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Effect of cross-wise perch designs on perch use in laying hens

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Running head: Laying hens and cross-wise perches

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Abstract

1. The use of cross-wise perches by laying hens was investigated in 8 groups of 6 hens. During a period of 5 weeks each group was exposed to 4 different perch arrangements: a single straight perch of 60 cm (P60), a 30 cm perch crossing the middle of another 30 cm perch (P30+30), crossing a 45 cm (P45+30) or crossing a 60 cm perch (P60+30).
2. Perch arrangement influenced perch use. Perch occupancy (the mean number of hens using the perches) was lowest in the P30+30 treatment during daytime, evening and night. Perch occupancy was lower for P45+30 than for P60+30 during daytime and for P60 during evening and night. Perch occupancy did not differ between P60 and P60+30.
3. Perch utilisation (perch use per unit of total perch length provided) was lower for the three cross-wise perch arrangements than for P60, indicating that the area near the crossing was not used optimally.
4. There were indications that the process of taking roosting positions was more disturbed with cross-wise perches.
5. Legislation and guidelines about the minimal perch length per hen should be refined to take into account the arrangement of the perches. A perch of 30 cm cross-wise to another perch should not be included in the total amount of perch length provided to the hens. For longer cross-wise perches, the precise distance near the cross that should be excluded remains to be determined.

23 INTRODUCTION

24 From 2012 onwards, conventional battery cages for laying hens will be banned in the
25 European Union. According to Council Directive 1999/74/EC, which lays down
26 minimum standards for the protection of laying hens, permitted housing systems will
27 be furnished cages and non-cage systems like single or multi tiered systems (CEC,
28 1999). Both furnished cages and non-cage systems should be equipped with perches
29 providing at least 15 cm per hen. Although it is not known to what extent perching is
30 a behavioural priority, hens are prepared to work to gain access to perches at night
31 (Olsson and Keeling, 2000). Because synchronism is important in roosting behaviour
32 (Appleby, 2004; Appleby *et al.*, 2004), perch space should be sufficient for all birds
33 to perch simultaneously (Appleby *et al.*, 1992). This is supported by observations in
34 furnished cages. When given at least 15 cm perch space, 90 to almost 100% of hens
35 perch at night in furnished cages. During daytime, time spent perching varies
36 between 25 and 46% (Appleby *et al.*, 1993; Appleby, 1995; Appleby *et al.*, 2002). In
37 most experiments conducted with furnished cages, perches are positioned parallel to
38 the feed trough (Tauson, 1984; Appleby *et al.*, 1993; Appleby, 1998; Appleby *et al.*,
39 1998). However, according to Council Directive 1999/74/EC, there is a difference in
40 furnished cages between the required length of feed trough per hen (12 cm per hen)
41 and the perch length per hen (15 cm per hen). The Directive also prescribes the
42 incorporation of a nest and an area with litter (CEC, 1999). These regulations and the
43 need for efficient dimensions make it under practical conditions, difficult to provide
44 15 cm perch length per hen with only one perch parallel to the feed trough. Possible
45 alternatives are the incorporation of multiple parallel perches, the construction of T-
46 perches or the construction of cross-wise perches. All these alternatives can be found
47 in recently-developed furnished cages, because the Directive gives neither

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recommendations nor restrictions concerning the arrangement of the perches. Recently, Wall and Tauson (2007) reported that perch arrangement affected the use of perches at night by laying hens. They found that perch use at night by the hens was similar or lower on perches arranged in a cross as compared with a straight perch, although the cross-wise perches provided more perch length per hen than the straight perch.

Our study was undertaken because there is, to our knowledge, almost no scientific information, except for the study of Wall and Tauson (2007), regarding the use of cross-wise perches during day and night. In addition, we studied perch use during the day and evening period and made detailed behavioural observations during evening and night.

MATERIALS AND METHODS

Animals and experimental arrangements

Forty eight beak-trimmed medium hybrid Bovans goldline laying hens were reared commercially in a deep litter system without perches. The hens arrived at the experimental farm at 17 weeks of age and were housed in conventional wire cages in groups of three hens. The experiment started when the hens were 33 weeks of age and took place in a separate room located in the experimental farm which accommodated 8 test cages (120 cm W x 55 cm D) with sloping floors (7°). Each test cage had three solid sidewalls of galvanised metal (preventing visual contact between birds from different cages) and one front wall consisting of widely spaced horizontal bars (Figure 1). The roofs (55 cm above floor level) were made of wire mesh which allowed filming the hens from above (one black and white camera per 4 test cages).

At the beginning of the experiment, 8 groups of 6 hens were randomly assigned to the test cages. They were tested with 4 perch arrangements each according to a balanced extra period design (Lucas, 1957), which enables testing for carry-over effects. This so-called Williams design corresponds to a Latin square (with group as row and period as column) to which one extra period has been added which is assigned to the treatment of the last period in the Latin square (Table). The design with 4 treatments was replicated once so that 8 groups of hens were tested at the same time. The initial perch arrangement (week 1) is shown in Figure 1. Perch arrangement 60 (P60) consisted of one perch of 60 cm parallel to the feed trough (10 cm perch length per hen). In perch arrangements P60+30, P45+30 and P30+30, the perch parallel to the feed trough, respectively 60, 45 and 30 cm long, was crossed in the middle with an additional perch of 30 cm. This provided a total perch length of respectively 90 cm (15 cm per hen), 75 cm (12.5 cm per hen) and 60 cm (10 cm per hen). The wooden rectangular perches (4.5 cm wide) were placed 11 cm above floor level in the centre of each test cage.

Food and water were available *ad libitum*. Water was available from nipple drinkers. Food was provided in a feeder trough at the front of the cages. Light schedule was 16L:8D with a period of 5 min non-gradual subdued lighting during transitions (03:55 – 04:00 and 19:55 – 20:00 h). Lights were fully on and off at 04:00 and 20:00 h respectively.

<Insert Figure 1>

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Observations

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After 6 habituation days per perch arrangement, hens were filmed during the day (04:30 – 12:30 h and 15:00 – 19:30 h) and night (23:30 – 00:30 h). Infrared light sources switched on when lights were off which allowed filming the hens in the dark. Also a period of 15 min starting from light dimming (19:55 h) in the evening was filmed (evening period). Preliminary observations showed that hens started to move towards the perches at the moment lights were dimmed. The images were analysed by counting the number of hens on the perches every min (evening period) or every 15 min (day and night period). Perch use is described in terms of both perch occupancy (mean number of hens on the perch) and perch utilisation. In the latter case, perch use is defined as a function of the nominally available hen places. Because 15 cm perch length per hen is obligatory according to EU-Directive 1999/74/EC, perch arrangements P60, P60+30, P45+30 and P30+30 had respectively 4, 6, 5 and 4 hen places. Therefore, if only one hen was perching in each group of 6 hens, the perch utilization would 25%, 16.7%, 20% and 25% for the respective perch arrangements, whereas the perch occupancy would be one for all perch arrangements. During the evening and night period, frequency of stepping on or off the perches, wing flapping (balancing wing movement when hens became temporarily unstable) and pecking at a cagemate was recorded for the hens on the perches. The frequency of pecks directed to hens on the perches was also recorded. In addition, during the night, frequency of turning around on the perches and frequency of displacements (change of position) on the perches were recorded. At 20:30 h, the positions of the hens on the perches was drawn on a map of the test cages. From our previous experience in other experiments and previous research (Appleby *et al.*, 1992), it seemed that 0.5 h after lights-off hens had taken up settled roosting positions. Hens were not individually identified during the observations.

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The time between light dimming and taking up roosting position was determined for every group of hens through 1 min interval scans of images. The first scan of 5 subsequent scans with hens at the same location and performing the behaviours standing (posture with stretched legs without moving), sitting (resting the breast on the floor or perch), sleeping (bird motionless with the head tucked into the feathers above the wingbase) or preening (beak or claw movements directed at own feathers) indicated the roosting position.

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Statistical analysis

Perch occupancy, perch utilisation and frequency of a particular behaviour were analysed using a mixed model with group as random factor and period (day, evening, night), perch arrangement and carry-over effect as fixed effects at the 5% global significance level (mixed procedure, SAS Version 9.1.3). No significant carry-over effects were detected and were therefore removed from the model. Perch arrangements were compared pair-wise using Tukey's method to adjust for multiple comparisons.

RESULTS

Day period

During the day, perch arrangement affected both perch occupancy ($F_{3,25}=9.86$, $P<0.001$) and perch utilisation ($F_{3,25}=8.88$, $P<0.001$). Mean number of hens on the perch (perch occupancy) was higher on P60 compared to P30+30 ($P<0.05$) and on P60+30 compared to P45+30 ($P<0.01$) and P30+30 ($P=0.0001$) (Figure 2). Perch utilisation was higher for P60 than for the other perch arrangements (P60 - P30+30: $P<0.05$; P60 - P45+30: $P<0.001$; P60 - P60+30: $P<0.01$) (Figure 3).

147 <Insert Figures 2 and 3>

148 **Evening period**

149 In a 15 min period starting from the dimming of the lights, perch occupancy differed
 150 between perch arrangements ($F_{3,18}=20.84$, $P<0.0001$) (Figure 2). Perch occupancy
 151 for P30+30 was lower than for the other perch arrangements (P30+30 – P60:
 152 $P<0.0001$, P30+30 – P60+30: $P<0.0001$, P30+30 – P45+30: $P<0.01$) and the
 153 occupancy of P45+30 was lower than for P60 ($P<0.01$). Perch utilisation was s
 154 higher for P60 than for the other perch arrangements ($F_{3,18}=26.28$, $P<0.0001$)
 155 (Figure 3).

156 Frequency of wing flapping ($F_{3,18}=2.02$, $P=0.147$) and stepping on or off the
 157 perch ($F_{3,18}=0.09$, $P=0.966$) did not differ significantly between perch arrangements
 158 (Figure 4). However, when expressed in terms of mean number of hens on the perch,
 159 frequency of wing flapping was higher in P30+30 than in P60+30 ($P<0.05$).
 160 Similarly, the frequency of wing flapping tended to be higher in P45+30 compared to
 161 P60+30 ($P=0.066$). Frequency of stepping on or off the perch per hen on the perch
 162 increased gradually from P60, P60+30, P45+30 to P30+30, but differences were not
 163 significant ($F_{3,18}=2.42$, $P=0.099$). Pecking was rarely observed and was mainly
 164 reciprocal between hens on the perches and those on the floor. There was no
 165 significant effect of perch arrangement on the latency of taking up roosting position
 166 ($F_{3,18}=0.63$, $P=0.604$) (P60: 6.8 ± 0.86 min, P60+30: 5.9 ± 0.86 min, P45+30: $6.4 \pm$
 167 0.86 min, P30+30: 7.5 ± 0.86 min).

168

169 <Insert Figure 4>

170

171 **Night period**

At night, perch arrangement affected perch occupancy ($F_{3,25}=20.30$, $P<0.0001$) and utilisation ($F_{3,25}=22.66$, $P<0.0001$). Pair-wise comparisons showed the same significant differences as in the evening period (Figure 2 and Figure 3). Wing flapping, stepping on or off a perch, turning around and displacements were rarely observed. Pecking was never observed at night. Roosting positions of the hens at 20:30 h are shown in Figure 5. In P60, the number of hens roosting on the perches was 3 (50%), 4 (40%) and one single occasion 5 (10%). In P30+30, providing the same total perch length of 60 cm, there was not a single night with 4 or more hens roosting together and only one night (10%) with three hens roosting together. In P45+30, there were most of the time (80%) three hens perching together. In P60+30, the number of hens on the perches at 20:30 h was roughly similar to P60, although more than 4 hens roosting together was never observed. It was estimated from the drawings that for hens positioned parallel to each other on a perch without another hen on the 30 cm perch perpendicular in between them, the nearest neighbour distance (distance between hen contours) was between 0 and 5 cm. Figure 5 shows that this distance between two hens on the same perch increased when there was another hen on the 30 cm perch at a right angle between them (for example, 20 cm for the second drawing in P60+30, 15 cm for the 7th drawing in P45+30).

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DISCUSSION

During day, evening and night, perch arrangement had an effect on perch use in laying hens. Although P30+30 provided the same perch length as P60 (60 cm), the cross-wise arrangement reduced both perch occupancy and utilisation. This was most pronounced during evening and night but was also noticed during the day.

197 When perch length was increased to 45+30 cm, perch occupancy was still lower than
198 in P60 during the evening and night. Increasing perch length further to 60+30 cm
199 resulted in an occupancy similar to that in P60, but a lower utilisation. At night, 58%
200 of the hens roosted on the perches in P60+30 (15 cm/hen), which is lower than in
201 other studies in which the same legislative minimal amount of perch length was
202 provided by non-crossing perch arrangements (Appleby and Hughes, 1995,
203 Abrahamsson *et al.*, 1996). For instance, in a study by Appleby (1995), which also
204 provided 15 cm of perch length per hen, 95% of the animals roosted on the perches.
205 Our study allows us to recommend that legislation should be refined, so that a perch
206 of 30 cm cross-wise to another perch is no longer included in the total amount of
207 perch length provided to the hens. Apart from the present study, very few other data
208 are available on the use of cross-wise perches. Wall and Tauson (2002) mentioned
209 that 81.2 % of hens roosted on cross-wise perches but in that study 17 cm perch
210 length per hen was provided. In another study by Wall and Tauson (2007), 80.6 and
211 82.5 % of the birds were on the cross-wise perch providing 15 cm per hen, after dark
212 in two consecutive trials. Neither publication presented data on perch use during
213 daytime.

214 In P30+30, mostly two hens were roosting on the perches at night. It seems
215 that on a cross-wise perch with arms of 15 cm each, it is physically not possible for 4
216 hens to roost together. As a consequence, on cross-wise perches with arms longer
217 than 15 cm, some centimetres near the crossing will not be used by the hens.
218 Therefore, in perch arrangements with a cross the actual perch length that can
219 actually be used by the hens is less than the total perch length provided. This finding
220 is in accordance with the results of Wall and Tauson (2007) who found that the use

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221 of a long perch providing 12 cm perch length per hen was higher than with a cross-
222 wise perch providing 15 cm per hen.

223 Frequency of wing flapping per hen on the perch was higher for perch
224 arrangements P30+30 and P45+30 compared to P60+30. The wing flaps were largely
225 due to the hens extending their wings to regain balance on the perch when making
226 body contact with another hen. Frequency of stepping on or off the perch per hen on
227 the perch increased with decreasing perch length in cross-wise perches and was
228 lowest for the perch without cross, although there were no significant differences.
229 Overall, these observations during the evening period indicate that hens were more
230 disturbed during perching in P30+30 and P45+30 compared to the other perch
231 arrangements. Indeed, when perch space is limited, hens are reported to struggle
232 vigorously to secure a perching place for the night (Appleby *et al.*, 1992).
233 Nonetheless, there was no significant difference between perch arrangements in time
234 between light dimming and taking up roosting position. During the night, in all
235 perch arrangements, locomotory activity of the hens was very low. This is in
236 accordance with previous observations of Appleby *et al.* (1992) who found that, at
237 night, out of 104 hens in cages with perches, only 5 moved between the perch and
238 the floor and only one hen turned round on a perch.

239 In conclusion, when 60 cm of perch length was provided to a group of 6 hens,
240 the number of hens perching was much reduced when the perch was arranged in a
241 cross instead of a straight line. Increasing total perch length to 75 cm in a cross-
242 arrangement still didn't approach perch occupancy at night of a single straight 60 cm
243 perch. Furthermore, increasing total perch length to 90 cm by adding a 2x15 cm
244 perch perpendicular to the original 60 cm perch, had no positive effect on the number
245 of hens perching. Therefore, current legislation stipulating a minimum of 15 cm

perch length per hen should be refined to take into account the arrangements of the perches. By comparing P60 with P60+30 in the present study, we deduce that the addition of 30 cm perch length cross-wise to another perch should not be included in the total amount of perch length provided to the hens as it does not increase perch occupancy and reduces perch utilisation. For longer cross-wise perches a certain distance near the cross should be excluded for calculating the minimal perch length per hen, but further studies are needed to determine the precise distance.

ACKNOWLEDGEMENTS

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301 **TABLE.** *The balanced extra period design with 4 treatments (P60, P60+30,*
302 *P45+30, P30+30) and additional period. The design of the first 4 groups was*

Group	Week 1	Week 2	Week 3	Week 4	Week 5
1	P60	P30+30	P45+30	P60+30	P60+30
2	P30+30	P60+30	P60	P45+30	P45+30
3	P45+30	P60	P60+30	P30+30	P30+30
4	P60+30	P45+30	P30+30	P60	P60
5	P60	P30+30	P45+30	P60+30	P60+30
6	P30+30	P60+30	P60	P45+30	P45+30
7	P45+30	P60	P60+30	P30+30	P30+30
8	P60+30	P45+30	P30+30	P60	P60

replicated once..

306 **Figure 1.** *Top-view of the 8 test cages with initial set-up (week 1) of the perch*
307 *arrangements.*

FIGURE 2. Effect of perch arrangement (P60 □, P60+30 ■, P45+30 ▨, P30+30 ■) on perch occupancy (mean number of hens on the perches) during day, evening and night (*mean ± S.E.*). Perch arrangements sharing the same letter do not differ significantly (at 5% global significance level).

FIGURE 3. Effect of perch arrangement (P60 □, P60+30 ■, P45+30 ▨, P30+30 ■) on perch utilisation (i.e. perch use in function of the *nominally* available hen places) (*mean ± S.E.*) during day, evening and night. Perch arrangements sharing the same letter do not differ significantly (at 5% global significance level).

FIGURE 4. Effect of perch arrangement (P60 □, P60+30 ■, P45+30 ▨, P30+30 ■) on frequency of wing stretching and stepping on or off the perch during the 15-min evening period (*mean ± S.E.*). Perch arrangements sharing the same letter do not differ significantly (at 5% global significance level).

FIGURE 5. Schematic overview of all records of the positions of the hens on the perches at 20:30 h according to perch arrangement. Groups are labelled with their group number (G1 to G8).

Figure 2. Effect of perch arrangement (P60 □, P60+30 ■, P45+30 ▨, P30+30 ■) on perch occupancy (mean number of hens on the perches) during day, evening and night (mean ± S.E.). Perch arrangements sharing the same letter do not differ significantly (at 5% global significance level).

Figure 3. Effect of perch arrangement (P60 □, P60+30 ■, P45+30 ▨, P30+30 ■) on perch utilization (i.e. perch use in function of the **nominally** available hen places) (**mean $\pm$ S.E.**) during day, evening and night. Perch arrangements sharing the same letter do not differ significantly (at 5% global significance level).

Figure 4. Effect of perch arrangement (P60 □, P60+30 ■, P45+30 ▨, P30+30 ■) on frequency of wing stretching and stepping on or off the perch during the 15-min evening period (mean ± S.E.). Perch arrangements sharing the same letter do not differ significantly (at 5% global significance level).

Figure 5. Schematic overview of all records of the positions of the hens on the perches at 20:30 h according to perch arrangement. Groups are labelled with their group number (G1 to G8).

Table 1. The balanced extra period design with 4 treatments (P60, P60+30, P45+30, P30+30) and additional period. The design of the first 4 groups was replicated once.

Group	Week 1	Week 2	Week 3	Week 4	Week 5
1	P60	P30+30	P45+30	P60+30	P60+30
2	P30+30	P60+30	P60	P45+30	P45+30
3	P45+30	P60	P60+30	P30+30	P30+30
4	P60+30	P45+30	P30+30	P60	P60
5	P60	P30+30	P45+30	P60+30	P60+30
6	P30+30	P60+30	P60	P45+30	P45+30
7	P45+30	P60	P60+30	P30+30	P30+30
8	P60+30	P45+30	P30+30	P60	P60

Figure 1. Top-view of the 8 test cages with initial set-up (week 1) of the perch arrangements.