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Emergence and dispersal behaviour in domestic hens: effects of social rank and novelty of an outdoor area

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Abstract

The apparent reluctance of many free-range laying hens (*Gallus gallus domesticus*) to disperse in the available outdoor area may be due, in part, to the large discrepancy between the indoor and outdoor environments. The objective of this study was to alter the novelty of an outdoor paddock by the introduction of familiar feeders, and examine hens' subsequent readiness to emerge from a familiar box and disperse in the area. In addition, the possible influence of social rank on emergence behaviour was examined. In Experiment 1, there were three treatments (T1, feeder inside box; T2, feeder 1 m outside box; T3, two feeders, one in either position), and hens' latencies to emerge from the box were recorded. Birds emerged earlier in T2 than in either of the other treatments. Social rank within the group did not influence emergence latency, and emergence times decreased with repeated testing. Using the same three treatments, Experiment 2 examined birds' use of four areas of the paddock. These were: 1, inside box; 2, within 1 m of box door; 3, within 30 cm of outside feeder; 4, more than 1 m from box door. Birds spent less time inside the box when there was a feeder in the paddock, but there was no treatment effect on the amount of time spent in Area 4. In Experiment 3, the positions of three feeders were altered to investigate whether dispersing feeders throughout the paddock caused birds to disperse further. Both emergence and dispersal behaviour were recorded. There were three treatments: T1, no feeders (control); T2, three feeders within 2 m of the box; T3, three feeders placed 1.5 m, 5 m and 7.5 m from the box. Compared with T1, birds emerged earlier, spent less time inside the box and more time immediately outside the box in both T2 and T3. There were no significant differences between T2 and T3, and there was no treatment effect on the amount of time spent in the area furthest from the box. Thus, birds tended to emerge earlier, and spend less time inside the box, when a feeder(s) was present in the outdoor area, but tended not to disperse further than the point of the nearest feeder.

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1. Introduction

The readiness of domestic hens to enter into and subsequently disperse in a novel area may be influenced by a number of factors. One such factor may be the relative novelty of the area, as the degree of discrepancy between an animal's home environment and a novel area could influence the animal's response to the novel area. Extreme or intense novelty evokes fear responses (such as avoidance or withdrawal), whereas moderate novelty often evokes exploration (Murphy and Wood-Gush, 1978). The presence of familiar cues in an otherwise unfamiliar environment may serve to reduce the novelty of that environment, and, as a result, may affect animals' subsequent behaviour in it (Jones, 1977a); for example, chicks showed attenuated tonic immobility responses (indicating reduced underlying fearfulness) in the presence of familiar cues relative to unfamiliar cues (Rovee et al., 1973). The presence of familiar objects in an otherwise novel environment has also been shown to enhance exploration of that environment; for example, broiler chicks familiarized to coloured boxes in a small pen show an even distribution in a larger (novel) pen when these boxes are spread throughout the larger pen. Non-imprinted chicks display an uneven distribution by crowding around one end of the large pen (Gvaryahu et al., 1987, 1989). One aim of the experiments described in this paper was to investigate the reactions of laying hens towards an open, unfamiliar environment, while varying the novelty of the environment by the introduction of familiar feeders.

In addition to the presence of familiar cues, responses of grouped individuals to a novel area may be related to the social structure within the group. The relationship between dominance and leadership, in which one animal sets the pace of group activity or initiates changes in it, varies between species. Squires and Daws (1975), for example, in a study on sheep, found that there was a high correlation between overall movement order score and dominance score. Conversely, Meese and Ewbank (1973) found no correlation between social rank and incidence of leadership among pigs in an outdoor enclosure. Similarly, no consistent leader was found in a herd of dairy cows, and overall herd movement was influenced by all herd members (Leyhausen and Heinemann, 1975). Katzir (1982), in a study on jackdaws (*Corvus monedula* L.), found that early exploration of a novel space was carried out predominantly by socially mid- to low-ranking birds. High-ranking birds were neither the first nor the last to enter the new area. Willingness to explore may be correlated with rank only when high-ranking individuals could benefit from such exploration. Otherwise, high-ranking birds may be reluctant to explore, as they have more to lose by being exploratory. Conversely, lower-ranking birds may benefit by being exploratory, and might therefore be more willing to leave a familiar home area for a novel area.

In domestic fowl, it might be predicted that low-ranking birds will show the greatest willingness to leave a familiar environment for a novel area, as a number of studies have indicated that low-ranking hens might be at a disadvantage compared to higher-ranking birds. Eskeland (1977) found that, in floor pens, high-ranking individuals spent up to one-third of the time feeding, whereas low-ranking birds were continually disturbed while trying to eat, and only spent 5% of the time feeding. In addition, ground-scratching and dustbathing decreased with diminishing rank, while standing, resting, pacing and running were all more frequently observed among low-ranking birds. High-ranking birds were able to remain in preferred areas, whereas low-ranking individuals had irregular movements and were frequently chased around. Similarly, in high-density cages, low-ranking hens have increased heart weights (a symptom of increased stress) and longer durations of tonic immobility, indicating higher underlying fearfulness (Cunningham et al., 1988). High-ranking birds may also enjoy greater freedom of movement; for example, Mankovich and Banks (1982) reported differential use of areas by individuals, with high-ranking birds frequently beside the food dispenser and the lowest-ranking individual spending most time on the perch, which served as a refuge. Based on the above findings (which indicate that low-ranking birds are possibly disadvantaged in their home environment), it is hypothesized that low-ranking hens will show the greatest readiness to enter a novel area, as they have more to gain by being exploratory.

This paper investigates the effects of both social rank and varying the novelty of an outside area on the dispersal of laying hens in the novel area. The novelty of the outdoor area was varied by altering the presence and/or positions of familiar objects within the area. Hens in free-range systems often show an apparent reluctance to leave the house and enter the outside area. Furthermore, outside birds display a non-random distribution, with bird density decreasing as distance from the house increases (Davison, unpublished data; Keeling et al., 1988). A possible explanation for this is that most, if not all, of the birds' basic requirements (such as food and water) are available inside the house. An alternative explanation is that birds may be inhibited from leaving the house because the degree of discrepancy between the inside and outside environments is too great. Introducing familiar objects, such as feeders, into the outside area might reduce this discrepancy, thus increasing birds' willingness to leave and move away from the house. The present study describes three experiments in which the effects of providing familiar feeders in an outdoor area and altering the positions of these feeders on birds' readiness to enter and subsequently disperse in the area were examined. Experiment 1 also investigated the effect of social rank on readiness to emerge.

2. Animals, materials and methods

2.1. Experiment 1

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

Twenty-two 125-week-old medium hybrid (ISA Brown) laying hens were housed in two indoor floor pens (11 birds per pen). Each pen measured 2.4 m × 2.4 m, and contained a covered box (0.9 m × 0.9 m × 0.9 m) with an open side, so that all birds could enter it and became familiarized to the box in their pen. Each pen also contained a ''tower'' feeder, which was situated inside the box. Observations on agonistic interactions began 1 week after the birds were moved into the pens. Around 80 h of observation were made over a 4 week period. An aggressive interaction was counted when one bird pecked, chased, threatened or displaced another. The winner and loser of each interaction were noted. A total of 1841 aggressive interactions were observed during this time. Dominance–subordinance hierarchies were determined for each pen, and each bird was assigned a social rank. Once hierarchies had been established for both pens, birds were randomly assigned to test groups of three or four pen-mates each (i.e. three groups per pen). Each group contained one high-ranking bird (selected from Ranks 1–3 in the pen hierarchies), one or two middle-ranking birds (from Ranks 4–8), and one low-ranking bird (from Ranks 9–11). In the groups containing four birds, the two middle-ranking birds were of adjacent ranks, so that they were of similar social status.

Food deprivation has been shown to increase animals' exploratory tendencies (Fehrer, 1956); therefore, to minimize the likelihood that birds' emergence responses were influenced by hunger, birds had free access to food in their home pens prior to testing. Birds' emergence responses were tested in an outdoor (grass-covered) paddock, measuring 11 m × 5.5 m. A covered box, similar to those in the indoor pens, was placed in one corner of the paddock. During testing, each group was transported to the outside paddock in a holding crate and placed in the covered box (with the door closed), where they were left to acclimatize for 2 min. Tower feeders (similar to those in the indoor pens) were used to alter the novelty of the outside area. There were three treatments: T1, one feeder inside the box; T2, one feeder in the outside area, 1 m from the box door; T3, one feeder in both positions (one inside and one outside).

Following the 2 min acclimatization period, the box door was raised (and secured), and the times taken for each bird to emerge from the box were recorded. Each group was given three replications of each treatment in a randomized block design. All testing took place in the afternoon to reduce the possibility of the birds' responses being influenced by egg-laying behaviour.

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

2.2. Experiment 2

Experiment 1 used latency to emerge from the box as a measure of birds' willingness to enter the outside area. However, this method did not give any indication as to how birds occupied different areas of the paddock. In Experiment 2, the amount of time which birds spent in different areas of the paddock was used as an alternative measure of their readiness to disperse in the outside area. (This method was analogous to that used by Nicol (1986) in a study on non-exclusive use of different areas in preference tests.)

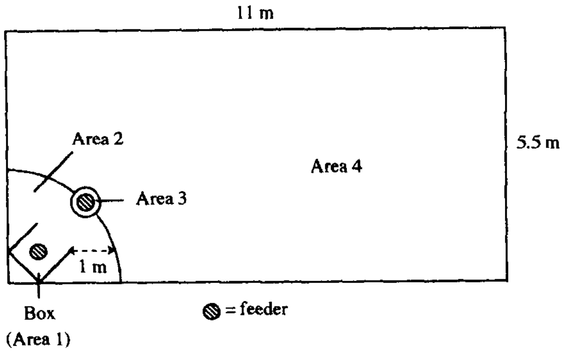

Fig. 1. Plan view of paddock (Experiment 2).

Twenty-four 32-week-old medium hybrid (HISex) laying hens were housed in two indoor floor pens (12 birds per pen), and were randomly assigned to test groups of four pen-mates each (i.e. three groups per pen). As before, both indoor pens contained a covered box and a "tower" feeder. The treatments used were the same as in Experiment 1: T1, feeder inside the (outdoor) box; T2, feeder 1 m from the box door; T3, two feeders, one in each position. The paddock was divided into four areas: 1, inside the box; 2, outside the box, within 1 m of the box door; 3, within 30 cm of the outside feeder; 4, more than 1 m from the box door (Fig. 1). In each trial, the paddock group was scanned every 30 s over a 60 min period, and the position of each test bird was recorded; this gave an indication of the proportion of time each individual spent in each area. Each group was given three replications of each treatment in a randomized block design. All testing again took place in the afternoon.

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

2.3. Experiment 3

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

Thirty-six 65-week-old medium hybrid (HISex) laying hens were housed in three indoor floor pens (12 birds per pen). Birds were randomly assigned to test groups of four pen-mates each (i.e. three groups per pen). Each indoor pen contained a covered box and a "tower" feeder, and birds' emergence and dispersal behaviour were tested in the same

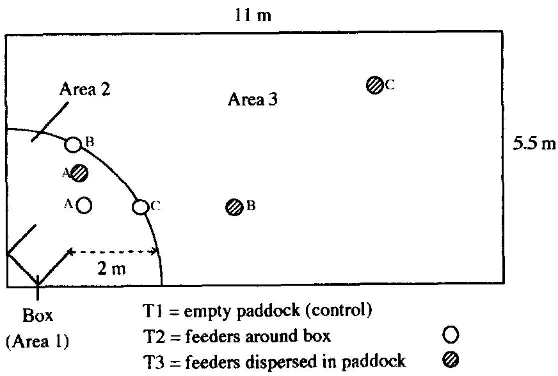

Fig. 2. Plan view of paddock (Experiment 3).

outdoor paddock as before. There were three treatments: T1, empty paddock (control); T2, three "tower" feeders within 2 m of the box door (Feeder A 1 m from the box; Feeders B and C 2 m from the box); T3, three feeders dispersed in the paddock (Feeder A 1.5 m from the box; Feeder B 5 m from the box; Feeder C 7.5 m from the box). Each group was given two replications of each treatment. The paddock was subdivided into three areas: 1, inside box; 2, within 2 m of the box door; 3, more than 2 m from the box door (Fig. 2). The following measures were recorded: (a) the latencies of each bird to leave the box, once the box door was raised; (b) the area in which each (test) bird was seen, scanning every 30 s over a 60 min period (to permit log-transformations to be carried out, 1 was added to each total to allow for zero-scores); (c) the number of birds which were observed feeding at each feeder during each scan.

Analysis of the latencies to emerge from the box, as well as the number of scans in which birds were seen in Area 3, were carried out on log-transformed data. The raw data had a skewed variation; log-transformation produced a more normal distribution and homogeneity of variance. The data for the number of scans in which birds were seen in Areas 1 and 2 conformed to the conditions for parametric statistics, so analysis was carried out on untransformed data.

3. Results

3.1. Experiment 1

Birds' latencies to emerge were not influenced by their social rank ($F_{2,8} = 1.15$, not significant (NS)). A significant day effect (Fig. 3) indicated that emergence times decreased with habituation ($F_{8,84} = 12.04$, $P < 0.001$). There was also a significant treatment effect ($F_{2,84} = 5.60$, $P < 0.01$). Pairs of treatments were compared using unpaired *t*-tests (Fig. 4). Compared with T1 and T3, birds emerged earlier when there was a feeder outside (T2). There was no significant difference between T1 and T3.

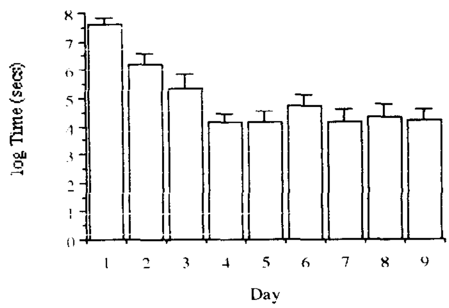

Fig. 3. Experiment 1: day effect on (log) emergence time (mean + standard error, SE).

3.2. Experiment 2

There was a significant treatment effect on the number of scans in which birds were seen in Areas 1, 2 and 3 (Area 1: $F_{2,172} = 36.60$, $P < 0.001$; Area 2: $F_{2,172} = 4.39$, $P < 0.05$; Area 3: $F_{2,172} = 138.58$, $P < 0.001$), though not in Area 4 ($F_{2,172} = 0.32$, NS). To clarify which treatment(s) had an effect in Areas 1, 2 and 3, *t*-tests were carried out on the means for each pair of treatments (Fig. 5). Birds spent significantly more time in Area 1 (inside the box) in T1 than in either of the other two treatments, and also spent significantly more time in Area 1 in T3 than in T2. Birds spent significantly more time in Area 2 (within 1 m of the box) in T2 than in either of the other two treatments, and there was no significant difference between T1 and T3. Birds occupied Area 3 (within 30 cm of the outside feeder) significantly more in T2 than in either of the other two treatments, and spent more time there in T3 than in T1.

3.3. Experiment 3

3.3.1. Latencies to emerge

The treatment used had a significant effect on the time taken to emerge from the box ($F_{2,159} = 10.87$, $P < 0.001$). Pairs of treatments were again compared using unpaired *t*-tests

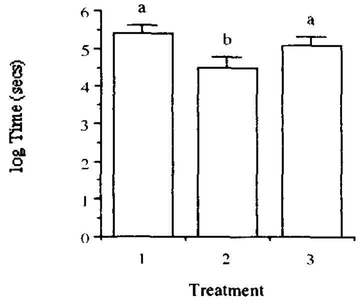

Fig. 4. Experiment 1: treatment effect on (log) emergence time (mean + SE). Means with no letter in common differ significantly ($P < 0.05$ or less).

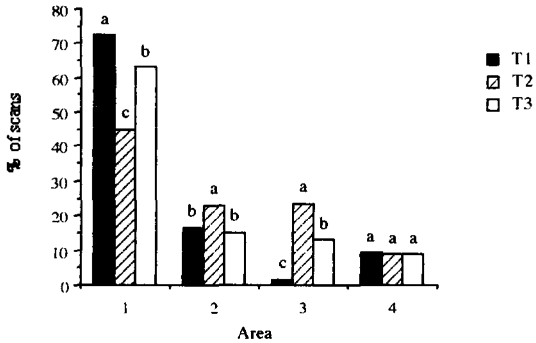

Fig. 5. Experiment 2: treatment effect on the percentage of scans birds spent in each area. Within-area means with no letter in common differ significantly ($P < 0.05$ or less).

(Fig. 6). Compared with T1 (empty paddock), birds emerged significantly earlier in both T2 (feeders clustered around box) and T3 (feeders dispersed in paddock). There was no significant difference between T2 and T3.

3.3.2. Use of each area

There was a significant treatment effect on the number of scans in which birds were seen in Areas 1 and 2 (Area 1: $F_{2,159} = 7.23, P < 0.001$; Area 2: $F_{2,159} = 12.74, P < 0.001$), though not in Area 3 ($F_{2,159} = 1.77$, NS). To clarify which treatment(s) had an effect in Areas 1 and 2, *t*-tests were carried out on the means for each pair of treatments (Fig. 7). Birds spent significantly more time in Area 1 (inside the box) in T1 than in either of the treatments where feeders were present in the paddock (T2 and T3). There was no significant difference between T2 and T3. This pattern was reversed in Area 2 (within 2 m of the box door): compared with T1, birds spent significantly more time in Area 2 in both T2 and T3. Again, there was no significant difference between T2 and T3.

3.3.3. Use of the feeders

Table 1 shows (a) the percentage of scans in which outside birds were seen feeding at the feeders, (b) the distribution of feeding events expressed as percentages, and (c) feeding events expressed as percentages of all scans. Birds were observed at the feeders in a higher

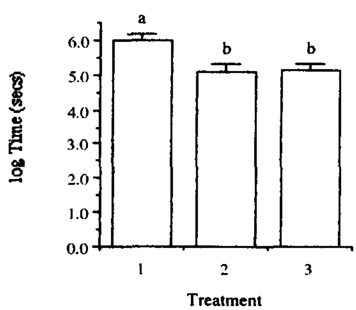

Fig. 6. Experiment 3: treatment effect on (log) emergence time (mean + SE). Means with no letter in common differ significantly ($P < 0.05$ or less).

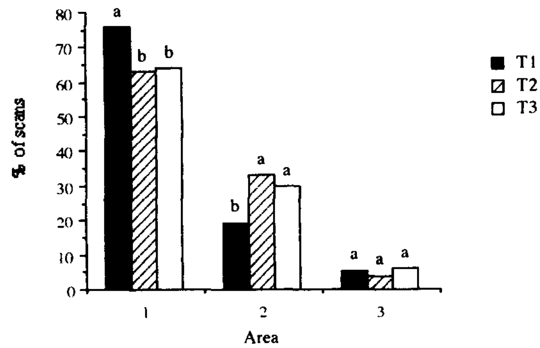

Fig. 7. Experiment 3: treatment effect on the proportion of scans birds spent in each area. Within-area means with no letter in common differ significantly ($P < 0.05$ or less).

Table 1
Experiment 3: distribution of birds at the feeders

Treatment	2			3		
Feeding occasions (%)	26.0			18.3		
Feeder	A	B	C	A	B	C
Distribution of feeding events	61.5	14.9	23.5	99.1	0.9	0
Feeding events as percentage of all scans	16.0	3.9	6.1	18.2	0.2	0

proportion of scans in T2 (26.0%) than in T3 (18.3%). Birds were observed at Feeder A in approximately equal proportions in both treatments (T2, 16.0%; T3, 18.2%). In both treatments, birds used Feeder A (the feeder nearest the box) more often than the other two feeders. In T3, birds were seen using Feeder B in less than 1% of the scans, and were never seen at Feeder C (the feeder furthest from the box). Thus, in both T2 and T3, birds were observed more frequently at the feeder which was closest to the box. This was especially so when the other feeders were further away from the box (T3).

4. Discussion

In Experiment 1, birds emerged earlier when there was a single feeder outside (T2) than in either T1 (single feeder inside the box) or T3 (feeders in both positions). Therefore, birds were no more willing to leave the familiar environment (the covered box) which contained a familiar object (the feeder) when there was another feeder in the otherwise unfamiliar open paddock. The open paddock had the same degree of familiarity (one feeder outside) in both T2 and T3, but in T2 the birds may have been more willing to forego the familiar environment of the box as there was no feeder in the box to encourage them to remain there. Thus, a familiar feeder in an otherwise unfamiliar (and exposed) area increased birds' willingness to move out of the box and into the area, though only when a similar feeder was not present in the box. As previous studies have reported, the presence of a familiar stimulus in a novel area reduces an animal's fear of the area (Rubel, 1970; Zajonc et al., 1974; Jones, 1977b). In this study, some emerging birds went to the outside feeder and fed, despite the fact that the birds had not been food-deprived beforehand. This introduced some degree of uncertainty as to whether the birds saw the outside feeder primarily as a source of food, or as a familiar stimulus, or both. In a similar study, Newberry (1992) found that broilers were more highly motivated to move into a novel area when the area contained resources (food, water, heat), even though these resources were available in the birds' home area.

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

The lack of a significant rank effect on emergence times contrasts with Katzir's (1982) result that lower-ranking jackdaws emerged first, but is in line with with other studies on domestic fowl, which indicate that "leadership" is not linked with rank (Fischel, 1927; Allee, 1942). Banks and Allee (1957) found no consistent pattern in which flock members entered a pen, and concluded that the highest-ranking bird did not provide leadership for the rest of the group. Thus, a bird's willingness to emerge was influenced by feeder position, but not (significantly) by its social rank within a group. The hypothesis that low-ranking individuals should emerge from the box significantly earlier than middle- or high-ranking birds was therefore rejected. Dawkins (1985) suggested that birds of different ranks may have alternative behavioural strategies, all of which are equally successful. By following such strategies, low-ranking hens might fare as well as those of higher rank; for instance, subordinate hens might remain near their dominants as familiar dominants might protect them against other dominants, or because dominant birds might be more successful foragers (Nicol and Pope, 1994). Therefore, low-ranking hens might not find the presence of higher-ranking birds as aversive as originally thought. Dominant hens might in turn regard subordinates as a resource which they can use to help them find food, and will therefore tolerate their presence.

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

In Experiment 3, which determined whether dispersing feeders throughout the paddock caused birds to disperse further, having feeders in the outside paddock (T2 and T3) encouraged birds to leave the box earlier, to spend less time inside the box, and to spend more time within 2 m of the box (though not more time more than 2 m from the box). Compared with T2, birds did not show greater dispersal (in terms of spending more time in the area furthest from the box) in T3. Placing feeders further from the box (T3), therefore, did not encourage birds to spend more time in the area furthest from the box. This result contrasts with that of Gvaryahu et al. (1987), who reported an even distribution of broiler chicks in a novel area which contained familiar objects. Although birds used the feeder nearest the box more often in both T2 and T3, in T3 it was used to the almost total exclusion of the other two feeders. Högstad (1988) found that willow tits, when given a choice of feeding sites at increasing distances from cover, preferred feeding close to cover. Most (95%) of their visits were to the feeder within 3 m of cover, while the feeders sited 10 m and 20 m from cover were never visited. In the present study, hens displayed a clear preference for feeding at the feeder nearest the covered box. This was probably because the box provided the only cover in an otherwise open paddock, and birds may have felt wary about venturing further from the box than was necessary.

5. Conclusions

The results from these three experiments indicate that the presence of familiar objects in an otherwise unfamiliar (and open) environment can have limited effects on increasing birds' use of the novel area. The presence of functional stimuli (such as feeders) reduced birds' emergence latencies even though birds had free access to food in their home pens prior to testing, though birds tended not to disperse further than the point of the nearest feeder. Finally, no relationship was found between "leadership" (in terms of the order of emergence into the paddock) and social rank.

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References

Allee, W.C., 1942. Group organization among vertebrates. Science, 95: 289–293.

Banks, E.M. and Allee, W.C., 1957. Some relations among flock size and agonistic behaviour in domestic hens. Physiol. Zool., 30: 255–268.

Cunningham, D.L., van Tienhoven, A. and Gvaryahu, G., 1988. Population size, cage area and dominance rank effects on productivity and well-being of laying hens. Poult. Sci., 67: 399–406.

Dawkins, M., 1976. Towards an objective method of assessing welfare in domestic fowl. Appl. Anim. Ethol., 2: 245–254.

Dawkins, M.S., 1983. Cage size and flooring preferences in litter-reared and cage-reared hens. Br. Poult. Sci., 24: 177–182.

Dawkins, M.S., 1985. Social space: the need for a new look at animal communication. In: R. Zayan (Editor), Social Spacing For Domestic Animals. Martinus Nijhoff, Dordretch, pp. 15–22.

Eskeland, B., 1977. Behaviour as an indicator of welfare of hens under different systems of management, population density, social status and by beak trimming. Meld. Nor. Landbrukshoegsk., 56: 1–20.

Fehrer, E., 1956. The effects of hunger and familiarity of locale on exploration. J. Comp. Physiol. Psychol., 49: 549–552.

Fischel, W., 1927. Beitrage zum Sociologie des Haushuhns. Biol. Zentralbl., 47: 678–695.

Gvaryahu, G., Snapir, N. and Robinzon, B., 1987. Research note: application of the filial imprinting phenomenon to broiler chicks at a commercial farm. Poult. Sci., 66: 1564–1566.

Gvaryahu, G., Cunningham, D.L. and van Tienhoven, A., 1989. Filial imprinting, environmental enrichment, and music application effects on behaviour and performance of meat strain chickens. Poult. Sci., 68: 211–217.

Högstad, O., 1988. Social rank and antipredator behaviour of Willow Tits *Parus montanus* in winter flocks. Ibis, 130: 45–56.

Jones, R.B., 1977a. Open-field responses of domestic chicks in the presence or absence of familiar cues. Behav. Proc., 2: 315–323.

Jones, R.B., 1977b. Repeated exposure of the domestic chick to a novel environment: effects on behavioural responses. Behav. Proc., 2: 163–173.

Jones, R.B., 1979. The hole-in-the-wall test: its validity as a measure of the "timidity" aspect of fear in the domestic chick. IRCS Med. Sci., 7: 167.

Katzir, G., 1982. Relationships between social structure and response to novelty in captive jackdaws, *Corvus monedula* L., I. Response to novel space. Behaviour, 81: 231–263.

Keeling, L.J., Hughes, B.O. and Dun, P., 1988. Performance of free-range laying hens in a polythene house and their behaviour on range. Farm Build. Prog., 94: 21–28.

Leyhausen, P. and Heinemann, I., 1975. "Leadership" in a small herd of dairy cows. Appl. Anim. Ethol., 1: 206.

Mankovich, N.J. and Banks, E.M., 1982. An analysis of social orientation and the use of space in a flock of domestic fowl. Appl. Anim. Ethol., 9: 177–194.

Meese, G.B. and Ewbank, R., 1973. Exploratory behaviour and leadership in the domesticated pig. Br. Vet. J., 129: 251–259.

Murphy, L.B. and Wood-Gush, D.G.M., 1978. The interpretation of the behaviour of the domestic fowl in strange environments. Biol. Behav., 3: 39–61.

Newberry, R.C., 1992. Motivational factors influencing use of space by chickens. J. Anim. Sci., 70 (Suppl. 1): 174.

Nicol, C.J., 1986. Non-exclusive spatial preference in the laying hen. Appl. Anim. Behav. Sci., 15: 337–350.

Nicol, C.J. and Pope, S.J., 1994. Social learning in small flocks of laying hens. Anim. Behav., 47: 1289–1296.

Rovee, C.K., Agnello, A.M. and Smith, B., 1973. Environmental influences on tonic immobility in three- and seven-day-old chicks (*Gallus gallus*). Psychol. Rec., 23: 539–546.

Rubel, E.W., 1970. Effects of early experience on fear behaviour of *Coturnix coturnix*. Anim. Behav., 18: 427–433.

Squires, V.R. and Daws, G.T., 1975. Leadership and dominance relationships in Merino and Border Leicester sheep. Appl. Anim. Ethol., 1: 263–274.

Zajonc, R.B., Markus, H. and Wilson, W.R., 1974. Exposure, object preference, and distress in the domestic chick. J. Comp. Physiol. Psychol., 86: 581–585.