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Ability of laying hens to negotiate horizontal perches at different heights, separated by different angles

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Abstract 1. This paper describes how birds move between horizontal perches at different heights with different angles separating them, using the time to complete the task and the number of birds failing to indicate ability.

2. For the first experiment, 4 groups of 15 birds (ISA Brown) were subjected to each of the experimental treatments (using three perches with angles of 0° (horizontal control), 30°, 45° or 60° between them). The birds were required to move upward between the perches for each treatment and then to move downward between the perches, as a second part of the experiment.

3. Birds moving up between the perches took significantly longer at 60° than at any other angle. No birds failed to complete the task.

4. For birds moving downward between the perches, the median time to complete the task increased significantly with angle. Furthermore, the number of birds failing to complete the task increased with angle.

5. A second experiment was conducted to test whether the vertical or horizontal component of distance affected birds' ability to negotiate perches separated by different angles.

6. For the second experiment 4 groups of 10 Lohmann Brown laying hens were subjected to each of the following treatments: two horizontal perches separated by 30° or 60° and either directly, horizontally or vertically separated by a set distance of 50 cm. Birds were required to move both up and down between perches.

7. Birds negotiated horizontally-separated perches more successfully at 30° than at 60°. However, when the vertical distance between the perches was 50 cm there was no significant difference in the ability of birds to move downward at 30° or 60°. For birds moving upward, 60° was easier to negotiate than 30°.

8. The vertical and horizontal separations, as well as the different angles affected the ability of birds to move between perches. There was a general decreasing trend in ability with increasing vertical separation between perches.

9. The findings are important in terms of arrangements of perches to improve bird welfare. To minimise the risk of injury, the angle between perches at different heights should be no more than 45 degrees, and the horizontal and vertical distances between these perches minimised, to allow the birds to be able to move downwards more easily.

INTRODUCTION

For years there has been concern in the UK over the welfare of laying hens kept in battery cages (Baxter, 1994). Factors associated with good welfare have been outlined in the Farm Animal Welfare Council's "Five Freedoms" (FAWC, 1991), which includes the freedom for the animals to perform normal patterns of behaviour. The main criticism of cages is that birds are unable to perform easily many normal behaviour patterns in a cage environment (Nicol, 1990; Wegner, 1990). In response to this criticism and pressure from welfare and consumer groups and the more influential high street retailers, the non-cage sector of the UK egg-production industry has grown. A feature of many of the alternative systems is the use of perches, which can be used to improve bird welfare (Baxter, 1991; Appleby and Hughes, 1991, Duncan *et al.*, 1992). One alternative to battery egg production is the perchery, of which several designs exist (Michie and Wilson, 1985; Baxter, 1991; 1994). All contain the same basic elements: perches, nest boxes, feeding and drinking systems, and a litter area to allow the birds to perform dust bathing behaviour. Percheries are commercially viable (Michie and Wilson, 1985; Elson, 1991), with costs of production about 14% more than comparable costs of battery cage production (National Farmers Union, 1995). The perches not only meet a behavioural need of the birds to perch (Appleby and Hughes, 1991; Appleby *et al.*, 1992), but also allow stocking densities above those for litter systems without perches, because birds can use the third dimension (Michie and Wilson, 1985; McLean *et al.*, 1986). However the ease with which birds are able to negotiate different perch arrangements has hardly been investigated. A major problem with percheries is bone breakage during the

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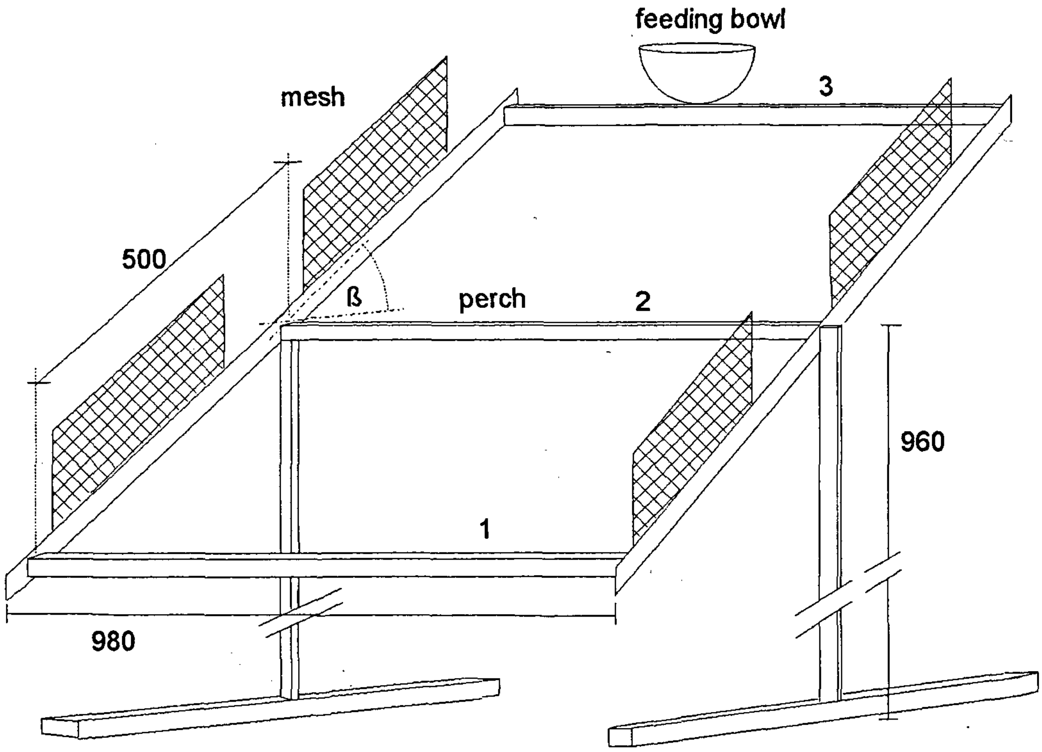

Figure 1. *Sloping perch arrangement showing dimensions (mm) and slope angle (β).*

production period (Gregory *et al.*, 1990), probably caused by birds falling off perches and crashing into the system. Such injuries may result if the system is poorly designed and the birds are not able to easily move from perch to perch. Scott and Parker (1994) showed that individual birds cannot easily move between horizontal perches more than 1 m apart, suggesting they may have a threshold of ability. Any system which supposedly improves welfare must not require birds to perform beyond this limit.

This paper investigates how birds move up and down between horizontal perches at different heights separated by different angles and whether there is some threshold of ability with these combinations.

MATERIALS AND METHODS

Experiment 1

Sixty ISA Brown birds were kept in pens containing litter, nest boxes and sufficient feeding and drinking space per bird, conforming to welfare codes. The birds had previous experience of perches and were able to perch without difficulty. The birds were allocated at random to 4 groups of 15 birds and leg-banded with one of 4 colours (silver, blue, green or gold), numbered so that individual birds could be recognised. The birds with silver and green bands were in one pen while those with gold and blue leg bands were in another pen. All birds were fed twice each day using the same feeders (metal bowls). Food was withdrawn for a short period prior to testing.

Each group of birds was subjected to each of the experimental treatments in a randomised block design. Three parallel, horizontal, wooden perches (98 × 4·5 × 7 cm) were set at different angles to give 4 treatments: 0° (horizontal), 30°, 45° and 60° (Figure 1). Birds were subjected to each of these treatments and were required to move between the perches, up, or down, or across in the horizontal treatment (0°). The perches were separated by 50 cm throughout the experiment, because Scott and Parker (1994) showed that laying birds can easily negotiate horizontal perches at this separation. At each slope, they were adjusted so that the perch tops were parallel to the floor. Chicken wire was fastened to the sides of the frame to prevent birds from walking along the frame to the next perch (Figure 1).

Individual birds were taken from their home pen placed on perch 1 (Figure 1) and were required to move to perch 3 to obtain a food reward. The feeder on perch 3 (Figure 1) was given a standard shake (Scott and Parker, 1994) to attract the bird's attention. On reaching perch 3 the bird was allowed to feed before being returned to the pen. The bird was placed on the perch most remote from the pens so that they always moved towards their conspecifics during the task. The

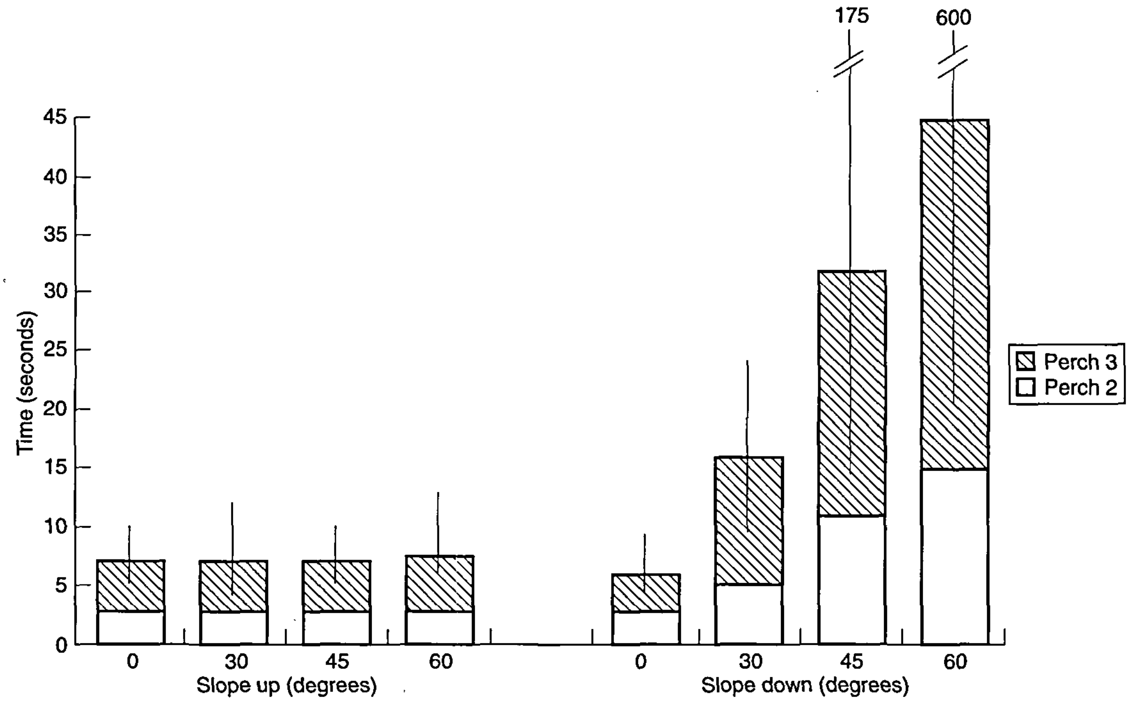

Figure 2. *Median time taken for birds to reach perches 2 and 3 at each treatment.*

time taken for the birds to reach perches 2 and 3, and, the number of birds jumping off the perches to the ground was recorded. If a bird jumped, but failed to land on the destination perch, it was replaced on the perch from which it jumped. If the bird failed a second time it was returned to the pen without a food reward. Birds which stayed on the perch apparatus for 10 mins, without reaching perch 3, were deemed to have failed and returned to the pen unrewarded.

The time taken to complete the task and the number of birds failing were used as indicators of the ease with which the birds could move across the three perches for each angle. Any birds that failed were arbitrarily given a score time of 600 s. The data were analysed by a Friedman non-parametric test (Campbell, 1967). Each treatment angle was ranked 1 to 4 (by time taken to complete the task) for each bird. Overall scores (for all birds) were obtained for comparisons between angles. Friedman non-parametric tests were used to compare treatments using time taken to reach perches 2 and 3, both for birds moving up and down between perches. The data were also analysed to determine whether birds found the tasks easier with successive exposure.

RESULTS

Experiment 1

The median times to reach perches 2 and 3 are shown in Figure 2. For birds going up, there was no significant difference in the time taken to reach perch 3 between horizontal perches or those at 30° and 45°. However, at 60° time taken was longer than for all other groups ($P < 0{\cdot}05$). The time to perch 2 did not differ significantly between treatments. No birds failed to complete the task within 10 min for any of the slopes (Table 1) and birds found it easier to negotiate the apparatus with repeated exposure ($P < 0{\cdot}001$).

For birds moving downwards, the median time to reach perch 2, as well as to complete the task, increased with angle ($P < 0{\cdot}001$) (Figure 2). Time taken did not reduce significantly with previous exposure.

The number of birds which failed increased with angle (Table 1). In particular, the number staying on the perches for 10 mins showed a large increase between 30° and 45° and the number jumping off the perches to the ground increased markedly between 45° and 60°. Of birds that jumped to the ground 53% stayed on the perches for the remainder of the 10 mins after being replaced on the perch from which they had jumped, 42% jumped to the ground a second time and only 5% went on to complete the task within 10 mins. On 30% of the occasions when birds were unsuccessful they moved to perch 2, but not then to perch 3. On the other 70% of occasions they did not move beyond perch 1. Birds occasionally jumped from perch 1 to perch 2 and then back to perch 1.

MATERIALS AND METHODS

Experiment 2

A second experiment investigated whether the horizontal or vertical separation between perches at different heights, with different angles, affected

Table 1. *Percentages of birds which successfully negotiated each treatment in experimental 1. Also shown are percentages of birds which stayed on the perches for 5 min and birds which jumped unsuccessfully*

Treatment	Birds successful (%)	Birds on perches for 5 min (%)	Birds jumping unsuccessfully (%)
Up			
0°	100	0	0
30°	100	0	0
45°	100	0	0
60°	100	0	0
Down			
0°	100	0	0
30°	90	5	5
45°	78	17	5
60°	60	18	22

birds' ability to move beteween perches. Four groups of 10 Lohmann Brown hens were kept in similar home pens to those used in the first experiment, with the blue and gold groups together in one pen and the green and silver groups in another. Food was withdrawn for the same period for each group, prior to testing. Each group was subjected to each treatment using a randomised block design. The treatments were (Figure 3):

A = 30° between perches diagonally separated by 50 cm

B = 60° between perches diagonally separated by 50 cm

C = 30° between perches horizontally separated by 50 cm

D = 60° between perches horizontally separated by 50 cm

E = 30° between perches vertically separated by 50 cm

F = 60° between perches vertically separated by 50 cm

Birds were required to move both up and down between perches at these settings (12 treatments). Each group was tested at the same time on each day of the experiment. The order of testing within group varied at random for each treatment and within-bird comparisons removed any possible diurnal effect. The apparatus was the same as in experiment 1 (Figure 1), except that only two perches were used. Birds were placed individually on perch 1 and were encouraged by shaking a familiar feeder containing food to move to perch 2. On reaching perch 2 each bird was allowed to feed before being returned to the pen. If a bird jumped from perch 1 and did not land on perch 2 it was replaced on perch 1. If the bird jumped a second time and did not land on perch 2 it was returned to the pen. Each bird was given 5 min to perform the task, after which it was returned to the pen. The time taken to perch 2 was recorded, as was the time of any unsuccessful jump (a 'miss'), or the incidence of jumping to the ground (an 'escape').

The following criteria were used to rank the birds on their ability to negotiate the perches:

—A completed trial was ranked higher than a non-completed trial.
—In completed trials, no unsuccessful jumps was ranked higher than one 'miss' which was ranked higher than one 'escape'.
—In non-completed trials, two 'misses' were ranked higher than one 'miss'. Any attempt was ranked higher than no attempt at all.
—No attempt was ranked above one 'escape' which was ranked higher than two 'escapes'.

Within these criteria, individuals were ranked according to time taken to complete the task, or, if relevant, time to the first unsuccessful jump. Each bird was thus assigned a score for each treatment. The results were analysed by Wilcoxon matched-pairs test (Campbell, 1967).

RESULTS

Experiment 2

Each treatment was ranked according to how suc-

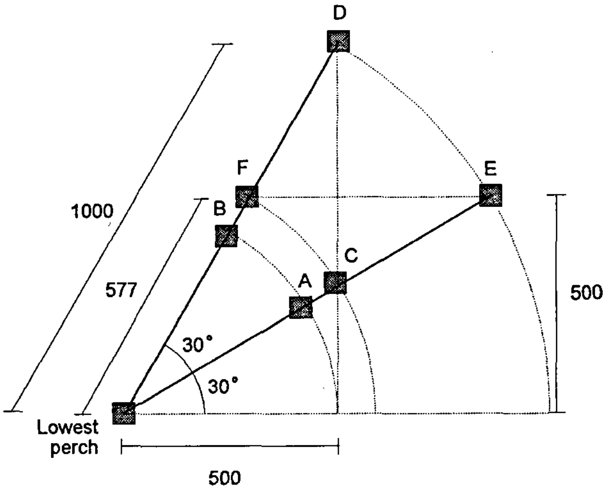

Figure 3. *Diagram of upper perch positions for each treatment in relation to the lowest perch.*

Table 2. *Ranks for each treatment in experiment 2. Direct diagonal, horizontal and vertical distances between perches are also shown for each treatment*

Treatment	Rank	Diagonal separation (cm)	Horizontal separation (cm)	Vertical separation (cm)
Up				
A (up to 30° diagonal)	1	50	43	25
C (up 30° horizontal)	2	58	50	29
B (up 60° diagonal)	3	50	25	43
F (up 60° vertical)	4	58	29	50
E (up 30° vertical)	5	100	87	50
D (up 60° horizontal)	8	100	50	87
Down				
C (down to 30° horizontal)	6	58	50	29
A (down 30° diagonal)	7	50	43	25
B (down 60° diagonal)	9	50	25	43
F (down 60° vertical)	10	100	87	50
E (down 30° vertical)	11	58	29	50
D (down 60° horizontal)	12	100	50	87

Key
Diagonal = perches diagonally separated by 50 cm.
Horizontal = perches horizontally separated by 50 cm.
Vertical = perches vertically separated by 50 cm.

cessfully birds negotiated the perches (Table 2). Figure 4a shows the rankings for movement upward and Figure 4b for movement downward. Birds were more successful at moving upward than at moving downward ($P < 0{\cdot}001$).

When comparing birds' abilities to move between perches with the same diagonal distance, but a different angle, the results agreed with experiment 1 in that angles of 30° were more successfully negotiated than 60°, both for birds moving up ($P < 0{\cdot}001$) and down ($P < 0{\cdot}001$). Perches with a horizontal separation of 50 cm were also more successfully negotiated, upward ($P < 0{\cdot}001$) and downward ($P < 0{\cdot}001$), at 30° than at 60°. However, where the vertical separation was 50 cm there was no significant difference in the ability of birds to move downward at 30° and at 60°. When birds were required to move upward between perches vertically separated by 50 cm they were more successful at 60° than 30° ($P < 0{\cdot}001$).

At 30° (vertically separated by 50 cm) or 60° (horizontally separated by 50 cm) the perches were 100 cm apart (Figure 3). Perches separated diagonally by 50 cm were easier to negotiate than those separated by 100 cm, both downwards at 30° ($P < 0{\cdot}001$) and 60° ($P = 0{\cdot}01$) and upwards at 30° ($P < 0{\cdot}001$) and 60° ($P < 0{\cdot}001$).

Percentages of successful birds (birds completing the task in less than 5 min without any unsuccessful jumps) and the percentage jumping unsuccessfully (with at least one 'miss' or 'escape') are shown in Table 3. Ranking treatments by the percentage of birds successfully negotiating the perches gave the same rank order as in Table 2. When birds jumped, but did not land on the destination perch, they were replaced on perch 1. On 71% of occasions they then stayed on perch 1 for the remainder of the 5 mins, on 26% of occasions a second unsuccessful jump was made and on only 3% of occasions the bird moved to perch 2.

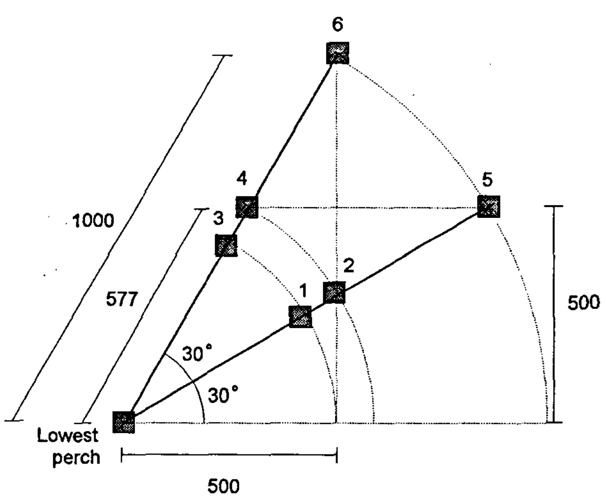

Figure 4a. *Rank of each upper perch position according to how successfully birds could move up from the lowest perch, from 1 (easiest) to 6 (most difficult).*

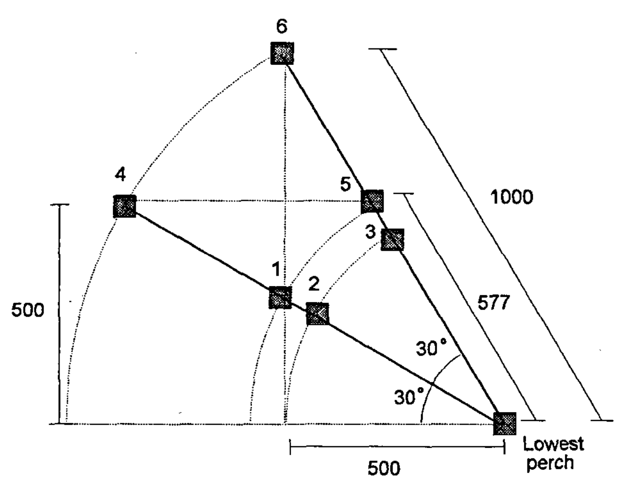

Figure 4b. *Rank of each upper perch position according to how successfully birds could move down to the lowest perch, from 1 (easiest) to 6 (most difficult).*

Table 3. *Percentages of birds which successfully negotiated each treatment in experiment 2. Also shown are percentages of birds which stayed on the perches for 5 min and birds which jumped unsuccessfully*

Treatment	Birds successful (%)	Birds on perches for 5 min (%)	Birds 'missing' (%)	Birds 'escaping' (%)	Birds jumping unsuccessfully (%)
Up					
A	93	8	0	0	0
B	88	10	0	2·5	2·5
C	88	13	0	0	0
D	60	38	2·5	0	2·5
E	78	18	0	5	5
F	85	13	0	2·5	2·5
Down					
A	68	28	0	5	5
B	33	48	10	10	20
C	70	25	0	5	5
D	5	65	10	20	30
E	28	50	10	13	23
F	28	63	2·5	8	10

DISCUSSION

The ability of birds to move between horizontal perches at different heights changed with the angle between perches. Although no birds failed to move upward, even at an angle of 60°, the time taken increased significantly at this angle. If time taken is an indication of difficulty, then angles of less than 60° were more easy to negotiate. Furthermore, the times taken to complete the task decreased with successive exposure, regardless of separation angle, suggesting some form of learning. It may be that birds learned that food was available at the destination perch (Figure 1), or that repeated exposure made the birds more familiar with the experimental technique. The birds may have been less frightened as the handling and experimental method ceased to be novel.

The number of birds failing when moving downward increased markedly with angle in experiment 1, reaching 40% of birds at 60°. Birds failing to move for the full 10 min could be described as passive avoiders. Birds which jumped off the perches to the ground may have been expressing escape behaviour (Wood-Gush and Guiton, 1967) and could be described as active avoiders. In experiment 1 no distinction was made between such active avoiders and birds which obviously aimed to reach the destination perch, but missed. However, birds which were unsuccessful for either reason could have been at risk from injury. At 60° 22% of birds jumped but did not land successfully, compared to 5% of birds at 30° and 5% at 45°. If risk of injury is directly related to failure to land safely, a 60° separation (with a 22% failure rate) would represent an unacceptable risk if it was incorporated into a perchery design.

For a particular angle, birds could more easily move upward between perches than they could go down, while time taken to go down was longer than time to go up (Figure 2). In experiment 1 the birds moved upwards to reach a food reward and later moved downwards. The birds may have learned that food was available at the uppermost perch and, if the position of the reward was important, birds may have associated reward with moving upward. This is unlikely, because in experiment 2 the position of the reward was randomised. The longer times to complete the task, and the higher number of birds which failed to negotiate the downward sloping perches, reflected the birds' unwillingness, or inability to perform the task.

If the perch arrangements in experiment 2 are ranked by median time on the uppermost perch and success rate, results indicate that ability to successfully negotiate perches was initially related to angle between perches. However, distance between perches may have been more important as the 'threshold of ability' was reached (Scott and Parker, 1994). For birds moving upward, the limit at a diagonal (direct) separation, was between 58 cm and 100 cm (equivalent to horizontal distances of 50 cm and 87 cm respectively). However, for birds moving downward there was no evidence of any such interaction. The results do not allow a permissible horizontal distance to be specified, which would minimise injury.

The vertical component appears to be important for birds jumping upward and downward (Table 2). This can be explained in terms of pure physics and energetics, disregarding bird physiology (Bolton, 1974; Halliday and Resnick, 1978). Assuming full conservation of energy and for simplicity, losses due to friction and sound will be disregarded. A bird on a perch will have a potential energy

$$E_{pot} = m\ g\ h \quad (1)$$

where m = average mass of the bird (kg), g = acceleration due to gravity ($9{\cdot}81\,\mathrm{m s^{-2}}$), h = vertical height of perch (m).
This potential energy will change if the bird moves from perch 1 to perch 2.

$$\Delta E_{pot} = m_1\ g_1\ h_1 - m_2\ g_2\ h_2 \quad (2)$$

If perch 2 is higher than perch 1 the − becomes + (potential energy increases). Then:

$$\Delta E_{pot} = m\ g\ (h_1 - h_2) \qquad (3)$$

In a conservative field the difference in potential energy must equal the difference in kinetic energy, assuming that the birds are passive and supply no chemical (muscle) energy.

$$m\ g\ (h_1 - h_2) = 1/2\ m\ (v_2{}^2 - v_1{}^2) \qquad (4)$$

However, the bird starts at rest.

$$m\ g\ (h_1 - h_2) = 1/2\ m\ v_2{}^2 \qquad (5)$$

$$g\ (h_1 - h_2) = 1/2\ v_2{}^2 \qquad (6)$$

$$\text{therefore } v_{final} = \surd\ (2\ g\ (h_1 - h_2)) \qquad (7)$$

For birds moving upward, the observed limit (vertical separation) was between 50 cm and 87 cm. In this case the final velocity is zero and this limit may be related to the maximum chemical energy that can be supplied by the muscles to increase the potential energy by the required amount. For birds moving downward, the observed limit in vertical separation was between 29 cm and 43 cm. By substitution in equation (7), this corresponds to a free-fall velocity of between 24 m/s and 29 m/s. This may represent a maximum safe velocity beyond which, even with wing flapping to reduce acceleration, the birds are less able to control the descent.

Horizontal separation must also be important because, taken to extremes, birds could not successfully move directly between vertically separated perches, nor could they be expected to move between perches several metres apart, even if the perches are vertically separated by less than 29 cm. Laying hens are not good fliers. Even with wing assistance they cannot overcome gravitational effects completely. This affects the birds' ability to land safely at the destination perch. The greater the gravitational influence on the flight path, the higher the risk of an uncontrolled landing and injury. When birds are moving upwards the influence of gravity can be used to advantage because it acts to decelerate the birds as they reach the destination. However, this is not the case with downward movement, where there is a marked reduction in ability. Other factors, such as the presence of other birds, lighting intensities and perch design, may be relevant and may be considered in the future.

These findings have implications for perchery designs. If birds cannot easily use a system there may be an appreciable risk of injury. Inability to move easily between perches could partly account for the high incidence of skeletal damage in birds in perchery systems found by Gregory *et al.*, (1990). The risk of injury may be minimised if the slope between horizontal perches at different heights is no more than 45°, to allow the birds to be able to move downwards more easily. By also reducing vertical distance (possibly to no greater than 29 cm) and horizontal distance between these perches, birds may be more successful at negotiating perches at different heights.

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