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Effects of social rank and familiarity on dustbathing in domestic fowl

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Abstract

*The objective of this study was to investigate the effects of social rank (Experiment 1) and familiarity (Experiment 2) on dustbathing in domestic hens (*Gallus gallus domesticus*). We conducted choice tests between two conditions using actual birds as the stimuli and evaluated the effects in terms of quality and quantity of dustbathing performed. Twenty-four, medium-ranked hens were selected as test subjects. The stimuli presented were combinations of a high-ranked hen, a low-ranked hen, or no hen at all for Experiment 1, and a combination of a familiar hen, an unfamiliar hen, or no hen for Experiment 2. The number and duration of dustbaths, wing tosses as well as other behaviours were measured. For Experiment 1, the test hen performed dustbathing more frequently on the side of the hen, regardless of its social rank, when presented with a choice of a high- or low-ranked hen, or no hen. For Experiment 2, the test hen performed dustbathing more frequently on the side of the familiar hen when presented with a familiar hen or no hen, and more frequently on the side of no hen when presented with an unfamiliar hen and no hen. It was concluded that dustbathing was not affected by social rank, and that the quality and quantity of dustbathing was greater on the side of the familiar hen. However, dustbathing was restricted by the presence of an unfamiliar hen.*

Keywords: *animal welfare, dominance, dustbath, familiarity, laying hen, social rank*

Introduction

Domestic hens (*Gallus gallus domesticus*) are social animals. Conspecifics are recognised if the flock is small enough, and their behaviour is affected by a variety of social factors. The chicken was the first species in which hierarchy was systematically demonstrated (Guhl 1953). This hierarchy is generally linear, and dominant individuals have priority over the use of resources, such as resting places. In stable groups where rank is established, aggressive interactions are rarely observed and each individual lives with the others according to their rank (Appleby *et al* 2002).

Dustbathing is a behaviour in which hens dust sand onto their body by tossing their wings and legs and it is behaviour unique to birds (Van Liere 1992). It serves to remove parasites and excess oiliness, which leads to an increased survival rate (Van Liere & Bokma 1987). A study by Vestergaard (1982) reported that domestic fowl gathered to dustbathe together in a large pen supplied with litter. Since this study was published, a number of studies have been conducted to determine whether dustbathing is synchronised by social facilitation (Olsson *et al* 2002; Lundberg & Keeling 2003). Conversely, it was reported that only dominant hens use dustbaths in furnished cages with a limited dustbath area (Shimmura *et al* 2008a). Lundberg and Keeling (2003) hypothesised that the dustbathing of low-ranking hens is restricted by that of high-ranking hens, and investigated the effect of hierarchy on the social facilitation of dustbathing. They reported that dustbathing was not increased by presentation of video images of hens dustbathing regardless of social order, although dustbathing of high-ranked hens was restrained by presentation of a medium-ranked hen showing dustbathing behaviour. However, these results were not consistent and suggested a problem in that this may have been caused by hens not recognising the video image of a hen. While a video can present a uniform stimulus, it has the disadvantage of being unable to present the exact stimulus as an actual bird (D'Eath & Dawkins 1996). Therefore, the effect of social rank on dustbathing has remained unclear, although the presence of an individual with a different social rank clearly has an influence (Olsson *et al* 2002; Lundberg & Keeling 2003; Shimmura *et al* 2008a).

In the European Union, conventional cages for laying hens will be banned by 2012, where furnished cages and non-cage systems with a litter area have been developed. Therefore, demonstration of the effects of social rank on dustbathing is important for the improvement of the dustbathing area in furnished cages, as there has been shown to be competition for the limited dustbathing area in these cages (Shimmura *et al* 2006a,b).

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Hens in a flock with small group size avoid unnecessary aggression, resulting in a stable group, but they fear unfamiliar hens and will even eject them from their own flock (D'Eath & Dawkins 1996). On the other hand, the situation is different in large groups. The red jungle fowl (*Gallus gallus*), an ancestor of the domestic hen, creates subgroups and inhabit the same territory (Collias *et al* 1966; Collias & Collias 1996). However, there has been no evidence for the formation of subgroups or the existence of territories in non-cage systems for domestic hens (Preston & Murphy 1989; Widowski & Duncan 1995; D'Eath & Keeling 2003; Rodenburg & Koene 2007). In contrast to this, aggressive interactions in housing systems with large groups are as low as in cages with sufficient small groups, possibly because hens are no longer able to recognise all group members (Lindberg & Nicol 1996; Hughes *et al* 1997; Bilčík & Keeling 2000). Therefore, the assessment of social status differs between small and large groups of laying hens, which is shown in mixing groups or individuals. Unfamiliar hens are avoided or attacked when two small groups are mixed (eg Hughes 1977), while aggressive interactions remain low when two large groups are mixed (Hughes *et al* 1997). Also, behaviour in the small group being affected by the presence of unfamiliar hens has been reported in various situations as well as mixing group (eg D'Eath & Dawkins 1996). However, the effect of familiarity on dustbathing is yet to be studied.

The objective of this study was to investigate the effects of social rank (Experiment 1) and familiarity (Experiment 2) on dustbathing in the domestic fowl. We conducted choice tests between two conditions using actual birds as stimuli and evaluated the quality and quantity of dustbathing performed.

Materials and methods

Animals and housing

In total, 120 White Leghorn layers (Julia; Farm Kurihara, Japan) were used. The hens were housed in furnished cages for a series of unrelated studies and had been beak-trimmed at one day of age, a routine practice for hens placed in this type of housing system. The chicks were reared in cages. At the age of 17 weeks, the birds were randomly allocated to medium furnished cages (10 hens per cage) with separated resources on both sides (Shimmura *et al* 2008b). Each home cage was a laying cage 180 × 46.5 × 50 cm (length × breadth × height) at the front and 180 × 46.5 × 47 cm at the rear. At both sides of the cage there were nest boxes (25 × 46.5 × 21 cm). The tops of the nest boxes had dustbaths 4.5 cm deep. All wood shavings in the dustbaths were removed and replaced with fresh shavings each morning. One wooden perch (4 cm deep and 3 cm high with a rounded top edge) was fitted across the width of the cage. The design and the equipment of the furnished cages satisfied EU regulations (Blokhuis 2004) and the experiments took place when hens were 74 to 85 days of age.

The henhouse was ventilated with six fans. The average temperature in the house during the day was 24.9°C during the observation period. Lighting was provided by two fluorescent lights (37 W) installed on the ceiling of the henhouse to give an intensity of 10 lux at the feed troughs. The illumination cycle was 14 h of light and 10 h of darkness, with the light period lasting from 0500 to 1900h. The hens had *ad libitum* access to water and commercial feed. The feed contained more than 16% crude protein and 2,900 kcal metabolic energy per kg (Nosan, Yokohama, Japan). Feeding and all other routine tasks (such as supplying wood shavings) were carried out from 0800 to 0900h and 1600 to 1700h.

Test protocol

The test cage was the same size and design as the home cage (Figure 1). The test cage was divided into right and left sides, and when the hen stepped over the central line, the side that the hen moved to was recorded as being the area used. Since the experiments were conducted in the same henhouse and changes in social rank were not desirable, a period of habituation to the test cage was not provided. Stimulus cages (25 × 46.5 × 4.5 cm) were placed on both sides to introduce the stimulus hens (Figure 1). Since hens recognise objects within 30 cm (Dawkins 1995), the distance between the dustbath and the stimulus hen was kept relatively short (maximum 25 cm). A wire mesh (2.5 × 2.5 cm) was placed between the test cage and the stimulus cage so that one hen could not peck the other hen directly.

The period of deprivation of wood shavings prior to tests being carried out was set at 6 days, according to the results of a pre-experiment. In order to preserve the hierarchy in each cage, dustbathing was prevented by placing lids on the dustbath in the furnished cages. The litter material in the tests was wood shavings, and the observation time during testing was 90 minutes.

Experiment 1 — Effect of social rank

The objective of Experiment 1 was to investigate the effect of social rank on the dustbathing of laying hens. Firstly, the social rank of each hen was determined in order to select the stimulus hens in Experiment 1 and the test hens in Experiments 1 and 2. For focal sampling, all 120 birds were individually marked using a combination of coloured leg-rings. Observations of aggressive interactions were conducted when the birds were between 65 and 68 weeks of age. Aggression in all cages was counted in periods of 20 min per cage. These observations were conducted through choosing the cages randomly for a total of 4 h per day; 2 h each in the morning (1000 to 1200h) and afternoon (1300 to 1500h), for a total of 10 days. The total observation time was therefore 200 min per cage (20 min per day × 10 days). The order of the observed cages was distributed randomly. The aggressive behaviours recorded were aggressive pecking, displacing, and chasing and threatening, with both winner and loser noted (Shimmura *et al* 2008a,b). From the data showing aggressive interactions observed, the dominance index of each individual hen was calculated by using the Index of Clutton-Brock

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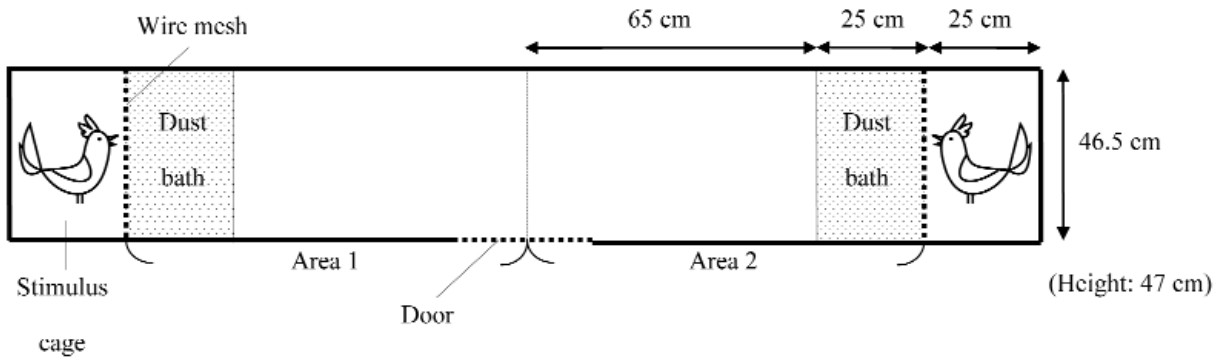
Figure 1



Schematic diagram of the test cage.

(ICB; Clutton-Brock *et al* 1979, 1986; Shimmura *et al* 2008a,b). This index takes the success of opponents into account, so that an individual's score is determined by the scores of the individuals it dominated and of those dominating it. The formula is especially effective in the case of a linear and fixed hierarchy, such as that seen in domestic hens (Boyd & Silk 1983). The linearity in each cage was also calculated using Landau's index of linearity (Lehner 1996). Normalised index values (h) range from 0 (non-linear) to 1 (perfectly linear), and $h \geq 0.9$ would be a reasonable (although arbitrary) cut-off criterion for 'strong', virtually linear hierarchies.

The mean (± SD) index value of linearity (h) was 0.9 (± 0.1), confirming that the hierarchies in each cage were almost linear. The dominance value of each hen was calculated by using the ICB, by which the rank of each hen in each cage was identified. Rank 1 was the highest-ranked hen, rank 5 or 6 was the middle-ranked hen, and rank 10 was the lowest-ranked hen. The highest and lowest ranked hens in each cage were used as the stimulus hens, and the two middle-ranked hens were used as the test hens (total 24 hens). The mean (± SD) dominance values of the high- , middle- and low-ranked hens were 15.9 (± 10.1), 1.0 (± 0.5) and 0.1 (± 0.0), respectively. A significant difference was found between ranks (Friedman's test with replication; $P < 0.001$), and dominance values were higher in high-ranked hens compared to middle-ranked hens and these, in turn, were higher than low-ranked hens (Steel-Dwass' multiple comparison test; all $P < 0.01$).

The stimuli were presented as follows: Experiment 1–1, a high-ranked hen vs a low-ranked hen; Experiment 1–2, a high-ranked hen vs an empty cage and Experiment 1–3, a low-ranked hen vs an empty cage. To control for the effect of experimental order, the six tests (Experiments 1–1, 1–2, 1–3, 2–1, 2–2 and 2–3) were conducted by using the Latin square method (Martin & Bateson 1993; Lehner 1996). To offset the effect of side, the test stimuli presented on both sides were also allocated by changing right and left side randomly.

Experiment 2 — Effect of familiarity

The objective of Experiment 2 was to investigate the effect of familiarity on dustbathing in laying hens. The tests were as follows: Experiment 2–1, familiar hen vs unfamiliar hen; Experiment 2–2, familiar hen vs an empty cage and Experiment 2–3, unfamiliar hen vs an empty cage. The test hens were the same middle-ranked hens as those used in Experiment 1. Hens living in the same cage were defined as familiar hens. Thus, when one of two medium-ranked hens in the same cage was used as the test hen, the other hen was the stimulus hen. Hens in another cage were defined as unfamiliar hens. To offset the effect of social rank, a hen from another cage with a middle rank to that of the test hen was used as the unfamiliar hen. This unfamiliar individual was allocated randomly from any cage except the adjacent one because there was no partition between cages, which resulted in the hens in two cages side-by-side being familiar with each other. Also, different hens were used as the unfamiliar hen in Experiment 2–2 and 2–3 because hens become familiar with each other within a few hours (Bradshaw 1992).

The frequency of dustbathing reaches a peak at six hours after lights are turned on (Hogan & Van Boxel 1993); the frequency of dustbathing is lower before 1100h because the first hours after lights go on are used for laying eggs (Vestergaard 1982). Therefore, the experiments started at 1200h. Firstly, the stimulus hen, which had been kept without litter for six days, was introduced into the stimulus cage. After the stimulus hen calmed down (average five minutes), a test hen was introduced into the test cage. The test hen was put in front of the open central door, which was then closed after the hen voluntarily entered without being pushed by the experimenter, and then the experiment began.

Observations were recorded by video camera (CCD-TRV116, Sony, Japan) with a wide-conversion lens (VCL-0637S, Sony, Japan). Observations using all-occurrences recording were conducted to record the number and duration of dustbathing events and the number of wing tosses during dustbathing of the test hen on each side of the

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cage. Point sampling at one-minute intervals was also used to record the location and behaviour on each side. Dustbathing was recorded when one of three actions (vertical wing-shaking, head-rubbing or scratching with one leg) was observed (Van Liere 1992). The start of dustbathing was defined as the time the hen's breast was placed on the floor of the dustbath before any of these three actions were observed. The end was defined as the point when the hen left the litter area after dustbathing or when the bird remained in the dustbath area without performing any of the three actions for three minutes. When the hen started dustbathing after lying or resting in the dustbath, the time at which one of the three actions was observed was determined as being the start. The following activities were recorded: resting, dustbathing, litter-pecking, litter-scratching, object pecking, fighting, escaping, sham dustbathing, and moving (Appleby *et al* 2004). Since litter-scratching was performed with litter-pecking and the total duration was short, both were classified as litter exploring. The litter-pecking during dustbathing was treated as dustbathing. When the test hen stepped over the central line, that side was recorded as the area used.

Statistical analysis

For dustbathing, the total duration and the total number of dustbaths, and the total number of wing tosses on each side were calculated for each test hen. Similarly, from the point-sampling data, the proportion of time each hen spent on each side performing each behaviour was calculated. Data were analysed using the statistical software Statcel (Yanagii 2007). Since the normal distribution and homogeneity of variance were not found, even after several transformations (eg, square-root, arcsine square-root, log), a non-parametric test was used for analysis (Martin & Bateson 1993; Quinn & Keough 2002). Since the two data sets on each side of the central line from a test hen were paired, Wilcoxon signed-ranks test was used.

Results

Experiment 1 — Effect of social rank

Of the 24 test hens, the number that performed dustbathing during the test was 17 in Experiment 1–1, 18 in Experiment 1–2 and 18 in Experiment 1–3.

The total duration of dustbathing and the number of dustbaths, the total number of wing tosses and the proportion of time spent on each side and litter-exploring by the hens in Experiment 1 are shown in Table 1. For Experiment 1–1, no significant differences between the high- and low-ranked hens were found in all measurements of dustbathing: the total duration of dustbathing and the number of dustbaths, the total number of wing tosses, and the proportion of time spent on each side and litter-exploring. For Experiment 1–2, the total duration of dustbathing ($T = 39$, n = 18, $P < 0.05$), the proportion of time spent on each side ($T = 25$, n = 18, $P < 0.01$) and litter-exploring ($T = 13$, n = 18, $P < 0.05$) were higher on the side of the high-ranked hen than on the side of the empty cage. The total number of dustbaths ($T = 28.5$, n = 18, $P = 0.074$) and wing tosses ($T = 42.5$, n = 18, $P = 0.108$) also tended to be higher on the side of the high-ranked hen than on the side of the empty cage. For Experiment 1–3, the total number of dustbaths ($T = 49$, n = 18, $P < 0.05$) and wing tosses ($T = 21$, n = 18, $P < 0.05$) and the proportion of time spent on each side ($T = 38.5$, n = 18, $P < 0.05$) were higher on the side of the low-ranked hen than on the empty side. The total duration of dustbathing ($T = 49$, n = 18, $P = 0.112$) and the proportion of time spent on litter exploring ($T = 37.5$, n = 18, $P = 0.065$) also tended to be higher on the side of the low-ranked hen than on the empty side. No significant differences were found for the other measurements.

Experiment 2 — Effect of familiarity

Of the 24 test hens, the number that performed dustbathing in the test was 18 in Experiment 2–1, 18 in Experiment 2–2 and 19 in Experiment 2–3.

The total duration and the number of dustbaths, the total number of wing tosses and the proportion of time spent on each side and litter-exploring in Experiment 2 are shown in Table 2. For Experiment 2–1, the total duration of dustbathing ($T = 23$, n = 18, $P < 0.01$) and the number ($T = 18.5$, n = 18, $P < 0.05$) of dustbaths, the total number of wing tosses ($T = 11$, n = 18, $P < 0.01$), the proportion of time spent on each side ($T = 21$, n = 18, $P < 0.01$) and litter exploring ($T = 15$, n = 18, $P < 0.01$) were higher on the side of the familiar hen than on the side of the unfamiliar hen. For Experiment 2–2, the total number of dustbaths ($T = 21.5$, n = 18, $P < 0.05$), the proportion of time spent in each area ($T = 20$, n = 18, $P < 0.01$) and litter-exploring ($T = 22.5$, n = 18, $P < 0.05$) were higher on the side of the familiar hen than on the side of the empty cage. The total duration of dustbathing ($T = 49$, n = 18, $P = 0.112$), and the total number of wing tosses ($T = 36.5$, n = 18, $P = 0.059$) tended to be higher on the side of the familiar hen than on the empty side. For Experiment 2–3, the total duration of dustbaths ($T = 29$, n = 19, $P < 0.05$), the total number of wing tosses ($T = 33$, n = 19, $P < 0.05$), and the proportion of time spent on litter-exploring ($T = 33.5$, n = 19, $P < 0.05$) were higher on the side of the unfamiliar hen than on the empty side. The proportion of time spent on each area tended to be higher on the side of unfamiliar hen than on the empty side ($T = 55.5$, n = 19, $P = 0.112$). No significant difference between the total number of dustbathing episodes on the side of the unfamiliar hen and the empty side was found. No significant differences were found for the other measurements.

Discussion

Experiment 1 — Effect of social rank

The results of Experiment 1 indicate that dustbathing is not affected by the presence of a high-ranked hen. This result is in contrast to previous studies, which reported that laying hens tended to avoid the dominant hen when presented with high- and low-ranked hens during feeding (Syme *et al* 1982; D'Eath & Dawkins 1996). In this study, the partition

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Table 1 Mean (± SD) total duration of dustbathing, number of dustbathing bouts, total number of wing tosses and proportions of time spent on each side and litter exploring for high- and low-ranked hens in Experiment 1.

Measurement	Experiment 1–1		Experiment 1–2		Experiment 1–3	
	High-rank	Low-rank	High-rank	None	Low-rank	None
Total duration of dustbathing bout (s)	491.4 (± 458.4)	514.7 (± 568.9)	697.9 (± 497.2)*	357.0 (± 409.5)	771.2 (± 683.3)‡	379.2 (± 447.5)
Total number of dustbathing bouts	1.9 (± 1.9)	1.4 (± 1.7)	2.0 (± 1.2)†	1.1 (± 1.2)	2.1 (± 1.1)*	1.1 (± 1.2)
Total number of wing tosses	52.8 (± 44.3)	57.6 (± 62.8)	71.1 (± 54.7)‡	40.4 (± 49.7)	76.2 (± 58.8)*	30.4 (± 36.2)
Proportion of time spent on each side (%)	53.6 (± 27.3)	46.4 (± 27.3)	66.6 (± 23.2)**	33.4 (± 23.2)	62.7 (± 23.5)*	37.3 (± 23.5)
Proportion of time spent on litter exploring (%)	7.5 (± 6.6)	5.4 (± 3.3)	11.2 (± 9.4)*	6.2 (± 3.9)	9,7 (± 4.3)†	7.0 (± 4.5)

** $P < 0.01$; * $P < 0.05$; † $P = 0.07$; ‡ $P = 0.11$.

Table 2 Mean (± SD) total duration of dustbathing, number of dustbathing bouts, total number of wing tosses and proportions of time spent on each side and litter exploring for high- and low-ranked hens in Experiment 2.

Measurement	Experiment 2–1		Experiment 2–2		Experiment 2–3	
	Familiar	Unfamiliar	Familiar	None	Unfamiliar	None
Total duration of dustbathing bout (s)	693 (± 545.1)**	167.3 (± 313.5)	749.8 (± 647.0)‡	433.3 (± 477.2)	241.4 (± 407.7)	620.9 (± 462.6)*
Total number of dustbathing bouts	2.5 (± 1.5)*	0.8 (± 1.4)	1.9 (± 1.3)*	1.0 (± 1.1)	1.1 (± 1.5)	1.9 (± 1.4)
Total number of wing tosses	65.0 (± 54.3)**	11.8 (± 20.3)	82.3 (± 77.5)†	47.4 (± 57.0)	23.0 (± 39.0)	67.1 (± 49.1)*
Proportion of time spent on each side (%)	68.5 (± 23.0)**	31.5 (± 23.0)	69.0 (± 19.8)**	31.0 (± 19.8)	39.0 (± 30.1)	61.0 (± 30.1)‡
Proportion of time spent on litter exploring (%)	8.8 (± 5.9)*	4.6 (± 5.0)	11.4 (± 9.6)*	6.3 (± 5.7)	5.1 (± 4.9)	9.6 (± 6.8)*

** $P < 0.01$; * $P < 0.05$; † $P = 0.07$; ‡ $P = 0.11$.

between the test cage and the stimulus cages was large enough to allow the test hen to recognise the stimulus hen, but the hens could not peck each other. This suggests that only actual aggressive pecking of the domestic hen may have an effect on the behaviour of the test hens. Van Rooijen (1999) observed that when low-ranked hens lay on the litter area, they received aggressive pecking from the other hens, resulting in the subordinate hens leaving without dustbathing. Our previous studies also indicated that aggressive interactions frequently occurred in the dustbath due to competition for the resource and resulted in the dominant hens having priority use of the litter area and subordinate hens not being able to use the resource due to being pecked by the high-ranked hens (Shimmura *et al* 2007a,b,c, 2008a,b,c). Therefore, the presence of a high-ranking hen showing no effect on dustbathing might be due to prevention of directly aggressive pecking from the dominant hen towards the test hen, indicating that the presence of the dominant hen alone does not affect dustbathing. This may be because the dominant hens are simply cage mates, even for subordinate hens in those situations where the subordinates are not pecked. In fact, low-ranked hens continued to dustbathe as long as they were not disturbed by other hens (Van Rooijen 1999). It was also demonstrated that fear of a dominant bird was less than fear of an unfamiliar bird, which may be related to decreased aggression in the familiar group due to the existence of the hierarchy (D'Eath & Dawkins 1996). Taken together, the dominant birds might not be a threat to subordinate birds and, instead, simply creatures that should be given priority.

The perception that a dominant bird is a cage mate was confirmed in Experiment 1–2 (high-ranked hen vs none) and 1–3 (low-ranked hen vs none), in which the performance of dustbathing was dependent on the hen's presence regardless of social rank, similar to the result of Experiment 2–2 (familiar hen vs none). Thus, the presence of a cage mate, a familiar bird, affected the occurrence of dustbathing and social rank did not play a role.

Experiment 2 — Effect of familiarity

The results of Experiment 2 indicated that dustbathing was performed more frequently in the presence of a familiar hen, confirming the results of Experiment 1. A variety of studies have demonstrated that hens prefer being near familiar birds and cage mates (Hughes 1977; Dawkins 1982; Bradshaw 1992; Jones *et al* 1996; Hauser & Huber-Eicher 2004). This is because domestic fowl and their ancestor, the red jungle fowl, are social birds living in groups (Collias *et al* 1966; Collias & Collias 1996). It was also reported that the fear response was lower when the hen was in a group rather than

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alone in free range (Pulliam 1973; Roberts 1995). This is because the risk of being preyed upon is decreased when living in a group. Therefore, it seems clear that the test hen stayed closer to the familiar hen for safety when left alone in a test cage. Next, comparing Experiment 2–1 (familiar hen vs unfamiliar hen) and Experiment 2–2 (familiar hen vs none), dustbathing was performed relatively more frequently on the side of the empty cage in Experiment 2–2 compared with the unfamiliar hen in Experiment 2–1, although the use of the side of the empty cage in Experiment 2–2 and the unfamiliar hen in Experiment 2–1 was similarly low. This might suggest that the hen does not prefer to perform the dustbathing on the side of the empty cage in the performance of dustbathing, although she prefers to be on the side of a familiar hen in area usage. Thus, a hen prefers to be near the familiar hen regardless of the behaviour she would wish to perform, which might result in greater dustbathing on the side of familiar hen.

All hens used in Experiments 2–2 and 2–3 were of middle rank and, in this sense, these experiments only studied middle-ranked hens. Regarding this point, further verification in the case of high or low rank would be needed. However, the results in Experiments 2–2 and 2–3 were clear, which indicated that the performance of dustbathing was restricted by the presence of the unfamiliar hen. The exchange of members between groups of red jungle fowl, an ancestor of the domestic fowl, is very rare compared with other birds, and they live together and stay within the same territory throughout the year, except for the mating period (Collias & Collias 1996). Also, hens in a group small enough to recognise each other avoid unnecessary aggression, resulting in a stable group (D'Eath & Dawkins 1996). Therefore, hens in such small groups might be exclusive and have a strong suspicion of hens outside their own group. This is because the risk of aggression is higher due to the lack of knowledge about social rank within the other group (D'Eath & Dawkins 1996). Therefore, as a precaution, in the present study, hens might not perform dustbathing near an unfamiliar hen.

Conclusion and animal welfare implications

The presence of a high-ranking hen did not affect dustbathing. This would appear to be due to the fact that the high-ranking hens were cage mates and they were not able to peck the test hens when they were dustbathing. Thus, a dominant bird might not be a threat to the subordinate bird, but her presence may ensure priority for the use of a resource, such as the dustbath. Also, it was demonstrated that dustbathing was performed more frequently on the side of a familiar hen as hens prefer to be near other hens. On the other hand, however, dustbathing was restricted by the presence of an unfamiliar hen. This basic knowledge about the effect of social rank and familiarity on dustbathing will be helpful information for the rational development of dustbaths, especially in furnished cages for laying hens. In these, large dustbaths that are large enough to be used by a number of hens at the same time may be required. However, considering that dominant hens have priority use of the litter area in situations in which actual pecking occurs, it may be more effective to separate the resource as in the test cage of this study.

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References

Appleby MC, Walker AW, Nicol CJ, Lindberg AC, Freire R, Hughes BO and Elson HA 2002 Development of furnished cages for laying hens. *British Poultry Science 43*: 489-500

Appleby MC, Mench JA and Hughes BO 2004 *Poultry Behaviour and Welfare*. CABI Publishing: Oxfordshire, UK

Bilčík B and Keeling LJ 2000 Relationship between feather pecking and ground pecking in laying hens and the effect of group size. *Applied Animal Behaviour Science 68*: 55-66

Blokhuis HJ 2004 Recent developments in European and international welfare regulations. *World's Poultry Science Journal 60*: 469-477

Boyd R and Silk JB 1983 A method for assigning cardinal dominance rank. *Animal Behaviour 31*: 45-58

Bradshaw RH 1992 Conspecific discrimination and social preference in the laying hen. *Applied Animal Behaviour Science 33*: 69-75

Clutton-Brock TH, Albon SD, Gibson RM and Guinness FE 1979 The logical stag: adaptive aspects of fighting in red deer (*Cervus elaphus L*). *Animal Behaviour 27*: 211-225

Clutton-Brock TH, Albon SD and Guinness FE 1986 Great expectations: dominance, breeding success and offspring sex ratios in red deer. *Animal Behaviour 34*: 460-471

Collias NE, Collias EC, Hunsaker D and Minning L 1966 Locality fixation, mobility and organization within an unconfined population of red jungle fowl. *Animal Behaviour 14*: 550-559

Collias NE and Collias EC 1996 Social organization of a red junglefowl, *Gallus gallus*, population related to evolution theory. *Animal Behaviour 51*: 1337-1354

Dawkins MS 1982 Elusive concept of preferred group size in domestic hens. *Applied Animal Ethology 8*: 365-375

Dawkins MS 1995 How do hens view other hens? The use of lateral and binocular visual fields in social recognition. *Behaviour 132*: 591-606

D'Eath RB and Dawkins MS 1996 Laying hens do not discriminate between video images of conspecifics. *Animal Behaviour 52*: 903-912

D'Eath RB and Keeling LJ 2003 Social discrimination and aggression by laying hens in large groups: from peck orders to social tolerance. *Applied Animal Behaviour Science 84*: 197-212

Guhl AM 1953 Social behaviour of the domestic fowl. *Kansas Agricultural Experiment Station Technical Bulletin 73*: 3-46

Hauser J and Huber-Eicher B 2004 Do domestic hens discriminate between familiar and unfamiliar conspecifics in the absence of visual cues? *Applied Animal Behaviour Science 85*: 65-76

Hogan JA and Van Boxel F 1993 Causal factors controlling dustbathing in Burmese Red Junglefowl: some results and a model. *Animal Behaviour 46*: 627-633

Hughes BO 1977 Selection of group size by individual laying hens. *British Poultry Science 18*: 9-18

Hughes BO, Carmichael NL, Walker AW and Grigor PN 1997 Low incidence of aggression in large flocks of laying hens. *Applied Animal Behaviour Science 54*: 215-234

Jones RB, Larkins C and Hughes BO 1996 Approach/avoidance responses of domestic chicks to familiar and unfamiliar video images of biologically neutral stimuli. *Applied Animal Behaviour Science 48*: 81-98

https://doi.org/10.1017/S0962728600001184 Published online by Cambridge University Press

Lehner PN 1996 *Handbook of Ethological Methods, 2nd Edition.* Cambridge University Press: Cambridge, UK

Lindberg AC and Nicol CJ 1996 Effects of social and environmental familiarity on group preferences and spacing behaviour in laying hens. *Applied Animal Behaviour Science 49*: 109-123

Lundberg AS and Keeling LJ 2003 Social effects on dustbathing behaviour in laying hens: using video images to investigate effect of rank. *Applied Animal Behaviour Science 81*: 43-57

Martin P and Bateson P 1993 *Measuring Behaviour: An Introductory Guide, 2nd Edition.* Cambridge University Press: Cambridge, UK

Olsson IC, Duncan IJH, Keeling LJ and Widowski TM 2002 How important is social facilitation for dustbathing motivation in laying hens? *Applied Animal Behaviour Science 79*: 285-297

Preston AP and Murphy LB 1989 Movement of broiler chickens reared in commercial conditions. *British Poultry Science 30*: 519-532

Pulliam HR 1973 On the advantages of flocking. *Journal of Theoretical Biology 38*: 419-422

Quinn GP and Keough MJ 2002 *Experimental Design and Data Analysis for Biologists.* Cambridge University Press: Cambridge, UK

Roberts G 1995 A real-time response of vigilance behaviour to changes in group size. *Animal Behaviour 50*: 1371-1374

Rodenburg TB and Koene P 2007 The impact of group size on damaging behaviours, aggression, fear and stress in farm animals. *Applied Animal Behaviour Science 103*: 205-214

Shimmura T, Eguchi Y, Uetake K and Tanaka T 2006a Behavioral change of laying hens after introduction to battery cages, furnished cages and an aviary. *Animal Science Journal 77*: 242-249

Shimmura T, Eguchi Y, Uetake K and Tanaka T 2006b Effects of light intensity and beak trimming on preventing aggression in laying hens. *Animal Science Journal 77*: 447-453

Shimmura T, Eguchi Y, Uetake K and Tanaka T 2007a Differences of behavior, use of resources and physical condition between dominant and subordinate hens in furnished cages. *Animal Science Journal 78*: 307-313

Shimmura T, Eguchi Y, Uetake K and Tanaka T 2007b Behavior, performance and physical condition of laying hens in conventional and small furnished cages. *Animal Science Journal 78*: 323-329

Shimmura T, Hirahara S, Eguchi Y, Uetake K and Tanaka T 2007c Behavior, physiology, performance and physical condition of layers in conventional and large furnished cages under hot environment. *Animal Science Journal 78*: 314-322

Shimmura T, Azuma T, Hirahara S, Eguchi Y, Uetake K and Tanaka T 2008a Relation between social order and use of resources in small and large furnished cages for laying hens. *British Poultry Science 49*: 516-524

Shimmura T, Eguchi Y, Uetake K and Tanaka T 2008b Effects of separation of resources on behaviour of high-, middle- and low-ranked hens in furnished cages. *Applied Animal Behaviour Science 113*: 74-86

Shimmura T, Azuma T, Eguchi Y, Uetake K and Tanaka T 2008c Effects of separation of resources on behaviour, physical condition and production of laying hens in furnished cages. *British Poultry Science 50*: 39-46

Syme GJ, Syme LA and Barnes DR 1982 Fowl sociometry: Social discrimination and the behaviour of domestic hens during food competition. *Applied Animal Ethology 11*: 163-175

Van Liere DW 1992 The significance of fowls' bathing in dust. *Animal Welfare 1*: 187-202

Van Liere DW and Bokma S 1987 Short-term feather maintenance as a function of dust-bathing in laying hens. *Applied Animal Behaviour Science 18*: 197-204

Van Rooijen J 1999 Dust-bathing by hens in group cages. *Proceedings of XXVI the International Ethological Conference.* 2-9 August 1999, Bangalore, India

Vestergaard K 1982 Dust-bathing in the domestic fowl — diurnal rhythm and dust deprivation. *Applied Animal Ethology 8*: 487-495

Widowski TM and Duncan IJH 1995 Do domestic fowl form groups when resources are unlimited? *Applied Animal Behaviour Science 44*: 280

Yanagii H 2007 *4 Steps Excel Statistics, Volume 7*. OMS Publishing: Tokorozawa, Japan

https://doi.org/10.1017/S0962728600001184 Published online by Cambridge University Press