected in the pattern of movements. If a particular transition results in an increase in inter-individual distance, then the opposite transition results in a decrease in inter-individual distance (McBride et al., 1963; Keeling and Duncan, 1991). When space is adequate, birds in a group position themselves at distances appropriate for an activity and perform that activity at the optimum frequency for the environmental condition (Keeling, 1994). The maintenance of an inter-individual distance appropriate for an activity is important to the bird because changes in inter-individual distance are associated with changes in activity. Inter-individual distances are largest when birds are foraging and decrease in the order of walking, standing, ground pecking, and then preening (Keeling and Duncan, 1991). It is suggested that sufficient inter-individual distance is important to the performance of activity as birds would tolerate a decrease in the frequency of the activity rather than carry out the activity at the same frequency at an inappropriate distance (Keeling, 1994).

The study of spacing in farm animals has gained new impetus as a consequence of the animal welfare debate, since a major criticism of intensive husbandry systems is that they may affect the welfare of animals adversely by providing insufficient space for them. Under intensive husbandry conditions, the movement of individuals away from each other is restricted by physical barriers, and the social space requirement will exceed the actual space available in the housing condition even if the physical space requirement is met. The spacing pattern has resulted from evolutionary selection for spacing as activity under natural conditions is conserved in a more artificial environment (Keeling, 1994); the resilience of a behaviour in an animal's repertoire is considered to be the cost to the animal of abstaining from that activity (Houston and McFarland, 1980). When the frequency of the behaviour has reached its lowest level (determined by its resilience) then further decreases in space do not result in any further decreases in frequency until it becomes physically impossible to perform the behaviour. It is assumed that behaviour with a higher resilience will still be performed, though it will be performed less often, even when the cost is high.

Although many factors will determine the motivational state of an animal in a group, one factor that is not usually taken into consideration is the space available to the animals and hence the distances between them. More attention should be paid to the importance of social spacing in motivational studies of behaviour (Keeling, 1994). Usually, resilience is measured by decreasing the time available to the animal and seeing how the time budget of the animal changes (McFarland, 1985), or by reducing the space available to the animal (Keeling, 1994). The technique of reducing the space available to birds may be useful in experimentally assessing the resilience of particular behaviour patterns and the importance birds attribute to expressing them.

This chapter examined the effect of presence and familiarity to a companion on the moving distance and inter-individual distance. Behaviour patterns of test birds were also recorded and used as complementary indicators of birds' motivational state.

5-2. Animals, Materials and Methods

Ten ISA Brown laying hens kept in group of five in two 0.7 × 0.7 m wire-floor wooden-wall cages with resources (food, water, perches and litter-box) set at four corners, at the age of 26 weeks. All birds were tested once in a 2 × 2 m wire-floor wooden-wall pen with: (1) an empty wire-cage (1 × 1 × 1.5 m: L × W × H) placed in the corner (treatment C); (2) a familiar bird in the wire-cage (treatment F); and (3) an unfamiliar bird in the wire-cage (treatment U) (Fig. 5-1). Three treatments were carried out in a random order in the same day from 10.00 to 12.00 h, and only one bird was tested in one day. Each observation was 20 minutes long and with an extra 5 minutes before formally taking records for the test to recover from the handling. Birds from the two cages were used as both test and companion: birds from the same cage were used as 'familiar bird' in treatment F; and from the different cage were used as 'unknown bird' in treatment U. No food or water was supplied during the test, but all test birds were fed an hour before the observation, to ensure that they were neither hungry nor thirsty. Wing badges were used for individual identification. Video equipment was attached to the roof to provide a clear view of birds' movement without disturbing them .

Location and behaviour of test bird were recorded and analysed by methods similar to those in Chapter 3. The whole pen was demarcated into 16 equal size quadrates. The locations of all individuals were recorded as co-ordinates in the experimental pen at 10 second intervals for 20 minutes (Fig. 5-2). The distances between pairs of individuals could then be calculated from their co-ordinates (Keeling and Duncan, 1989). Change of location within each 10 second interval was estimated by the distance between two co-ordinates: $[(X_2-X_1)^2+(Y_2-Y_1)^2]$ and converted. The inter-individual distance between the test and companion birds was also calculated by the co-ordinate locations at 10 second intervals, and estimated by the same equation as above. Behaviour was also recorded at the same intervals and over the same period of time, and then converted to a percentage (given by the number of actual scans of a behaviour pattern/the number scans of all behaviour patterns). Eleven observed behaviour patterns were allocated to five main categories: locomotive (run and walk), non-locomotive (rest and stand), comfort (head-shake, preen, tail-wag and wing-flap), foraging (ground- and wall-peck), and aggressive (threat).

An analysis of variance (ANOVA) was performed on the three variables: distance moved; inter-individual distance; and behaviour, to examine the effect of presence and familiarity of a companion bird on each of the variables across the three treatments.

3. Results

There were significant differences between treatments in walking, resting, standing, preening, ground-pecking, wall-pecking, and threatening. All five main behaviour categories were different between treatments (Table 5-1). When a test bird was alone with an empty cage (treatment C), incidence of resting was higher, and there was less in preening, ground- and wall-pecking, than when there was another bird in the wire-cage (treatments F and U). Test birds showed more walking and preening when the restrained bird was a familiar cage mate, but standing and threatening were more frequent when an unknown bird was present. No significant difference was found in either moving distance or inter-individual distance among treatments (Table 5-2 and 5-3). Although there was no significant variation between individual birds in distance moved and inter-individual distance, some individuals, however, responded very differently to the treatments (Table 5-4). The majority of birds (6 out of 10) had greater inter-individual distances in U than in F, and moved further when the familiar bird was present (6 out of 10).

In general, test birds performed more non-locomotive behaviour when they were investigated alone; conversely, they showed more comfort and foraging behaviours when there was another bird present, regardless of whether it was a familiar cage mate or an unknown stranger. Familiarity also had significant effects on behaviour. Test birds expressed more locomotive and comfort behaviours when the companion bird was familiar to them (F), but more non-locomotive and aggressive behaviours were observed when the unknown bird was present (U).

4. Discussion

The two social factors investigated in this chapter: presence of another bird and familiarity between birds, influenced locomotion, inter-individual distance, and behavioural activities. Birds performed more non-locomotive behaviour, but less comfort behaviour and foraging behaviour when they were tested alone without another bird. When a test bird and a companion bird were familiar, the test bird showed more locomotive and comfort behaviours, and performed less aggressive and non-locomotive behaviours than when the companion bird was an unknown individual.

It has been suggested that social contact can reduce the emotional behaviour of isolated animals (Tolman, 1965). Isolation increases metabolic rate and affects digestion, causes more body heat loss and more activities in chicks, especially when they are under stress (Notermans and Kampelmacher, 1975). The removal of one chick from an established pair birds has been found stressful to the remaining bird (Jones and Williams, 1992). The presence of social companions reduces fear in an unfamiliar environment, social separation per se is stressful and increases fear reactions (Hogan and Abel, 1971). Familiar birds are more preferred when birds had to choose between an unfamiliar group and a familiar group (Hughes, 1977); the similar social influence of familiarity between individuals has also been observed that birds take longer to move past a dominant or unfamiliar bird than they do to move past a subordinate or an empty cage (Freire, 1994; Grigor et al., 1995). These studies suggest that animals are calmer and less emotional when they have companions, especially when the companions are familiar birds.

To examine the content of the two social factors investigated in the present experiment, firstly, the presence of another bird: the present findings are inconsistent with previous research as mentioned above, that the birds were less active (more non-locomotive behaviour) and rested more when they were alone in the experimental pen without any companion. Secondly, to examine the effect of familiarity with the companion bird: it was observed that foraging behaviour and comfort behaviour were more when the companion bird was present; the results are consistent with previous research, that birds ingest and preen more when there is social contact with other birds (Meunier-Salaün and Faure, 1984; Nicol, 1989). According to the informal observations, test birds appeared to be calmer when a companion was present, even if they were not familiar to each other. One test bird from treatment C (with no companion) flew up to the top of the wooden-wall and sat for the whole period of 20 minutes observation. The bird did not perform any movement but vocalised for some while, then rested on the wall until the observation ended. This may be explained by the fact that test birds were too fearful to move around when they were alone in the experimental pen, which may be due to the novelty of the environment and absence of a companion. Previous research has found that isolation may cause a fear reaction: solitary birds were more nervous and remained motionless (fear freezing) for a larger proportion of time, otherwise, they performed more behavioural activities with social content such as preening and ground-/wall-pecking (Jones, 1985; Jones and Williams, 1992). This indicates that companionship gives a positive support to an animal's psychological state: in this case, less fear in the new environment, thus test birds feel more secure and explore the surroundings more.

It was anticipated that, as birds showed more walking when the companion bird was a familiar individual, the distance moved would be further; and inter-individual distance would be larger if the companion bird was unknown to the test bird. Previous research (McBride et al., 1969; Keeling and Duncan, 1989) observed that social components influence spacing, and the spacing pattern adversely influences behaviour of birds. Familiarity with previous flock members is an important factor influencing their distribution (Keeling and Duncan, 1991). Nevertheless, results from the present experiment seem inconsistent with the original hypothesis: there was no significant difference either in moving distance between the solitary birds in treatment C and those with another companion in the other two treatments, or in inter-individual distance between familiar birds and unfamiliar birds.

In conclusion, the findings suggest that the presence of familiarity with flock mates may produce a situation where birds feel more secure and relaxed to explore the novel environment, as a consequence, inducing their motivation for locomotion. Familiarity between birds and companionship increased comfort and foraging behaviours. If the companion bird was unfamiliar to the test bird, there was more aggression between two birds, and the test bird was less active than when it was accompanied by a familiar individual.

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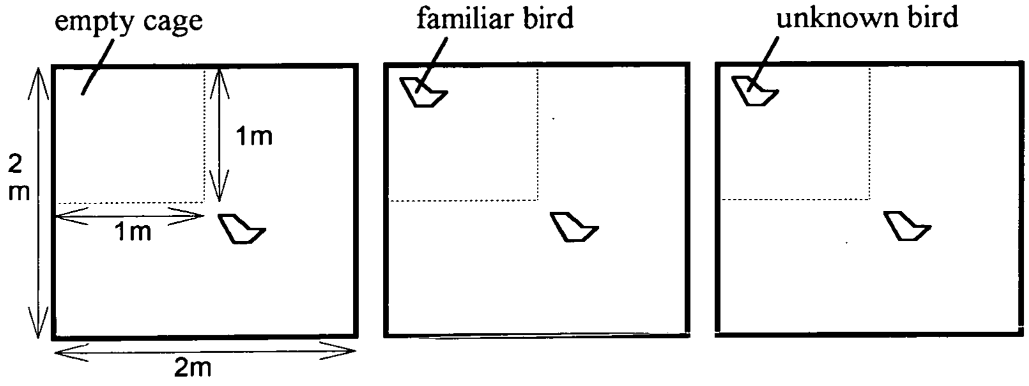
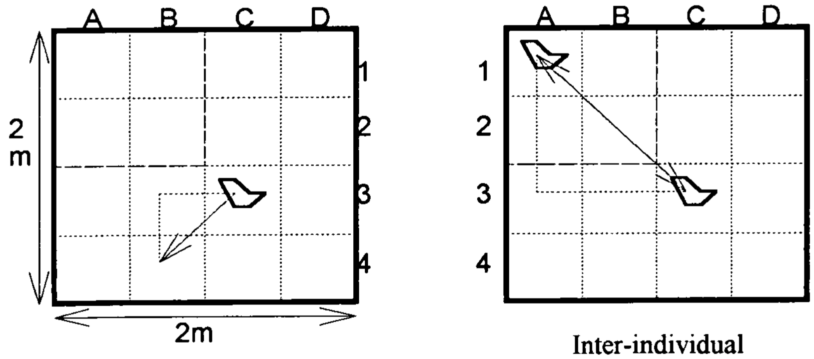
Fig. 5-1
Experimental treatments and the test pen: a wire-wall cage (1×1×5: L×W× H) was allocated in a corner of a wire-floor wooden-wall pen.



Treatment C **Treatment F** **Treatment U**

Fig.5-2
Recording method of moving distance and inter-individual distance. The moving distance from (C,3) to (B,4) is measured as the distance between two co-ordinates: (3,3) to (2,4); and for inter-individual distance, the distance between (A,1) and (C,3). A to D represent 1 to 4 on the X-axis, and the numbers 1 to 4 represent the Y-axis.



Walking Distance

Inter-individual Distance

Table. 5-1
Effects of presence of a companion bird on behavioural activity of test birds (% of scans, n=10).

Behaviour	Control	Familiar Bird	Unknown Bird
Locomotive	9.59a	13.47b	9.80a
Run	0.30	0.30	0.20
Walk	9.29a	13.17b	9.60a
Non-locomotive	88.01c	73.95a	79.52b
Rest	10.19b	0.10a	0.40a
Stand	77.82b	73.85a	79.12b
Comfort	1.70a	9.18c	7.09b
Head-Shake	0.00	0.10	0.00
Preen	1.30a	8.78c	6.59b
Tail-Wag	0.10	0.10	0.30
Wing-Flap	0.30	0.20	0.20
Foraging	0.70a	3.41b	3.30b
Ground-Peck	0.40a	1.83b	1.90b
Wall-Peck	0.30a	1.58b	1.40b
Aggressive	0.00a	0.00a	0.30b
Threat	0.00a	0.00a	0.30b
Total	100.00	100.00	100.00

* a and b represent significant difference (p<0.05) among treatments.

Table. 5-2

Effect of familiarity between birds on mean inter-individual distance.

Treatment	Mean Inter-individual Distance (m/min/bird)
Familiar Bird	7.19±0.33
Unknown Bird	7.76±0.33

Table. 5-3

Effect of existence and familiarity of another bird on mean moving distance among treatments.

Treatment	Mean Walking Distance (m/min/bird)
Empty Cage	1.26±0.30
Familiar Bird	1.75±0.30
Unknown Bird	1.32±0.30

Table 5-4

Mean inter-individual distance (m/min/bird) and mean walking distance (m/min/bird) of individual birds.

Bird	Mean Inter-individual Distance		Mean Walking Distance		
	F	U	C	F	U
1	6.20	6.77	0.49	0.23	0.00
2	7.18	8.73	0.05	2.22	1.32
3	6.56	7.99	0.00	0.90	1.32
4	7.84	9.18	2.33	2.25	2.67
5	7.21	6.58	1.44	2.86	1.43
6	8.13	7.45	0.00	1.74	0.52
7	8.54	8.33	1.24	1.61	2.06
8	7.05	0.78	2.87	0.94	1.34
9	6.00	6.50	1.88	0.10	1.60
10	7.17	6.26	2.30	4.65	1.00

Chapter 6 Cage- vs. Pen-Rearing and Strength of Motivation for Locomotion

Abstract

Motivation for locomotion in twelve pairs of ISA Brown laying hens previously housed in either cages or in pens was compared. The birds were tested in a 2 × 2 m pen which had a 0.7 × 0.7 m wire-wall cage in the corner of the pen. At the beginning of the observations, the birds were placed inside the cage which was equipped with food, water, perches and litter-box. An adjustable door attached to the wire-wall cage could be altered to vary the width of gap from 0 to 20 cm.

Two treatments, narrow-gap (10 cm) and wide-gap (20 cm), were introduced to each pair of birds from either housing environment to examine the willingness of the birds to squeeze through the gap to the space outside the cage. Measurements were made of five main behaviour categories derived from twenty two behavioural activities, and three putative indicators for motivation for locomotion: the frequency of passing through (in/out) the gap (passages/bird), the time spent outside the cage (sec/bird), and the mean walking distance (m/min/bird).

The results suggest that cage-reared birds were more motivated to locomote than pen-reared birds. Their willingness to visit the pen outside the wire cage was less inhibited by the narrow-gap compared to pen-reared birds.

6-1. Introduction

Most studies of effects of housing environments have assessed specific behavioural activities such as feeding and comfort behaviour, and productivity. However, few reports have related these individual behaviours to experience (housing environments) and its effects on motivation for locomotion and the need to perform locomotion.

Studies have investigated the need for space (Nicol, 1986; 1987 a) and how hard birds will work to gain access to additional space (Faure, 1985; Faure and Mills, 1987). While such experiments many help in assessing spatial requirements in the short term, they do not add to our understanding of spacing behaviour per se. Keeling and Duncan (1989) returned to the underlying problem of spacing behaviour in laying hens and concentrated on recording the location of individuals and measuring inter-individual distances.

Some investigations have been carried out on effects of spatial allowance and group size on the behaviour of hens in different husbandry conditions (Black and Hughes, 1974; Hughes and Black, 1974; Reed and Nicol, 1992). The performance of comfort behaviour is the key because hens are strongly motivated to perform these movements, and it is important to their welfare (Nicol, 1987 b). Moreover, enforced inactivity can have adverse effects on bone strength which will reduce welfare (Knowles and Broom, 1990). However, the complications of the various interactions involved and the weak association with other indicators of welfare would support the hypothesis that physical condition and productivity do not seem to be a useful measurement of long-term stress or welfare of hens if either is used solely (Duncan, 1981; Siegel, 1984; Cunningham et al., 1988). It is necessary to sort out multi-disciplinary approaches incorporating physiological, behavioural and production as methods of assessing welfare.

This experiment was conducted to investigate the relationships between behavioural indicators and motivation for locomotion, and effects of housing experience on motivation for locomotion in laying hens.

6-2. Animals, Materials and Methods

Two treatments, narrow-gap (10 cm) and wide-gap (20 cm) (Cooper and Appleby, 1994; 1995), were introduced to measure motivation for locomotion in twenty four ISA Brown laying hens reared in two housing environments. The housing environments were a 0.7 × 0.7 m cage and a 2 × 2 m pen, which had 5 birds reared in each cage/pen, with food, water, litter box and perches supplied. Twelve pairs of birds were randomly selected from 3 cages and 3 pens, 6 pairs from each environment, and tested in pairs starting at 23 weeks old after being reared in the home environment from the age of 9 weeks old for 14 weeks. The reason for using paired birds for observations is that isolation is stressful to birds, especially when they are moved to a novel test environment from their home cages. Using isolated birds is likely to greatly influence their behaviour, thus such consequences should be cautiously prevented.

The test arena was a 2 × 2 m pen with a 0.7 × 0.7 m wire-wall cage in the corner (Fig. 6-1) which had food, water, perches and litter-box placed in the same arrangement as both home environments. The wire-wall cage had an adjustable door to alter the width of gap between 0 cm to 20 cm. Each pair of birds was placed inside the cage at the beginning of observations and recorded for 20 minutes in each treatment in a balanced sequence. A video camera was attached to the ceiling with a view covering the whole test arena. The image was viewed on the monitor located outside the pen, the observer, therefore, could make the on-line records without interrupting the birds. Instantaneous records of locations and behavioural activities were made every 10 seconds (Fig. 6-2). The number of passages through the gap (events) and the time spent outside the cage (sec/bird) were recorded.

6-2-1. Frequency of Gap Passing

The numbers of times the birds passed in (entries from cage to pen) or out (exits from pen to cage) through the gap during 20 minute observations were counted (passages/bird).

6-2-2. Time Spent Outside the Cage

The duration of time the birds spent outside the cage was recorded as starting once half of their bodies passed through the gap until they returned to the cage. Since observations were made every 10 seconds, the time spent outside the cage was measured by converting the number of observations into seconds, observation number × 10 seconds equals time outside the cage (sec/bird).

6-2-3. Distance and Behavioural Activities Measures

Locations and behavioural activities of individual birds were recorded at 10 seconds intervals (Fig. 6-2). The sampling method of locations and behavioural activities was similar to Chapter 3. The whole pen was divided into 4×4 (16) equal quadrats. Number of quadrats crossed was converted to distance moved, by multiplying quadrats crossed by the horizontal width (0.5 m) when crossing straight, or by diagonal length (0.71 m) when crossing diagonally, to calculate the approximate distance moved per minute per bird (m/min/bird).

Statistical analysis was performed by an ANOVA for a 2×2 factorial experiment. This was determined after checking for normality and homogeneity of variance of the data.

6-3. Results

The effects of rearing conditions, gap widths, and their interaction were examined. Twenty two behavioural activities were analysed individually, and categorised into five behaviour patterns: locomotive (jump, run and walk); non-locomotive (dust-bath, rest and stand); comfort (body-shake, head-scratch/shake, preen, tail-wag and wing-flap); feeding (beak-peck, drink, eat, feather-peck, ground-peck/scratch, litter-peck/scratch and wall-peck) and aggressive (threat) behaviours. Three indicators were used as putative measurements of motivation for locomotion: frequency of in- or out-gap passing (entries to pen or exits from pen); time spent outside the wire-cage (duration); and mean walking distance.

Rearing condition had effects on locomotive and feeding behaviours, also on the three indicators of motivation for locomotion. A significant difference was also found in locomotive behaviour and all indicators of motivation for locomotion between gap widths treatments. Effects from the interaction of rearing condition by gap width were found for locomotive, comfort and feeding behaviours, and for all the indicators of motivation for locomotion.

6-3-1. Effects of Rearing Conditions

The effect of rearing conditions on behaviour is shown in Table 6-1. Birds reared in cages performed more locomotive behaviour (walking) than those reared in pens. Feeding behaviour (eating and ground-scratching) was observed more in pen-reared birds than in cage-reared birds. As regards the three indicators for motivation, cage-reared birds went through the gap more often; spent longer in the open area; and walked further than pen-reared birds (Table 6-2). Cage-reared birds visited the pen more frequently than pen-reared birds (17 and 12 passages, respectively), and stayed longer in there than pen-reared birds (677.06 and 484.17 seconds for each visit, respectively). The results suggest that cage-reared birds show more locomotive behaviour, and are more strongly motivated than pen-reared birds.

6-3-2. Effects of Gap Widths

Wide-gap (20 cm) and narrow-gap (10 cm) were introduced to alter the ease with which birds could enter the pen and thus to measure the strength of motivation for locomotion of test birds. A significant difference was found in locomotive behaviour (Table 6-3) and the three indicators (Table 6-4) of motivation for locomotion between narrow- and wide-gap width treatments.

The numbers of entries and exits from the pen during 20 minute observations under wide-gap condition were 4.00 and 3.38 (±0.40) passages/bird, respectively; and under narrow-gap were 0.25 and 0.04 (±0.40) passages/bird, respectively. In the wide-gap condition birds made 23 visits to pen compared to only 6 visits in the narrow-gap condition; and for each visit they stayed longer in the pen in the wide-gap condition (646 seconds) than in the narrow-gap condition (412 seconds). Birds in the wide-gap condition walked and ground-pecked more, but drank less than in the narrow-gap condition. In the narrow-gap treatment, the gap was so narrow, that it appeared to be aversive to the birds, so they preferred staying in the wire-cage instead of making efforts to squeeze through the narrow-gap. Overall, the time spent outside the wire-cage decreased, and the distance moved was also less than the wide-gap treatment.

These results suggest that gap width has influence on motivation for locomotion. The birds made fewer visits to the pen when they had to pass through the narrow-gap which is aversive to them compared to the wide-gap treatment. However, they still exhibited willingness to pass through the narrow-gap to get access to the open area outside, though the frequency was significantly less than the wide-gap treatment. It is surprising to find that the birds spent more time in the pen in wide-gap treatment than in narrow-gap treatment, this finding is contradictory with the intuition that birds in narrow-gap treatment should stay in the pen longer since they had to spend more effort to pass the gap than in wide-gap treatment. This is true of all the individuals which went through both the narrow-gap and wide-gap.

6-3-3. The Interaction of Rearing Condition by Gap Width

There were significant differences in behaviour (Table 6-5) and the three indicators for motivation for locomotion (Table 6-6) under the interaction of rearing condition by gap width. Pen-reared birds showed more comfort behaviour (body-shaking and preening) in the wide-gap treatment than in the narrow-gap treatment. Cage-reared birds showed more comfort behaviour (preening) and less eating than pen-reared birds in the wide-gap treatment. Only in the wide-gap treatment, rearing conditions showed influence on gap passing, duration and distance moved: cage-reared birds performed more visits to the pen outside the wire cage, spent more time in there, and moved further than pen-reared birds.

The number of passages and mean duration of each visit to the pen is shown in Table 6-7. Cage-reared birds spent similar number of passages and duration of time for each visit to the pen in the narrow-gap (5 passages, 462.00 seconds) and wide-gap treatments (12 passages, 766.67 seconds), while pen-reared birds spent a much shorter duration for each visit in the narrow-gap treatment (1 passage, 160 seconds) than in the wide-gap treatment (11 passages, 513.64 seconds). The findings suggest that cage-reared birds were less influenced by the gap width than pen-reared birds, their willingness to visit the pen was not suppressed as much as pen-reared birds.

6-4. Discussion

The main findings of the present experiment suggest that cage-reared birds showed a higher level of motivation for locomotion than pen-reared birds. Their willingness to visit the pen was less influenced by the narrow-gap compared to pen-reared birds.

Cage-reared birds were willing to pass through the narrow-gap (aversive choice) in order to get access to the open area outside the wire-cage, although their willingness apparently was reduced by the difficulty to pass through the narrow-gap. In contrast, pen-reared birds preferred not to make this effort to squeeze through the narrow-gap. Previous research has shown that suppression of behaviour by spatial restriction may lead to behavioural rebound (Nicol, 1987 b), it is possible that motivation for locomotion of cage-reared birds has built up during rearing in their home cages (0.7 × 0.7 m) in which some large body movements (e.g. locomotion) cannot be expressed properly in such a compact space, therefore, cage-reared birds had a stronger intention to squeeze through the narrow gap to reach the larger area outside the wire cage, compared to pen-reared birds.

In general, willingness to squeeze through the gap declined when the narrow gap made it more difficult. Even though it was less difficult to pass through the wide-gap, pen-reared birds did not appear to be as strongly motivated as cage-reared birds to get access to the open area outside the wire-cage, they spent more time foraging in the wire-cage rather than locomoting around the test arena. The three indicators all yield the same story and suggest that motivation for locomotion is influenced both by aspects of rearing condition and the effort needed to pass through the gap. There are two explanations for these results: (1) Cage-reared birds came from a more confined housing (0.7 × 0.7 m for five birds) compared with pen-reared birds (2 × 2 m for five birds), therefore, the test arena was a larger space to the cage-reared birds but a similar space for the pen-reared birds, compared to their home environments. Spatial contrast (different floor space between two home environments) may play a role in stimulating locomotive behaviour (also see Chapter 4). It has been found that behavioural activities were performed at a higher frequency as a rebound from increased motivational tendency during the period of spatial restriction or from a response to novelty

(Nicol, 1987b). (2) The home environment was so confining to the cage-reared birds that they were not able to perform some specific behavioural activities such as locomotion. Motivation for locomotion may be built up through the period of rearing and then released when there is an appropriate space to perform it. A similar situation has also been observed in motivation for dust bathing behaviour: motivation for dust bathing builds up in the absence of dust, so that deprivation increases the tendency to perform dust bathing after a period of deprivation (Vestergaard, 1982; van Liere and Wiepkema, 1992).

The present findings demonstrate that pen-reared birds showed significantly more comfort behaviour, mainly preening, than cage-reared birds under wide-gap treatment. These findings support previous research on the interaction between rearing condition and comfort behaviour that, comfort behaviour was less when spatial allowance decreased (Reed and Nicol, 1992) or more compact (Tanaka and Hurnik, 1991; 1992). However, the present finding is inconsistent with previous research (Black and Hughes, 1974) that preening was observed more in cages than in pens. Displacement preening has been proposed as a possible indicator of frustration by some researchers (Duncan and Wood-Gush, 1972; Black and Hughes, 1974). However, such a concept seems inappropriate for interpreting the higher level of preening in the present findings. It is suggested that the higher level of preening in pen-reared birds under wide-gap treatment may indicate that the birds were in a relaxed situation. There are two reasons for this interpretation: (1) more eating was observed in pen-reared birds, which shows the birds were not alert or under tension; and (2) the lay-out of the test arena was more similar to the home environment of pen-reared birds compared to cage-reared birds, therefore, pen-reared birds may be less fearful or influenced by the test arena than cage-reared birds.

Feeding behaviour such as eating and ground scratching was less in the cage-reared group, which supports previous studies which reported more grazing, ground-pecking/scratching and dust-bathing in birds on free range than in cages (Hughes and Dun, 1983). This finding possibly can be explained by time budget theory, that since the duration of observation was constant in all tests, birds would have to perform different behaviour patterns according to the behavioural priorities, i.e. the behaviour in higher priority will be performed more. Cage-reared birds spent more time on locomotion, at the expense of the time spent on other behavioural activities such as feeding, indicating that for cage-reared birds locomotion may be more important than other behavioural activities, while pen-reared birds did not show such a preference. Moreover, previous research categorised object pecking as stereotyped behaviour which may represent frustration (Siegel et al., 1978; Mauldin and Siegel, 1979). In the present experiment drinking and ground-pecking were more frequent in the narrow-gap treatment where access to the pen was more difficult to get to. Such a finding may indicate that drinking and ground-pecking might be a displacement behaviour, derived from the conflict between strong motivation to walk and the very aversive task of passing through the narrow gap.

In conclusion, the birds reared in the 0.7 × 0.7 m cage were more motivated to locomote than those reared in the 2 × 2 m pen. Their willingness to visit the pen outside the wire cage was less influenced by the narrow-gap compared to pen-reared birds. Locomotion in the cage-rearing condition may be suppressed due to insufficient space, compared to the greater freedom provided by pen-rearing condition. Less freedom to move may reduce locomotion and other whole body movements, thus building up motivation for performing these activities. However, further research is needed to investigate whether such deprivation will cause frustration or has a major impact on welfare; the present findings do not provide sufficient evidence on this aspect to come to a definitive conclusion.

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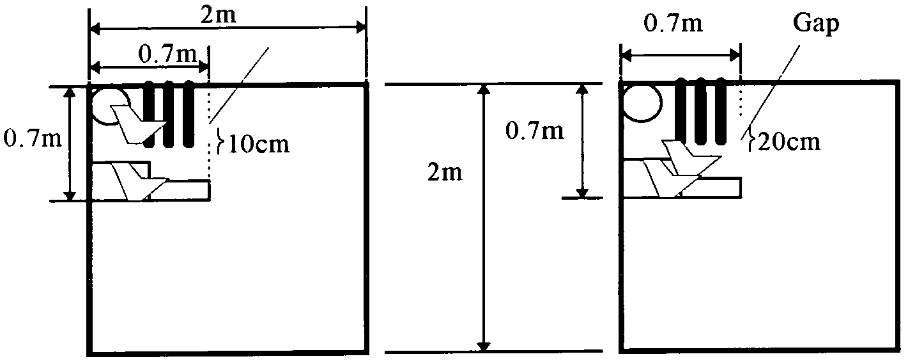
Fig. 6-1
Test arena (2m×2m) and a wire-cage (0.7m×0.7m) with resources (food, water, perches and nest-box). Two gap-width treatments were used: narrow-gap (10 cm) and wide-gap(20 cm). Gap



Narrow-gap

Wide-gap

Fig. 6-2
Location recording method. The test arena was divided into 4×4 (16) quadrats of equal size (0.5m×0.5m). Location of individual bird was recorded according to the X-co-ordinate (A to D) and the Y-co-ordinate (1 to 4).

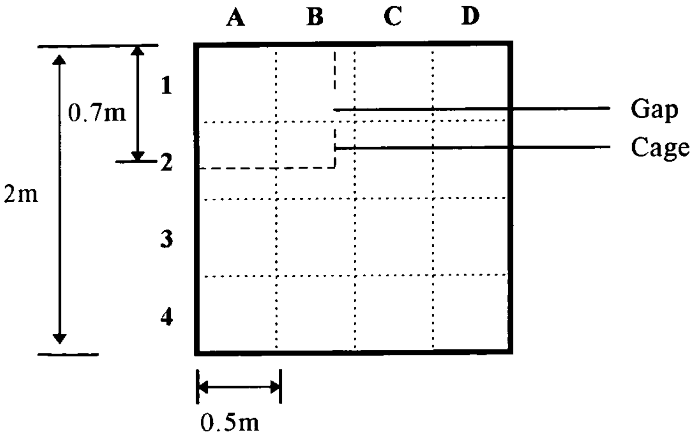


Table 6-1
Effects of rearing conditions on behavioural activities (%).

Behaviours	Cage	Pen
Locomotive	35.44a	20.81b
Jump	0.21	0.03
Run	0.21	0.03
Walk	35.02a	20.74b
Non-locomotive	28.61	23.82
Dust-Bath	0.00	0.38
Rest	0.07	1.44
Stand	28.54	22.00
Comfort	2.18	3.56
Body-Shake	0.10	0.19
Head-Scratch	0.07	0.10
Head-Shake	0.07	0.10
Preen	1.66	3.05
Tail-Wag	0.28	0.10
Wing-Flap	0.00	0.03
Feeding	33.70a	51.81b
Beak-Peck	0.03	0.00
Drink	3.95	1.41
Eat	19.04a	36.90b
Feather-Peck	0.00	0.29
Ground-Peck	1.21	1.67
Ground-Scratch	0.10a	0.77b
Litter-Peck	7.91	9.52
Litter-Scratch	0.17	0.26
Wall-Peck	1.28	0.99
Aggressive	0.07	0.01
Threat	0.07	0.01
Total	100.00	100.00

* a and b represent significant difference ($p<0.05$) between rearing conditions.

Table 6-2
Comparison of frequency of gap passing (passages/bird), duration spent outside cage (sec/bird) and mean walking distance (m/min/bird) between rearing conditions.

Treatment	In-frequency (passages/bird)	Out-frequency (passages/bird)	Duration (sec/bird)	Mean Walking Dist (m/min/bird)
Cage-reared	3.00±0.40a	2.46±0.39a	479.58±52.91a	3.38±0.36a
Pen-reared	1.25±0.40b	0.96±0.39b	242.08±52.91b	1.17±0.36b

* a and b represent significant difference ($p<0.05$) between rearing conditions.

Table 6-3
Effects of gap widths on average behavioural activities (%).

Behaviours	Narrow-Gap	Wide-Gap
Locomotive	21.95a	33.28b
Jump	0.00	0.22
Run	0.00	0.22
Walk	21.95a	32.83b
Non-locomotive	26.55	25.71
Dust-Bath	0.17	0.22
Rest	1.52	0.10
Stand	24.85	25.39
Comfort	1.97	3.75
Body-Shake	0.07	0.22
Head-Scratch	0.07	0.10
Head-Shake	0.10	0.06
Preen	1.42	3.27
Tail-Wag	0.31	0.06
Wing-Flap	0.00	0.03
Feeding	49.53	37.13
Beak-Peck	0.03	0.00
Drink	4.81a	0.61b
Eat	42.99	25.74
Feather-Peck	0.24	0.06
Ground-Peck	0.45a	2.37b
Ground-Scratch	0.55	0.353
Litter-Peck	11.11	6.55
Litter-Scratch	0.35	0.10
Wall-Peck	0.90	1.35
Aggressive	0.00	0.13
Threat	0.00	0.13
Total	100.00	100.00

* a and b represent significant difference ($p<0.05$) between gap widths.

Table 6-4
Comparison of frequency of gap passing (passages/bird), duration spent outside cage (sec/bird) and mean walking distance (m/min/bird) between narrow- and wide-gaps.

Treatment	In-frequency (passages/bird)	Out-frequency (passages/bird)	Duration (sec/bird)	Mean Walking Dist (m/min/bird)
Narrow-gap	0.250±0.40a	0.04±0.39a	102.92±52.91a	0.77±0.36a
Wide-gap	4.000±0.40b	3.38±0.39b	618.75±52.91b	3.78±0.36b

* a and b represent significant difference ($p<0.05$) between gap widths.

Table 6-5
Effect of interaction of rearing condition by gap width in behaviour (%).

Behaviour Pattern	Cage		Pen	
	Narrow	Wide	Narrow	Wide
Locomotive	27.76a	43.18b	16.10a	24.82ab
Jump	0.00	0.42	0.00	0.06
Run	0.00a	0.42b	0.00a	0.06ab
Walk	27.76ab	42.34a	16.10b	24.70ab
Non-locomotive	27.07	30.15	25.95	21.90
Dust-Bath	0.00	0.00	0.35	0.42
Rest	0.14	0.00	2.91	0.18
Stand	26.93	30.15	22.76	21.31
Comfort	2.97ab	1.39a	0.97a	5.77b
Body-Shake	0.07a	0.14ab	0.07a	0.30b
Head-Scratch	0.07	0.07	0.07	0.12
Head-Shake	0.14	0.00	0.07	0.12
Preen	2.14ab	1.18a	0.69a	5.06b
Tail-Wag	0.55	0.00	0.07	0.12
Wing-Flap	0.00	0.00	0.00	0.06
Feeding	42.20a	25.14b	56.90a	47.38a
Beak-Peck	0.07	0.00	0.00	0.00
Drink	7.11a	0.77b	2.50b	0.48b
Eat	23.90ab	14.14a	38.13bc	35.65c
Feather-Peck	0.00	0.00	0.49	0.12
Ground-Peck	0.28a	2.16bc	0.62ab	2.56c
Ground-Scratch	0.07a	0.14ab	1.04b	0.54ab
Litter-Peck	9.39ab	6.41a	12.83b	6.67ab
Litter-Scratch	0.21	0.14	0.49	0.06
Wall-Peck	1.17	1.39	0.62	1.31
Aggressive	0.00	0.14	0.00	0.12
Threat	0.00	0.14	0.00	0.12
Total	100.00	100.00	100.00	100.00

* a, b and c represent significant difference ($p<0.05$) within behavioural activity.

Table 6-6
Comparison of frequency of gap passing (passages/bird), duration outside the cage (sec/bird) and mean walking distance (m/min/bird) among treatments.

Treatment	In-frequency (passages/bird)	Out-frequency (passages/bird)	Duration (sec/bird)	Mean Walking Dist (m/min/bird)
Cage-reared				
Narrow-gap	0.42±0.56a	0.08±0.55a	192.50±74.83a	1.49±0.52ab
Wide-gap	5.58±0.56b	4.83±0.55b	766.67±74.83b	5.27±0.52c
Pen-reared				
Narrow-gap	0.08±0.56a	0.00±0.55a	13.33±74.83a	0.04±0.52a
Wide-gap	2.42±0.56c	1.92±0.55c	470.83±74.83c	2.29±0.52b

* a, b and c represent significant difference ($p<0.05$) among treatments.

Table 6-7
Mean duration of each visit to the pen through narrow-gap and wide-gap under different rearing conditions (sec).

Treatment	Number of visits	Mean Duration (sec)
Cage-reared		
Narrow-gap	5	462.00
Wide-gap	12	766.67
Pen-reared		
Narrow-gap	1	160.00
Wide-gap	11	513.64

Chapter 7 Movement by Broilers, ISA Brown Laying Hens and Taiwan Country Chickens: Genetic and Environmental Factors

Abstract

Two experiments are described in this chapter. Three different breeds: broilers (meat type), ISA Brown laying hens (egg type), and Taiwan Country Chickens (dual purpose type) were used in experiment 1. The aims of this experiment were to compare: (1) locomotion among genetically different domestic fowls on a diurnal basis by studying the use of pen space, behaviour and movements over a seven week rearing period; (2) the effect of rearing conditions (flock size and stocking density) on behaviour and movements. Measurements were made of the area of pen used and randomness of space use, behavioural activities, and mean weight gain. In experiment 2, ISA Brown hens from experiment 1 were used to investigate the influence of restraint and previous rearing condition over locomotion.

In experiment 1, the use of space was uneven: birds remained near to the resources and beside the walls. All three breeds behaved in the same manner. Behavioural activities were influenced by breed, environment, age and time of the day. ISA Brown laying hens were more active than Taiwan Country chickens, which, in turn, were more active than broilers. Weight gain differed significantly among the three breeds but rearing conditions did not seem to have any significant influence over weight gain. Results from experiment 2 suggest that previous confinement stimulated locomotive and feeding behaviours: the birds moved about more and performed more ground-pecking after being released from physical confinement to a larger space outside the wire-cage. The birds reared in the small pen were less sensitive to the physical confinement compared to those reared in the medium pen.

In conclusion, the use of space was uneven, and the birds remained near to the resources and the walls. Genetic selection may have influenced some essential behavioural activities: the egg type hens are apparently more active than the meat type broilers, while the dual purpose type is intermediate. Previous experience of confinement stimulated locomotive and feeding behaviours, indicating that these behavioural activities may be induced by deprivation.

7-1. Introduction

Behaviour is a part of animals' interaction with their environments and is their means of utilising available resources (Webster and Hurnik, 1989). In evolutionary change, adaptive systems have been developed by the new environmental conditions and the nature of pre-existing systems (McBride et al., 1969). In the history of domestication, while differences may be most marked in those traits which has been subjected to greatest genetic selection, such as egg and meat production, many other aspects of the chicken physiology and behaviour are heritable and may also have been changed, both intentionally and unintentionally as a by-product of selection for other traits (Dawkins, 1976). Such a continuing process has modified morphology, physiology and behaviour of animals to reach certain goals and demands of humans. Therefore, behavioural traits of domestic animals nowadays have been artificially selected rather than selected by nature; comparisons between them and their wild ancestors should be made with great caution. However, during domestication, modifications on behaviour were quantitative rather than qualitative, i.e. thresholds of response to stimuli were altered rather than enhancing introduction or elimination of behaviour patterns (Price, 1984). There is evidence that domestic chickens released on islands off Queensland, Australia, and the west coast of Scotland showed remarkably similar patterns of behaviour as their ancestors (Nicol and Dawkins, 1990). Near the late 20th century, as we moved into the era of putting more emphasis on animal welfare and animal rights issues, the adaptability of domestic animals highly selected for production traits and impacts of intensive husbandry practices on their welfare have been discussed (Hubrecht, 1995; Siegel, 1989).

Taiwan Country Chickens were brought into the Taiwan island from the South East Asia, the South Eastern area of China, Japan and Europe more than 300 years ago. They are hybrids of their ancestors from foreign continents. Taiwan Country Chickens are colourful, strong and healthy; exhibit strong broody behaviour, heat and disease resistance; adapt well to the environment. They have a similar growth curve (S-shape) as broilers, and their feeding efficiency is around 3.0 (feed weight/weight gain). They are usually sold at the age of 13-15 week old. The female birds weigh around 1.5 kg/bird and the males are around 2.0 kg/bird. Taiwan Country Chickens are used for both egg and meat (NCHU, 1992).

The objective of experiment 1 is to investigate the difference due to genetic selection: meat type, egg type, and the dual-purpose type (both for meat and egg); to look at the result of selection on use of space and general behaviour in domestic fowls. Related behaviours were categorised into locomotive, non-locomotive, feeding and comfort behaviour patterns. Time of the day was divided into 3 periods (morning, mid-day, and afternoon) to investigate the diurnal ethogram. The diurnal ethogram of hens has been systematically investigated by Fölsch and Vestergaard (1984) which indicated that behavioural activities shift with time over 24 hours. Mean weight gains of different breeds were also recorded to investigate the effects of age, genetics and environment on productivity. Previous research has shown that increased body weight along with advancing age may act as a physical limit to walking (Newberry and Hall, 1990). In Japanese quails, it has been estimated that the genetic correlation of locomotor activity with body weight was 0.45, and estimated h^2s (heterosis) for locomotor activity was 0.31. In fowls, the estimated h^2s was 0.18 (Bessei, 1979; Saleh and Bessei, 1981). In laying hens, the heritability of the locomotor activity, estimated on the basis of half-sib correlations, was $h^2=0.18$ (Jezierski and Bessei, 1978). In experiment 2, confinement was introduced to examine the effect of restraint on behaviour, ISA Brown breed from two rearing conditions in experiment 1 were introduced to compare the influence of stocking density.

7-2. Animals, Materials and Methods

Experiment 1: Movement, Other Behaviour and Weight Gain of Different Breeds of Chickens

7-2-I.1. Animals and Treatment Conditions

Three breeds: — broilers, ISA Brown laying hens and Taiwan Country chickens (TCC) — were used. There were 232 birds per breed. Within each breed, the birds were randomly allocated to three rearing conditions: large (treatment L: 6.4 × 6.4 m), medium (treatment M: 4.4 × 2.2 m) and small (treatment S: 2.2 × 2.2 m) deep litter floor pens (Fig. 7-1). In every M and S pen, there was one tube feeder and one bell-shape automatic drinker, while nine tube feeders and nine bell-shape drinkers were evenly distributed in each L pen. There were 200 birds/treatment/breed in L (0.20 m^2/bird), and 16 birds/treatment/breed in S (0.30 m^2/bird) and M (0.61 m^2/bird). All pens were built upon concrete floor covered with wood shavings and fenced by wire walls. Therefore, the birds in adjacent pens could see each other and the outside. All birds were fed ad libitum, and the feeders in all pens were checked and filled daily after the observations.

Every individual in S and M wore plastic wing-badges on both wings. In L, 16 birds were randomly chosen from the 200 birds and badged. The 1 day-old and end (7 week-old) weights of these badged birds were measured. Location (Fig. 7-3) and behaviour patterns of every badged bird in the three treatments were recorded by instantaneous sampling three times a day at 8.00-9.00 h, 11.00-12.00 h and 15.00-16.00 h. Observations started from December 1994 to February 1995. There were 39 observations in total for the period of 4 to 7 weeks old in all breeds, and another 20 observations for the period of 8 to 11 weeks old except broiler breed.

When observing the locations of the birds, the observer was standing beside the wire wall. There was a 5 minute delay before formal records started to allow the birds to get used to the presence of the observer. This is to minimise the disturbance induced by the observer.

7-2-I.2. Statistical Analyses

Use of Space

Preference for use of space was tested by the Chi-square analysis. Pen space was divided into 8 × 8 (64) quadrats of equal size in treatment L; 4 × 2 (8) equal quadrats in treatment M; and 2 × 2 (4) equal quadrats in treatment S (Fig. 7-2). Individual location was recorded by with the x- and y-co-ordinates. Observations were carried out three times in the early morning (8.00-9.00 h), at noon (11.00-12.00 h) and in the afternoon (15.00-16.00 h). Instantaneous records were done for those sixteen wing-badged birds in each of the three treatments. However, in treatment L the 16 birds were distributed among a 200 bird flock, which made complete observations of the 16 individuals difficult. therefore, the records of the 16 birds in each breed were scanned as many as possible. The proportion of sightings accounted for by use of space was compared with the expected value from the chance of randomly staying in each quadrat (1.56% in L, 12.5% in M, and 25% in S). Whether or not the distribution of locations varied significantly from those expected by chance was determined by the Chi-square test on samples of sixteen birds randomly selected from each flock of 200 birds from the three breeds in L, and the sixteen birds each of the three breeds in M and S.

Behaviour and Weight Gain

Analysis of variance (ANOVA) was done on behaviour and weight gain for all breeds under all rearing conditions. Nine behavioural activities were analysed independently, and then grouped into four behavioural categories for analysis: locomotive behaviour (run and walk); non-locomotive behaviour (dust-bath, rest and stand); feeding behaviour (drink, eat, and ground-peck); comfort behaviour (preen). The factors which were considered in the analysis were: breed, rearing condition (flock size and stocking density), period (time of the day), age and interaction between breed and rearing condition.

Due to limited numbers of pens, only one pen was allocated for each treatment in all breeds. The 16 birds in each pen was treated as 16 individual records, thus the sample size for each treatment in each breed was 16 birds.

Experiment 2: Effect of Restraint of Movement on Behaviour

7-2-II.1. Animals and Treatment Conditions

ISA Brown laying hens from the main experimental rearing conditions (S and M) were used again in this experiment in a 2×2 factorial experiment at the age of 15 weeks old. One factor is the effect of stocking density, and the other factor is the restraint of movement. Birds from each treatment were randomly divided into 2 groups of 7 birds at week 13, and were allowed 1 week to adjust to their new environment. Half the birds in each treatment were allocated to the control group (Control), which was moved to another pen with the same size as home pen. The rest was restrained in a square wire cage (90 × 90 × 30 cm), which was placed in a corner of the home pen with the same feeding and drinking facilities attached to the wire cage, for a week (Restraint) at week 14 before observations (Fig. 7-3). After restraint, the birds were released at week 15. Observations on whole-grouped behaviour patterns were instantaneously sampled every 30 seconds interval for 6 consecutive times.

7-2-II.2. Statistical Analyses

Analysis of variance (ANOVA) was used to investigate the effects of restraint and rearing condition on behaviour. The same four behavioural categories as in experiment 1 were used for recording behaviour. Incidence of behaviour patterns of 14 birds from the same pen were treated as 14 samples and analysed to give an average value for each treatment. Interaction between restraint and rearing condition was also studied.

7-3. Results

Experiment 1: Movement, Other Behaviour and Weight Gain of Different Breeds of Chickens

7-3-I.1. Use of Space

The proportion of sightings in each square, which represents the use of space, is presented separately for each breed in Fig. 7-4. Dark quadrats represent the areas used by the birds most frequently. The percentage of time spent in these quadrats is higher than the average value expected by chance (1.56% in L, 12.5% in M, and 25% in S).

The use of space was uneven in all three breeds in L. It was most uneven in ISA Brown breed (df=49, $p<0.001$, F=245.41), then in Taiwan Country chicken (TCC) (df=49, $p<0.001$, F=203.18), and in broiler (df=49, $p<0.001$, F=132.04, Chi-square test). The used areas were mostly centred around the location of feeders or drinkers and near the walls. In M, the use of space was uneven in broilers (df=3, $p<0.01$, F=26.43) and TCCs (df=3, $p<0.01$, F=12.51, Chi-square test). No significant preference was found in ISA Brown. All three breeds showed no preference for the use of space in S.

7-3-I.2. Behaviour

Genetic Factor (Breed)

When breeds were compared with consideration of the treatments, ISA Brown was the most active among the breeds, broiler breed was the most inactive, the TCC was intermediate. Other activities such as comfort behaviour and feeding behaviour happened more frequently in ISA Brown and TCC breeds, compared to broiler breed. TCC exhibited more comfort behaviour than the other two breeds (Table 7-1 and Fig. 7-5).

Most resting and least walking, standing, eating, and ground-pecking were found in broilers. Running was most frequent in ISA Brown. Preening and dust-bathing were found most frequently in TCC.

Rearing Condition

Comparisons of the effects of different rearing conditions on behaviour are presented in Table 7-2 and Fig. 7-6. Two factors were investigated: flock size (L vs. S i.e. 200:16) and stocking density (M vs. S i.e. 2:1). In general, the birds in L showed more locomotive behaviour than in S, while more non-locomotive behaviour and comfort behaviour were found in S than in L. No significant difference was found in the four behavioural categories between M and S.

Firstly, the effect of flock size on behaviour was compared between L and S. More drinking and walking were found in L than in S. However, running was observed more frequently in S than in L. Resting, dust-bathing, and preening were also more in S than in L.

Secondly, the effect of stocking density was compared between M and S. Only eating and dust-bathing were significantly different between M and S. Higher levels of eating and dust-bathing were performed in S compared to M.

Interaction of Breed and Rearing Condition

The interaction between breed and rearing condition had significant effects on all categorised behaviour patterns (Table 7-3). Flock size showed significant influence on feeding behaviour in broiler breed so that the birds in L had more feeding behaviour than in S. Stocking density had significant effects on locomotive behaviour in ISA Brown breed so that the birds locomoted more in M than in S. Stocking density also influenced non-locomotive behaviour and comfort behaviour in TCC breed so that more non-locomotive and less comfort behaviour were found in S than in M.

Period (Time of the Day)

The effect of period on behaviour is shown in Table 7-4. Locomotive behaviour occurred most in the morning. It was at mid-day when non-locomotive behaviour was more frequent. The observations were carried out during the winter season. The results suggest that birds were most active in the early morning when the weather was rather windy and cold, and rested during the mid-day when the sun rose and the temperature got higher. The birds in L crowded around the sunny side area either to rest or to perform activities from the mid-day onwards.

Age

The effect of age on behaviour is presented in Table 7-5. It shows that broiler breed exhibited more non-locomotive behaviour and less other behaviours than ISA Brown and TCC. There was no significant difference between ISA Brown and TCC at the earlier age (4-5 weeks) but the difference increased with age (6-11 weeks), so that ISA Brown performed more locomotive behaviour than TCC while TCC performed more comfort behaviour than ISA Brown. Broiler breed had more non-locomotive behaviour as the age increased. This is also seen in ISA Brown that non-locomotive behaviour occurred most in 8-11 weeks than in 4-7 weeks. Moreover, locomotive behaviour was also seen mostly in 8-11 weeks than in 4-7 weeks in ISA Brown and TCC. Other behaviour patterns such as feeding and comfort behaviours occurred more in 6-7 weeks than in 4-5 or 8-11 weeks in ISA Brown, while these two behaviours were observed more in the last rearing period in 8-11 weeks than in the earlier period in 4-7 weeks in TCC.

7-3-I.3. Weight Gain

Broilers had the greatest weight gain compared to the other two breeds. The mean weight gains from the heaviest to the lightest were broiler (2370.66±25.78), TCC (669.20±24.93) and ISA Brown (611.67±24.93). No significant difference was found among the three rearing conditions.

Experiment 2: Effect of Restraint of Movement on Behaviour

7-3-II.1. The Effect of Restraint

Confinement demonstrated effects on locomotive, non-locomotive and feeding behaviours (Table 7-6). The restrained birds (confinement treatment) performed more locomotive behaviour and feeding behaviour after they were released from the cage confinement but showed less non-locomotive behaviour than the birds which had not been confined (control group).

7-3-II.2. The Effect of Rearing Condition

Only non-locomotive behaviour was influenced by the rearing conditions (Table 7-7). Birds reared in the small pens (treatment S in experiment 1) had more non-locomotive behaviour than those reared in the medium pens (treatment M in experiment 1).

7-3-II.3. Interaction between Restraint and Rearing Condition

The influence of interaction between restraint and rearing condition is presented in Table 7-8. The medium pen birds showed more locomotive behaviour after being restrained in the compact wire-cage for 1 week than the control group. The small pen birds showed more feeding behaviour and less non-locomotive behaviour than birds from the control group after being physically restricted for 1 week. Without being confined for a week, birds from the medium pens showed more feeding behaviour and less non-locomotive behaviour than those reared in the small pens.

7-4. Discussion

In general, the egg type ISA Brown breed is the most nervous and active breed, while the broiler is more inactive than other two breeds. Other behaviours such as feeding behaviour and comfort behaviour occurred more frequently in ISA Brown and Taiwan Country Chicken breeds rather than in broiler breed. One interesting finding is that the meat type broiler breed, which is characterised by high feed efficiency and growth rate, performed the lowest frequency of eating and ground-pecking. This is consistent with previous research that the amount of time spent feeding does not reflect the amount of food eaten (Savory, 1975). These findings suggest that genetic selection has changed behaviour repertoires, even those essential for survival. The main reason is genetic selection by domestication for high growth rate and feed efficiency in broilers. They feed efficiently without spending much time on foraging activity such as ground-pecking and ground-scratching, compared to ISA Brown laying hens and Taiwan Country chickens.

Behaviour appeared to be related more to flock size than to flocking density, one possible reason could be that the contrast pen size (M:S = 2:1) used in this experiment was not sufficient to give a clear influence on behaviour. The incidence of locomotive behaviour was higher in the larger flocks than in the small flocks (L:S = 200:16). It was found that more non-locomotive behaviour and comfort behaviour were sighted in the small flock than in the large flock. One exception in locomotive behaviour is that more running was found in the small flock than in the large flock. This may be explained by the social tension among flock mates being stronger within a small flock (sixteen birds in a small pen), because the birds were able to recognise each individual, and social rankings were clearer compared to the large flock. More chasing in the small flock contributed to the higher level of running. This conclusion is drawn from the observations although no formal statistical analysis was carried.

The use of pen space was non-random, but the birds did not restrict their movements to particular areas (small proportion of areas). The use of space in the large pens (treatment L) varied significantly from those expected by chance, and was fairly uneven in three breeds. There was a great proportion of sightings that birds centred around the location of feeders or drinkers and near the walls. The tendency for individuals to stay close to the walls could explain why birds in large pen did not use a larger proportion of the available pen area. Similar situation was also found in the medium pens (treatment M) in broilers and Taiwan Country chickens. Greater use of space near walls has also been reported in earlier research (Pamment et al., 1983; Keeling, 1987; Newberry and Hall, 1990). Analysis of the locations of individuals in previous research has shown that animals do not use the area available to them evenly (Keeling and Duncan, 1989; Newberry and Hall, 1990). It was suggested that possible factors for such uneven use of space are the location of resources such as food, a nest site, etc. (McBride and Foenander, 1962), pen shape (Pamment et al., 1983; Keeling, 1987), position in the dominance hierarchy (van Enckevort, 1965; Pamment et al., 1983), or other minor environmental changes in temperature, light, etc. (Keeling, 1995). The results of present experiment in movement and use of space are consistent with some previous research that birds are generally attached to a particular site in the shed and that movement is random (McBride and Foenander, 1962; Crawford, 1966; Craig and Guhl, 1969; McBride et al., 1969; Pamment et al., 1983; Appleby et al., 1985; 1989; Preston and Murphy, 1989; Newberry and Hall, 1990). It means that though birds used the whole pen, they spent most of their time in some particular areas. It is suggested that the inconsistency in earlier references of movement is due to the method of records. For example, when sighting birds' locations at certain observation times, the record only includes the area where the subjects are seen at the specific timings, but the actual range moved is not counted. Thus the results may be concluded as 'the birds occupied certain areas, and did certain activities at certain areas'. Recording birds' actual movement will draw an impression that the birds move around the house and do not confine themselves to certain areas. In fact, both descriptions may only reveal half of the truth.

The diurnal ethogram shows that birds were most active in the morning and birds were least active at the mid-day. This is consistent with previous research that birds are more active during a few hours just after lights-on and before dark (Savory, 1980; Tanaka and Hurnik, 1992), and supports the idea that circadian changes in behaviour should be taken into account when observing birds' movement (Bessei et al., 1979). Locomotive and feeding behaviours tend to decrease over the seven week period. This is consistent with some previous research which suggested that there is a decline in behavioural activities with age (Newberry et al., 1986; Newberry and Hall, 1990; Tanaka and Hurnik, 1992), which may relate to the greater body mass along with advancing age. This is also supported by the present study that the heaviest breed (broilers) performed the least locomotive behaviour, while the lightest breed (ISA Brown) were the most active.

The restrained birds performed more locomotive and feeding behaviours and less non-locomotive behaviour, after being released from the 1-week confinement. The small pen birds performed more non-locomotive behaviour than the medium pen birds. After restraint, the birds in small pen rearing condition had less non-locomotive and more feeding behaviours than those in medium pen rearing condition. Without being restrained physically, the medium-pen birds did not show more locomotive behaviour than the small-pen birds, however, medium-pen birds performed more locomotive behaviour after confinement than the small-pen birds in control group. This suggests that physical restriction on movement may affect birds reared in a larger space more than birds from a more compact space. It has been demonstrated that spatial restriction induces a higher frequency rebound rate of behaviour, and such rebound may result from an increase in motivational tendency during the period of spatial restriction (Nicol, 1987). This may be explained by the medium-pen birds being adapted to a larger space. Therefore, birds from a larger space may accumulate their motivation for locomotion during the period of 1-week confinement and release such motivation via performing more locomotive behaviour than usual after being released.

In conclusion, results from the present experiments suggest that use of space was uneven. The birds remained near to the resources such as food and water, and also to the walls. Genetic selection may have influenced some essential behavioural activities, such as locomotion and feeding. Egg type hens are apparently more active than the meat type broilers. Experience to confinement induced more locomotive and feeding behaviours. The birds performed more locomotive and ground-pecking after being released from the confinement to a larger space. The birds reared in the small pen were less sensitive to the confinement compared to the medium pen reared birds.

Battery cage system has been criticised because that it constrains movement of domestic fowls. The results of this experiment suggest that it is important to supply domestic fowls space not only enough for body movements such as feeding behaviour and comfort behaviour, but also capable for a larger scale of activity such as locomotion, in order to assure the animals' basic natural needs. The tendency of the birds to increase behavioural activities after being released from the 1-week physical confinement may indicate that these behavioural activities may be induced by deprivation, and are displacement behaviour derived from motivation for locomotion.

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Fig. 7-1
Three main experimental rearing conditions.

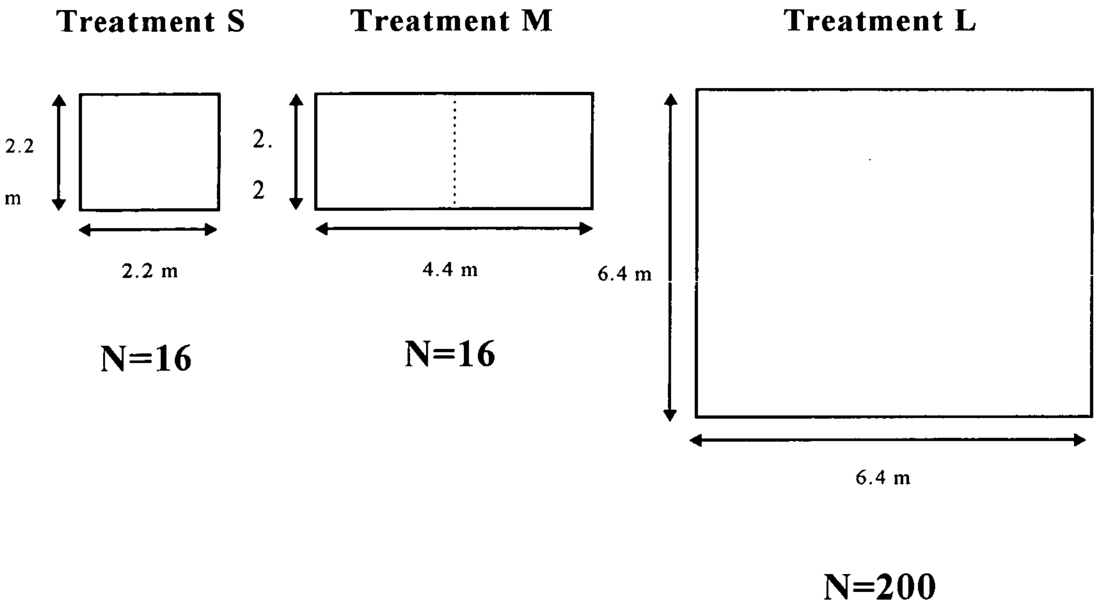
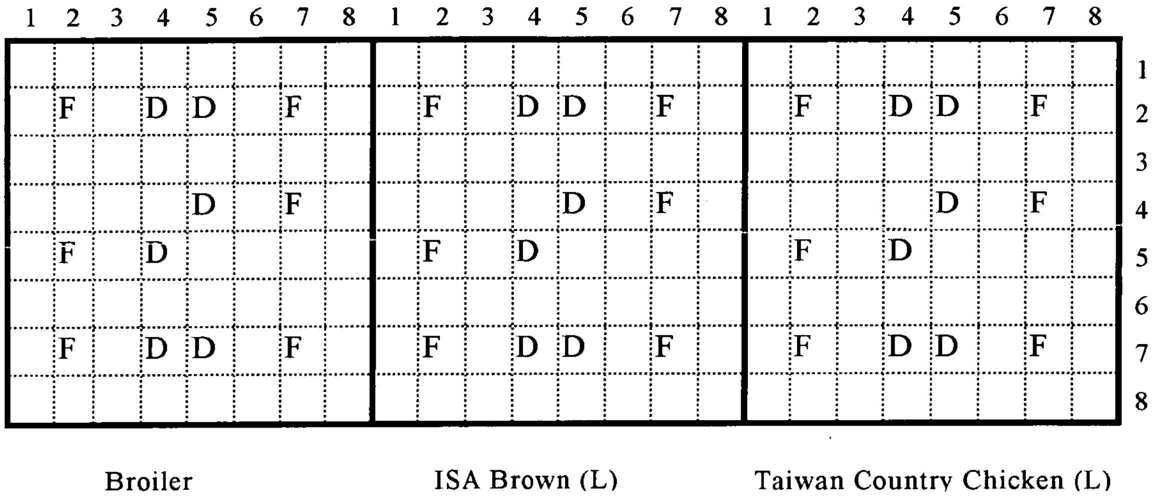


Fig. 7-2
Distribution of pens (L: large pen, M: medium pen, S: small pen) and recording method of locations (D: drinker, F: feeder).



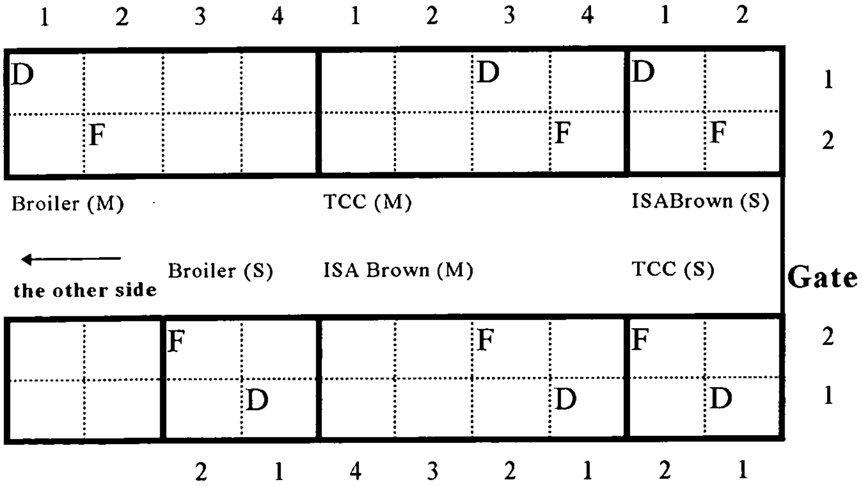


Fig. 7-3
Experiment design.

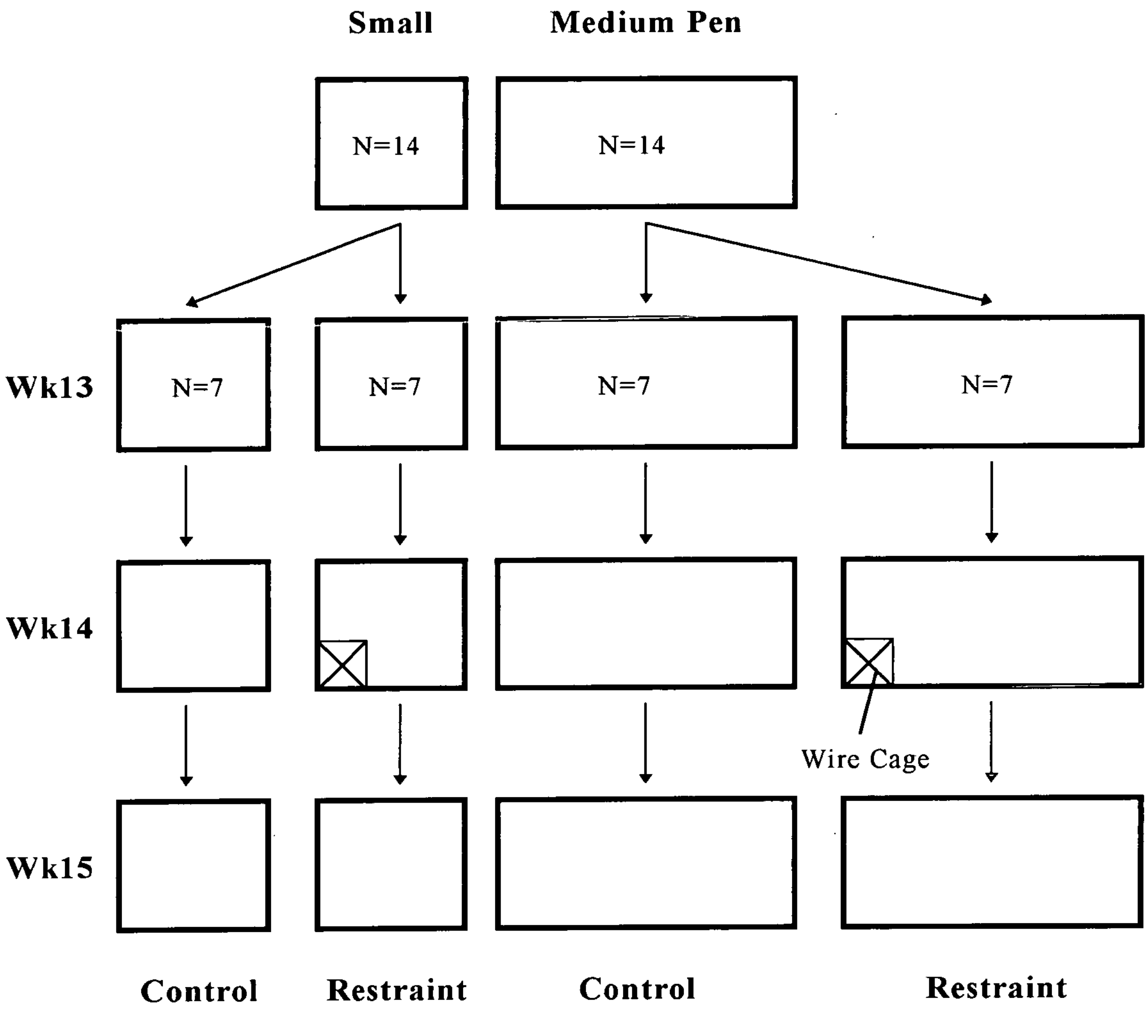


Fig. 7-4
Use of space in three rearing conditions (%).

Treatment L (dark areas: > 1.56 % expected by chance)

Broiler

1	2	3	4	5	6	7	8	
2.67	1.25	1.43	2.32	1.43	1.07	1.43	1.96	1
1.25	5.17	5.17	3.57	4.10	2.67	0.71	1.25	2
2.85	1.43	1.43	1.25	1.07	0.89	0.36	0.89	3
1.96	1.43	1.43	1.43	0.53	0.71	0.36	0.89	4
1.78	0.18	0.18	2.14	0.36	0.53	0.18	0.71	5
1.96	0.18	0.18	2.14	0.53	0.71	0.36	0.36	6
2.50	2.85	0.71	3.39	0.71	1.78	4.28	1.96	7
2.32	1.60	2.50	2.85	1.78	1.07	2.32	0.71	8

ISA Brown

1	2	3	4	5	6	7	8	
1.60	1.23	1.60	1.97	0.86	0.86	0.74	3.69	1
1.72	4.06	0.37	6.16	0.37	0.62	2.71	0.86	2
1.60	0.99	0.12	0.99	0.25	0.37	1.72	0.62	3
4.43	0.86	0.86	1.60	0.25	0.49	1.23	1.97	4
3.69	0.74	1.23	0.37	0.12	0.00	0.25	1.97	5
1.35	0.99	0.37	0.62	0.12	0.25	0.62	1.35	6
2.59	7.02	0.74	6.65	0.74	0.62	2.09	0.74	7
3.69	2.71	2.71	3.08	0.99	0.86	0.99	1.97	8

Taiwan Country Chicken

1	2	3	4	5	6	7	8	
3.33	3.21	2.10	3.58	0.74	0.62	1.48	3.83	1
2.96	8.89	1.23	5.93	0.37	0.49	4.20	2.10	2
1.60	0.62	0.86	0.86	0.37	0.00	0.86	1.23	3
3.21	0.74	0.37	1.85	0.37	0.12	0.62	3.21	4
1.60	0.62	0.99	0.62	0.49	0.49	0.49	2.96	5
0.49	0.37	0.00	0.74	0.12	0.49	0.86	0.99	6
1.23	3.95	0.62	1.60	1.98	0.49	3.09	1.48	7
2.47	0.86	1.48	1.98	1.23	0.74	0.74	1.73	8

Treatment M (dark areas: >12.5% expected by chance)

Broiler

1	2	3	4	
5.27	7.14	9.69	12.93	1
8.33	11.73	8.50	36.39	2

ISA Brown

1	2	3	4	
24.01	7.45	3.48	7.45	1
29.47	9.93	5.96	12.25	2

Taiwan Country Chicken

1	2	3	4	
10.10	6.09	8.33	12.02	1
15.71	8.65	9.62	29.49	2

Treatment S (dark areas: >25% expected by chance)

Broiler

1	2	
14.42	34.78	1
17.15	33.65	2

ISA Brown

1	2	
13.38	28.22	1
21.86	36.54	2

Taiwan Country Chicken

1	2	
20.99	26.44	1
22.28	30.29	2

Table 7-1
Comparison of categorised behaviours among broilers, ISA Brown laying hens, and Taiwan Country chickens (%).

	Breeds		
Behaviours	Broiler	ISA Brown	TCC
Locomotive	2.60a	17.37c	14.05b
Run	0.43a	1.80b	0.45a
Walk	2.31a	15.42b	13.60b
Non-locomotive	78.90b	37.13a	35.43a
Dust-bath	0.43a	0.30a	1.20b
Rest	75.58b	27.69a	25.86a
Stand	2.75a	9.28b	8.37b
Feeding	14.16a	36.68b	36.92b
Drink	1.59	1.80	2.09
Eat	9.54a	20.81b	20.63b
Ground-peck	2.89a	14.07b	14.05b
Comfort	4.34a	8.98b	13.75c
Preen	4.34a	8.98b	13.75c
Total	100.00	100.00	100.00

Different letters represent significant difference ($p<0.05$) among breeds.

Fig. 7-5. Comparison of categorised behaviours among bree

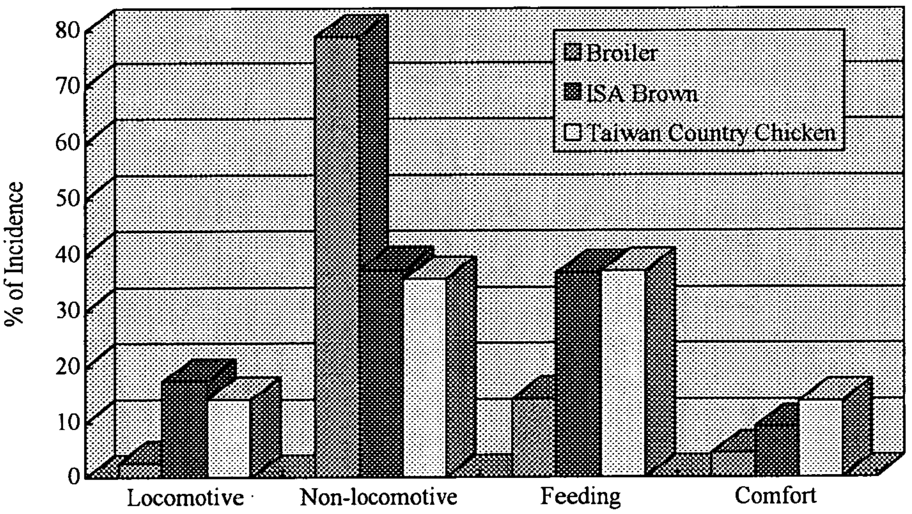


Table 7-2
The effect of flock size (treatment L vs. treatment S) and stocking density (treatment M and treatment S) on categorised behaviours (%).

Behaviours	Treatment L	Treatment M	Treatment S
Locomotive	19.03b	8.84a	7.09a
Run	0.50a	1.12b	0.97b
Walk	18.53b	7.72a	6.12a
Non-locomotive	39.90a	54.35b	56.47b
Dust-bath	0.33a	0.42a	0.97b
Rest	32.39a	47.89b	48.26b
Stand	7.18	6.04	7.23
Feeding	34.39	26.54	26.98
Drink	2.67b	1.97ab	0.97a
Eat	20.37b	13.62a	17.39b
Ground-peck	11.35	10.96	8.62
Comfort	6.68a	10.39b	9.46b
Preen	6.68a	10.39b	9.46b
Total	100.00	100.00	100.00

Different letters represent significant difference ($p<0.05$) among treatments.

Fig. 7-6. Comparison of categorised behaviours in different flock sizes (treatment L vs. treatment S) and flocking densities (treatme vs. treatment S)

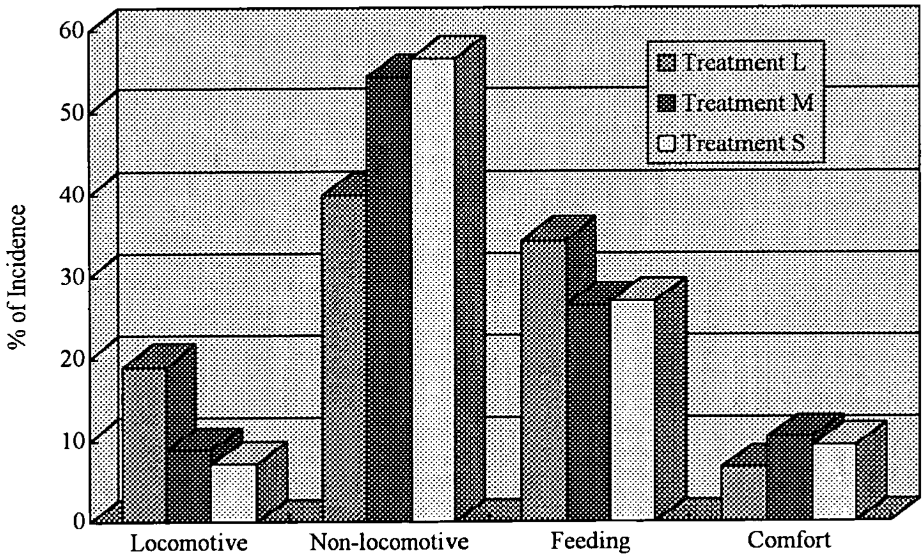


Table 7-3
The effect of interaction between genetic and environment on categorised behaviours (%).

Variables	Locomotive	Non-locomotive	Feeding	Comfort	Total
Broiler					
Treatment L	5.51b	63.86d	24.81b	5.82a	100.00
Treatment M	1.28a	86.93e	9.09a	2.70a	100.00
Treatment S	1.53a	84.47e	9.29a	4.72a	100.00
ISA Brown					
Treatment L	29.90f	26.40a	39.51c	4.20a	100.00
Treatment M	14.53d	41.20c	34.36c	9.92bc	100.00
Treatment S	9.99c	41.61c	36.75c	11.65c	100.00
Taiwan Country Chicken					
Treatment L	23.69e	25.78a	40.24c	10.28b	100.00
Treatment M	10.69c	35.14b	35.69c	18.47d	100.00
Treatment S	9.78c	43.16c	35.20c	11.87c	100.00

Different letters represent significant difference ($p<0.05$) within behaviour.

Table 7-4
Comparison on categorised behaviour patterns among different time of day (period) (%).

	Time of Day (Period)		
Behaviours	Morning	Mid-day	Afternoon
Locomotive	13.87b	9.42a	10.49a
Non-locomotive	47.01a	55.22b	49.85a
Feeding	29.78	26.81	30.55
Comfort	9.34	8.55	9.12
Total	100.00	100.00	100.00

Different letters represent significant difference ($p<0.05$) among periods.
Morning: 8.00-9.00. Mid-day: 11.00-12.00. Afternoon: 15.00-16.00.

Table 7-5
The effect of age on categorised behaviours (events/bird).

Breeds	Behaviours	Age 4-5 Weeks	 6-7 Weeks	 8-11 Weeks
Broiler	Locomotive	0.15±0.07a	0.06±0.07a	-
	Non-locomotive	4.68±0.12bx	5.36±0.12by	-
	Feeding	0.74±0.11a	1.04±0.11a	-
	Comfort	0.14±0.06a	0.27±0.06a	-
ISA	Locomotive	1.06±0.07bx	1.08±0.07cx	1.88±0.13by
	Non-locomotive	1.96±0.12ax	2.09±0.12ax	2.60±0.21y
	Feeding	2.02±0.11bx	2.78±0.11by	2.23±0.18x
	Comfort	0.40±0.06bx	0.65±0.06by	0.29±0.11ax
TCC	Locomotive	0.86±0.07bx	0.87±0.07bx	1.50±0.13ay
	Non-locomotive	1.96±0.12a	2.01±0.12a	2.13±0.21
	Feeding	1.98±0.11bx	2.70±0.11by	2.71±0.18y
	Comfort	0.64±0.06bx	0.97±0.06cy	0.94±0.11by

a, b, and c represent significant difference ($p<0.05$) between breeds.
x and y represent significant difference ($p<0.05$) between weeks. Data are not available for broiler in 8-11 weeks.

Table 7-6
The effect of confinement on categorised behaviours (%).

Behaviours	Control	Restraint
Locomotive	8.54a	15.25b
Non-locomotive	42.55a	23.98b
Comfort	4.43	5.15
Feeding	44.49a	55.62b
Total	100.00	100.00

Different letters represent significant difference ($p<0.05$) between treatments.

Table 7-7

The effect of rearing conditions (different stocking density) on categorised behaviours (%).

Behaviours	Medium Pen	Small Pen
Locomotive	13.83	10.37
Non-locomotive	28.75a	36.70b
Comfort	5.98	3.72
Feeding	51.44	49.21
Total	100.00	100.00

Different letters represent significant difference ($p<0.05$) between rearing conditions.

Table 7-8

The effect of interaction between confinement and rearing condition on categorised behaviours (%).

	Medium Pen		Small Pen	
Behaviours	Control	Restrain	Control	Restrain
Locomotive	9.58a	17.44b	7.65a	13.07ab
Non-locomotive	28.81ab	28.72b	54.15c	19.29a
Comfort	6.53	5.53	2.65	4.79
Feeding	55.08a	48.31a	35.55b	62.86c
Total	100.00	100.00	100.00	100.00

Different letters represent significant difference ($p<0.05$) within behaviour.

Chapter 8 General Discussion

8-1. Introduction

Behaviour has its origin in the animal's inherited constitution and the impact of the environment on genotype: the behaviour patterns shown by wild species will be those which have evolved by natural selection to fit the animal best to the environment (Duncan, 1980). Captive animals may therefore have an evolutionary legacy of an ethological need in a proximate sense, even if the particular environment in which they now live may have removed the need in the ultimate sense, and the proximate need may be similar but also be very different from what it would be in the wild (Dawkins, 1983). The ultimate and proximate causations are the mechanisms underlying biological events and their functional and evolutionary origins. In terms of ultimate causation, it is plausible to assume that natural selection of traits contributing to biological fitness has produced within an animal a set of interacting causal systems which function to deal with the major problems encountered (Colgan, 1989). Although the farm animals we deal with have all been in captivity and artificially selected for many generations, much of their behaviour still exists because natural selection has shaped them in their natural environments (Dawkins, 1985), and this repertoire has still persisted in spite of relaxed selection in captivity.

Comparisons with the behaviour of wild conspecifics are a common approach for assessing the welfare of captive animals; this approach assumes that animals may suffer if they can not perform the behaviour seen in their wild conspecifics. However, observed non-performance of some wild-type behaviour patterns is not necessarily informative about impoverished welfare (Veasey et al., 1996). Non-performance of some behaviour patterns may be due to causes such as another behaviour taking precedence, a high cost of alternating between activities, physical prevention, or a lack of relevant external stimuli. It is suggested that the expression of wild-type behaviour patterns may only correlate with rather than cause enhanced welfare (Veasey et al., 1996).

Rollin (1993) suggested that common sense tells us that animals built to move need to move to feel good; and suggested that there is no point in proving that they are willing to move or they are fine if kept immobile. In order to minimise pain and suffering of animals, it would be more appropriate for future research to concentrate on obtaining knowledge of how to improve housing or to figure out ways to let animals move and perform the behaviour which is similar to the behaviour in a natural environment, and this process should follow a motivational model which will be accepted by the public on the basis of neutral scientific assessment. Tudge (1995) also suggested that the behavioural era of 'animals as machines' is past: animals do think, they also feel. It has long been considered that such a concept is anthropomorphism, but the task now is to explain how animals think without speech. The mistake of anthropomorphism was not to admit that broad generalisation, but to suppose that the thoughts, feelings and aspirations of other animals resemble our own in detail, which is indeed pernicious. This new concept also proposed a new insight into two views: (1) it prevents the spurious assumption of scientific support for the notion that it is proper to treat animals as uncaringly as machines; and (2) it suggests that human beings themselves can serve as models of animal psychology at least as well as any machine.

It has been argued that the domestic chicken has a genetically determined need for locomotion, which has become established during evolution. This need for locomotor activity can't be satisfied under restricted conditions such as cages. Adaptation to these conditions will not be possible because of the genetic fixation of the trait. Thus, caging chickens will lead to permanent frustration (Bessei, 1980). However the argument goes, an accurate definition of the strength of motivation for locomotion in the domestic fowl is still needed to determine whether or not these animals have the need to perform locomotor activity, other than that merely required to seek for the resources (e.g. food, water, etc.). If they do locomote more than just to look for resources, we might say they do have motivation for locomotion and then determine those causations step by step in future research. This thesis investigated locomotion of domestic fowls in three main aspects:

(1) Environmental factors: the influence of experience to rearing condition, floor space, resource distribution, and flock size.

(2) Social factors: influence of companion and familiarity of a flock mate.

(3) Genetic factors: influence of breed. Age was also considered.

Detailed discussions for influence of the above factors on locomotion have been included within the previous chapters; the following sections will only present a brief summary of the experimental findings in this thesis (Chapter 2 to 7), and also assess the techniques applied in the thesis and its possible improvement.

8-2. Assessment of Locomotion and the Implications for Motivation

In any assessment of husbandry practices, theories of motivation must be considered (Wood-Gush, 1973). Before any specific recommendations can be made, much more knowledge is required on the full behavioural repertoire of the domestic species in question. This means much more than simply knowing which of the various behaviour patterns may appear: it also means studying their magnitude, quality and frequency, knowing their internal motivation as well as the stimulus situations in which they are found, including any specific releasing factors required for their performance; and correlating the behaviour patterns with physiological parameters which may give a more objective measurement of stress (Duncan, 1974). There has been too much emphasis on using abnormal behaviour as an indicator of welfare, but too little on the behavioural basis of welfare problems (Gonyou, 1993). To know what the normal behaviour is for each species one requires ethograms. These studies have usually been conducted in semi-natural environments to ensure that animals have the opportunity to respond to a wide variety of environmental features and to aid in the interpretation of the behaviours observed (Gonyou, 1994).

Due to the cost and risk of prominent behavioural responses, natural selection will not always favour animals that make prominent signals and carry on their social interaction by these obvious signs. Therefore, except at some occasions such as alarm calls to existence of predators, some animals have evolved to perform small, muted almost imperceptible signals when expressing daily behaviour. It would therefore be a mistake to count only on the obvious behavioural signs for indicators of stress, because the animals themselves may perceive small subtle cues more important in their interactions, although these signals are almost imperceptible to human beings. The indicators of stress which we might hope to pick up may not always be detectable (Dawkins, 1985).

The measurements adapted from previous research for recording movement (the number of squares entered adapted from open-field study in Study I, Chapter 2) and use of space (the percentage of individual birds sighted in specific areas adapted from 'taut string' in Study II, Chapter 2) to estimate locomotion quantitatively; and the narrow-gap technique (Chapter 6) introduced to measure strength of motivation for locomotion proved to be useful techniques in development of these ideas.

In Chapter 2, the recording technique adapted from the 'open-field' test and the 'taut string' approach were investigated and proved to be useful quantitative methods for studying locomotion. They were applied in this thesis as the general methods to record behaviour and location of birds. However, some disadvantages were found in these methods, and the details were discussed in Chapter 2.

The sampling interval of 10 seconds throughout an observation could be shortened to obtain more precise data. However, when recording behaviour patterns, the instantaneous sampling method may have some shortcomings when applied in the 'open-field' approach. The birds may seem to move less (according to the moving distance in formal statistical analysis) in a confined space than a larger space although they actually moved around in the small enclosure (according to observations or formal statistical analysis, i.e. more running). This is because the instantaneous sampling method cannot measure the actual moving distance within the 10 seconds interval. The birds moved around within the small enclosure, but the moving distance was only sampled according to the straight distance between the beginning and the final points of each 10 seconds interval. Thus this sampling method may under estimate the actual moving distance. This shortcoming can be assisted by the present computer software (for example, 'The Observer Support Package for Video-tape Analysis' developed by Noldus Information Technology b.v., 1994). Meanwhile, the tedious work of using video tape play-back technique could be reduced as well.

The three major factors investigated in this thesis: environmental factors, social factors, and genetic factors were proved to be essential influence on motivation for locomotion in domestic fowls.

First of all, in the environmental factors, previous experience of rearing conditions such as floor space, stocking density and resource distribution have effects on locomotion (Chapter 3). The frequency of walking and distance moved were proportional to the floor space, and were inversely proportional to the stocking density (Chapter 3). Physical restraint in a small cage induced more locomotion than the control group without confinement. The restrained effect on locomotion was especially obvious in pen-reared birds after being released from confinement (Chapter 7). Birds reared in small cages were less sensitive to restraint compared to pen-reared birds (Chapter 6). Exposure to space may be an extrinsic visual stimulus to induce motivation for locomotion, mainly due to accessibility to space more than merely visibility to space, i.e. physical accessibility to space may be a more important factor than visual stimulus (Chapter 4). Distribution of resources should be evenly arranged to prevent overt social conflicts and tension which may cause stress and damage welfare (Chapter 3). This is because birds had the tendency to remain near to resources and use space unevenly (Chapter 7). However, they seem to move further than is necessary just reach the resources (Chapter 3). Close grouping of resources may cause higher social tension and more aggression within a flock and therefore should be avoided.

Secondly, in the social factors, isolation may trigger a fear reaction. Individual housing is therefore not recommended. Familiarity between birds increases locomotion and prevent aggression. The presence of companions and familiarity with flock mates may produce a situation where birds feel more secure and relaxed to explore, as a consequence, inducing their motivation for locomotion (Chapter 5).

Finally, in the genetic factors, the discrepancy between broilers, ISA Brown laying hens and Taiwan Country Chickens in chapter 7 shows that genetic breeding has changed behaviour repertoires of domestic fowls, even those essential elements for survival such as feeding behaviour. Age shows little influence on locomotion. Moving distance and walking frequency declined over age, but the trend was only significant in grouped resources pens (Chapter 3). Broilers had more non-locomotive behaviour as they grew bigger, while ISA Brown were more locomotive and TCC performed more comfort behaviour with age (Chapter 7).

Moreover, the present findings of comfort behaviour are consistent with the earlier research. It has been found that increasing spatial allowance and reducing housing density could induce more comfort behaviour (Bessei, 1983; Reed and Nicol, 1992; Tanaka and Hurnik, 1992; Keeling, 1994). Close proximity to flock mates may also induce comfort behaviour such as preening, indicating that there may be social stimulus involved in such behaviour (Nicol, 1989). However, Black and Hughes (1974) found more comfort behaviour (preening) in cages than in pens. Such finding seems to be inconsistent with other findings that the incidence of comfort behaviour is proportional to the spatial allowance. In this thesis, the present findings are consistent with the earlier research: more preening and tail-wagging were found in a larger space and a lower stocking density (Chapter 3); more preening were exhibited in cages than in pens, where the birds had closer proximity to their flock mates (Chapter 4); more comfort behaviour occurred when a companion bird was present, suggesting that social stimulus may induce comfort behaviour (Chapter 5); the pen-reared birds performed more comfort behaviour than the cage-reared birds (Chapter 6) and more comfort behaviour was observed in a smaller flock than a larger flock (Chapter 7). It is suggested that the inconsistent findings in the effect of space on comfort behaviour are due to the interpretations of the results: close proximity could induce more preening, but the effect diverts as the decreasing spatial allowance reaches the threshold of performing it.

In conclusion, this thesis suggests that there is motivation for locomotion in the domestic fowls but such motivation has been modified and became less significant in broilers. Birds can perceive and be attracted by the visual stimulus of extra space but the previous rearing experience and the accessibility to space have more influence on motivation for locomotion. Behaviour can be used as complement of preference tests (Chapter 1) and indicators of motivation for locomotion. Gross body movements such as locomotion may be suppressed if there is no enough space to perform it. However, whether this will cause frustration and how strongly the domestic fowls demand for performing motivation for locomotion still need further investigations.

8-3. Implications for Animal Welfare and Housing Design

Even without making moral or ethical judgement, scientists can help in the welfare debate by producing scientific evidence on the facts for making a more neutral judgement. In making the best reasonable estimate of welfare, it is essential to take cognisance of all the available evidence. This will include evidence of the animal's health, production, physiology, biochemistry, and behaviour (Duncan, 1981).

8-3-1. Implications for Animal Welfare

Examining the effects of restricted freedom of movement in domestic fowls has been a complex task for behavioural scientists since there is no single indicator of suffering. The whole task is both technically and theoretically challenging. However, it has now been proved by scientific experiments that restrictions on movement within a cage cause frustration and prevent normal bone maintenance (Meyer and Sunde, 1974).

Public concern regarding the keeping of hens in battery cages has stimulated a search for alternative housing methods that would overcome some of the constraints imposed on caged birds (Hughes, 1976; Dawkins, 1978; Martin et al., 1980; Anonymous, 1995;

van Niekerk and Reuvekamp, 1995). For example, a modified deep litter system met the hens' welfare needs in terms of movement and behavioural expression, but perhaps entirely so only at the lowest stocking density (Craig and Guhl, 1969). Generally speaking, freedom of movement in litter system is high, compared to cages, at least at the lower stocking densities, and birds may spend up to 16% of their time in locomotion (running, walking, chasing, jumping, flying) at low densities (3.4 birds/m^2) (Appleby et al., 1989).

Although cage design has long been considered to restrict behavioural expression, locomotion and movement, there are positive features of cages which protect the welfare of hens in certain regards such as lower mortality, less cannibalism, better hygiene, and better protection from the extremes of climate and the environment compared with some alternative systems. Cannibalism is also more difficult to control in larger groups (Appleby, 1991; Dun, 1992). Work on improved cages began in the early 1970s with the so called 'get away' cage. Research on modified cages has been carried out to improve the deficiency of cages on welfare (Appleby et al., 1992; Reed and Nicol, 1992; Appleby, 1993).

The Edinburgh project on modified cages suggested that despite the remaining questions on freedom of locomotion and its physical effects such as bone weakness, welfare of hens in modified cages is appreciably improved compared to that of hens in conventional cages. In retaining the advantages of small group size and hygiene, welfare at the present state of knowledge may also be more reliably improved than in more radical alternatives such as extensive and floor-housed systems where there is the risk of cannibalism or the practice of beak trimming to prevent it. According to those involved in the project, at the current state of development of alternative systems, legislation which required cages for laying hens to be modified but did not actually ban them would on balance be most beneficial to the welfare of the birds concerned (Appleby, 1993).

8-3-2. Implications for Housing Design

What is an 'ideal environment' ? There have been three sorts of answer to this question: (1) the wild; (2) 'traditional' husbandry systems; (3) environments which can elicit a rich repertoire of behaviour (Hughes, 1980). There have been quantitative studies trying to estimate how much space is used by hens according to their different behaviours (Bognor et al., 1979; Dawkins and Hardie, 1989; Keeling, 1994). These studies have revealed a general picture that hens use more than the present 450 cm^2 they would normally be allocated in a battery cage. Confinement in a battery cage has been proved to restrict freedom to perform the full repertoire of behaviours in hens (Black and Hughes, 1974; Dawkins, 1985; Nicol, 1987), which have been believed to indicate frustration in battery cages (Duncan, 1970; Duncan and Wood-Gush, 1972).

In animal husbandry, there has been a development of husbandry systems for agricultural species, and the design of housing systems has been influenced by a variety of factors. Generally, farms have been designed to accommodate humans' requirements or economic considerations and not the behaviour of the animals that have been forced to live on them. The aim in such programmes is usually to get the maximum density and/or growth rates at a minimum cost to the producer. In this case, animals have usually been expected to adapt themselves to the housing supplied. Such an approach has had an impact on welfare. These systems often provide a very inappropriate physical environment which may frustrate certain behaviour patterns, lack essential stimuli, or provide too much or too little general stimulation. In addition, often animals are kept in an inappropriate social environment, with the group size being too large or too small, the population density being too great and the social mix being unsuitable for the animals concerned. Ideally, the housing should be designed to fit not only the animals' bodily needs, but also to accommodate their normal behaviour to minimise social tensions and distress (Bhagwat and Craig, 1979; Wood-Gush, 1990; Gonyou, 1994). In general, animals that can perform normal behaviour are more likely to achieve better welfare than those cannot. Providing for normal behaviour is a means of ensuring that animals have a reasonable opportunity to maintain adequate welfare.

Some amendments have been developed to solve such welfare problems in pig production systems (Stolba, 1981; Kerr et al., 1988), and have compared well with the average system in terms of production and profitability. However, they still cannot compete with the most efficient producers with highly intensive units. However, it is possible that features of modified systems will eventually find their way into conventional production systems. In the event of stringent legislation in animal welfare, more features of the modified system will probably be widely adopted in the future.

There also have been many attempts to design alternative husbandry systems to the battery cage for laying hens. The drive for efficiency in the egg industry has meant that the presence of 'unproductive' males would not be allowed, in spite of evidence that the presence of males may stabilise the social organisation in a group of hens (Bhagwat and Craig, 1979). Nicol and Dawkins (1990) proposed the possibility to provide infertile cockerels or masculinised females to lead and stabilise the group of hens without producing fertile eggs which are undesirable for the consumers. There is another advantage for such rearing condition: the existence of cockerels or masculinised females may encourage hens to explore in a free range system, therefore the use of space, vegetation and resources would be more even. The alternative systems to battery cages have thus concentrated on improving the physical environment and have avoided interfering with the social environment.

One approach has been to modify the battery cage in various ways. The simplest modifications to improve welfare are design changes to reduce the risk of trapped and injured birds (Tauson, 1980). A more radical approach has been to enrich the battery cage by enlarging it, particularly in the vertical dimension, providing perches and a nesting site and, in some models, providing a dust bath. This type of enriched cage has become known by the generic name of 'get-away cage' (Bareham, 1976; Elson, 1976; Brantas et al., 1978; Wegner et al., 1981). The 'get-away' cage takes account of the bird's preference for a larger cage and litter substrate, and therefore avoids the problems of pre-laying frustration and satisfies more needs for hens than a conventional cage. However, because of the higher expense and the design difficulties involved in providing the additional facilities for a small group of birds, the group size in get-away cages has been increased from the usual 3-5 to 10-25. This is greater than the optimum group size for laying hens under cage-housed condition (Hughes, 1975) and probably means that social friction is increased. Other difficulties have included feather soiling resulting from the vertical layout of these cages. In addition, there have been production problems such as dirty and cracked eggs and a higher food intake than in conventional cages (Elson, 1981). It seems that the ideal get-away cage has not yet been designed but development is continuing.

Another approach has been to modify the deep-litter system. This system, which depends on the activity of micro-organisms in the litter to kill off pathogens, has never worked well in north-west Europe, probably because of the cool damp winters; if the litter stops working and becomes cold and wet, disease outbreaks invariably follow. Alternative systems have tried to overcome this problem by increasing the bird numbers (and therefore the heat production) within a house by making more use of vertical space. There have been many variations on this theme, such as the 'perchery' which incorporates frames with perches (McLean et al., 1986), various types of 'aviary' with slatted or wire platforms (Hill, 1981 a, b), and 'tiered wire floors' (Ehlhardt, 1985). All of these systems allow stocking density to be increased and provide various facilities at different vertical levels. While they undoubtedly allow the birds more freedom to express a greater range of behaviour than do cages, there have been associated husbandry problems some of which may actually reduce welfare. There have also been management problems such as high food consumption and a high incidence of dirty and cracked eggs which have made it difficult for these alternative systems to compete commercially with battery cages. It is to be hoped that research and development will continue until a husbandry system is found which truly caters for the birds' welfare and which also can match the battery cage commercially.

Many commercial rearing systems are based on the assumption that resources will be shared equally between all individuals, which often oblige domestic animals to feed in conditions where competition is intense. Competition for resources results in higher levels of aggression and social conflicts (Chapter 3), spreading resources out more evenly will reduce the level of competition (Monaghan, 1990). Previous research has demonstrated that when providing sufficient feeding space, hens will feed at a point source without aggression, and it is common that hens tend to eat simultaneously at a same feeder. Therefore, the role of social attraction should be paid attention as well as to competition when designing a layout of a housing (Meunier-Salaün and Faure, 1984; Huon et al., 1986).

Providing cover is proposed by Agassiz Research Station in Canada that, although domestic fowl are less nervous and wary than their wild ancestors, the nature to use cover to conceal themselves from predators still exists. Birds may choose security over feeding and drinking if there is no sufficient cover provided, which may consequently reduce growth rate. Providing cover can ensure the security and therefore encourage chickens to make better use of their available space, and decreases vigilance among birds (Newberry, 1994).

It is suggested that when considering a proper distribution of feeders, drinkers, and nest boxes, etc. in a housing system, it is essential to arrange the resources evenly instead of congregating them within a certain area. This is to avoid the possibility of increasing competition for access to resources, to reduce the social tension within a flock, and to ensure the welfare of the flock.

8-4. Conclusions

1. The recording technique adapted from the open-field test and the 'taut string' approach are useful quantitative methods for studying locomotion. The sampling interval of 10 seconds throughout an observation could be shortened to obtain more precise data. This can be assisted by present computer software (for example, 'The Observer Support Package for Video tape Analysis' developed by Noldus Information Technology b.v.) to reduce the tedious work of using video tape play-back technique.

2. Previous experience of rearing conditions has effects on locomotion. The frequency of walking and distance moved are proportional to the rearing space, and are inversely proportional to the stocking density.

3. Exposure to space may be an extrinsic visual stimulus to induce motivation for locomotion. Moving from a small rearing cage to a larger test environment will stimulate more locomotion.

4. Restraint in a small cage induced more locomotion than the control group without confinement. Birds reared in a small cage are less sensitive to restraint compared to pen-reared birds, the latter showed more locomotive behaviour after being released from confinement.

5. Birds remain near to resources (food, water, perches and nest boxes) and use space unevenly, but they seem to move further than is necessary just reach the resources. One reason could be that feeding behaviour is usually accompanied by movement. Close grouping of resources may cause higher social tension and more aggression within a flock. Distribution of resources should be evenly arranged to prevent overt social conflicts and tension which may cause stress and damage welfare.

6. Isolation may cause a fear reaction; individual housing therefore is not recommended. Familiarity between birds can increase locomotion and prevent aggression. The presence of companions and familiarity with flock mates may produce a situation where birds feel more secure and relaxed to explore. Familiarity and companionship of another bird had no effect on inter-individual distance.

7. Genetic breeding has changed behaviour repertoires of domestic fowls, even those essential for survival. Age shows little influence on locomotion.

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Appendix I

Ethograms

(1) Locomotive Behaviour:

Jump: jumping or attempting to fly.

Run: moving with quick steps, faster than when walking.

Walk: moving about but not engaged in any specific activity.

(2) Non-locomotive Behaviour:

Dust-bath: performed with fluffed feathers while in a sitting position. Subsequent activity includes bill-raking, ground-scratching and head-rubbing.

Rest: Sitting did not preclude other activity, but it is associated with low activity.

Stand: standing and idle; may have head over feeder or not and eyes may be open or closed.

(3) Comfort Behaviour:

Body-shake: the neck and body feathers are ruffled and the entire body is rotated in an axial plane. Wings are slightly lifted.

Head-shake: the head, held normally, is moved from side to side.

Head-scratch: the head and bill are scratched with the foot, the leg passing beneath the wing.

Preen: preening while standing or crouching. Rearrangement of the feathers or scratching of the skin by beak or foot. Pecking, combing, stroking or nibbling the feathers.

Tail-wag: the tail is moved from side to side.

Wing-flap: the flapping action consists of several wing beats while standing still.

Wing-stretch: one wing is extended backwards and slightly sideways, generally together with the leg on the same side.

(4) Feeding Behaviour/Foraging Behaviour*:

Drink: drinking movements at the water trough.

Eat: pecking at feed in the feed trough.

Beak-peck: pecking at other bird's beak.

Feather-peck: pecking or preening-like acts directed to another bird's feathers.

Ground-peck: pecking at ground.

Ground-scratch: scratching at ground.

Litter-peck: pecking at litters.

Litter-scratch: scratching at litters.

Wall-peck: pecking at walls

(5) Aggressive Behaviour:

Fight: jumping or flying with the beak or claws attacking the other bird.

Threat: walking towards other bird, making them withdraw.

* Foraging Behaviour does not include drinking and eating.

Appendix II

Poster submitted for poster at the Scottish Centre for Animal Welfare Science (SCAWS) Meeting, 1993, St. Andrews.

Motivation for Locomotion in the Laying Hens

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Introduction

Recent findings in poultry motivation research has addressed nesting behaviour, housing environments, and social conditions. However, little attention has been given to motivation for locomotion, a large-scale movement which is a relative term of small-scale body movements.

This study investigates whether rearing conditions would have an effect on motivation for locomotion in laying hens, and will comprise part of the experimental series for my PhD thesis.

Methods

Behavioural observations on a flock of ISA Brown laying hens have been carried out since the 17th of January in 1994. The birds were 12 weeks old at that time, and will be continually monitored over a period of 19 weeks (30 weeks old).

Sixty birds were randomly assigned to one of 12 groups to be kept under three different rearing conditions (see Diagrams), with 4 replicates of each. All birds were exposed to their rearing conditions at age 9 weeks, allowing 3 weeks for them to become accustomed to their experimental environments.

The observing conditions were optimised to create the minimum disturbance to the birds. Instead of using preference tests, which requires animals to make an effort to get the resources they want, the experiment described below aims to examine the influence of rearing conditions upon motivation for locomotion by comparing walking distances among three rearing conditions in home pens/cages without the setting up of a novel device or handling the animals.

The behaviours were recorded using two methods so allowing both on-line and off-line analyses to be performed.

A. by video recording equipment

Four replicates were divided into 4 blocks (see Table 1), the recording schedule was carried out once a week, and a rota ensured that each treatment was observed in turn within each block. Locations (see Diagram) and behaviours (see Table 2) were recorded by reviewing video tapes with instantaneous sampling method every 10 sec for a 30 min period per bird.

B. by direct observation

Locations and behaviours of individuals were sampled instantaneously by an observer hourly, from 9:00 to 17:00 hr (9 observations), once a week.

Discussion

At the time of writing, this experiment is in the 9th of its 19 week duration, therefore, no statistical measures may be usefully included at this time.

Preliminary findings from the observations to date indicate that these birds do not confine themselves in the area of the resources (Pen B), meanwhile, it seems that the birds tend to rest in the floor area rather than the perches during the observing period. It is not clear whether there will be a significant difference in walking distances between Pen A and B, which the resources being grouped or separated, respectively. Generally, the birds in Cage C group seem relatively more active and show a 'jumping' behaviour unique to this experimental condition.

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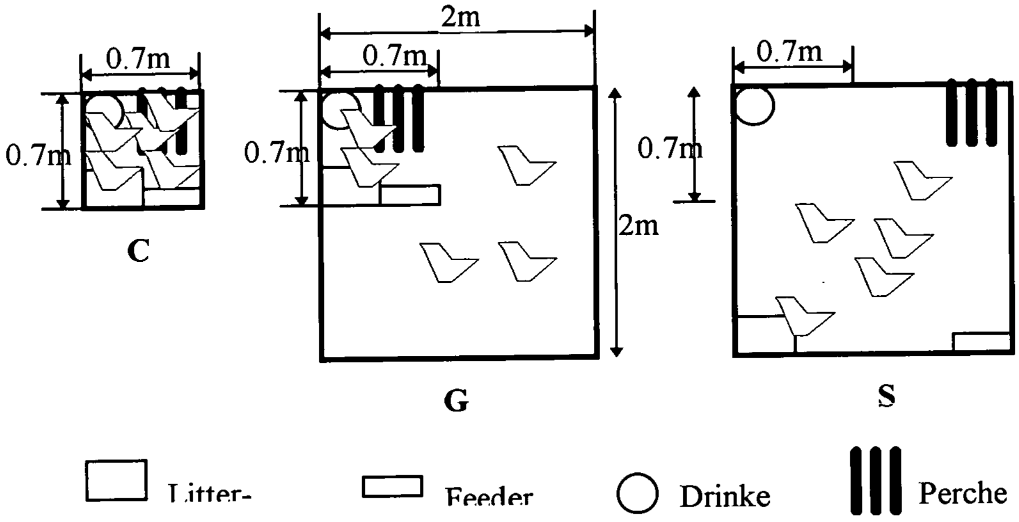
Table 1. Floor-space per bird

Pen-A	8000 cm^2
Pen-B	8000 cm^2
Cage-C	980 cm^2

Table 2. Video-recording periods

Block 1	09:00-11:00
Block 2	11:00-13:00
Block 3	13:00-15:00
Block 4	15:00-17:00

Diagram 1. Experimental designs.



Appendix III

Abstract submitted for *Research in Progress 1993* (eds. B.O. Hughes and G. Owens), Scottish Centre for Animal Welfare Sciences.

Motivation for Locomotion in Domestic Fowls

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Objectives

To understand how motivation for locomotion in domestic fowls is affected by housing condition. The development of walking distance will also be studied intra-individually through age. ISA Brown laying hens from 10 to 30 weeks old will be used in the present experiment.

Results

A preliminary investigation in a broiler house (14×64 m) in March 1993, showed that while growing broilers generally moved slowly, they moved over an average range which was approximately one third of the area (283 m^2). Broilers moved further than was necessary simply to reach food and water. This suggested that birds were generally not confined to a very restricted part of the shed.

In a pilot study the hens were observed in a chamber (3.5×2.9 m) individually or with two other cagemates. When the bird was observed individually she tended to cackle more than when other cagemates were present. When three birds were observed together in the chamber there was always one particular bird who led the way, and two other cagemates followed her. This behaviour might be caused by 'fearfulness' of the environment, which was different from their home cages. This suggests that the present experiment should be carried under circumstances where the test birds are familiar to the experimental surroundings. The presence of the observer influenced their behaviour markedly, so the present experiment will be carried out using video recordings.