Redesigning Battery Cages to Improve Laying Hen Welfare
Final Report

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Michelle Jendral[1], John S Church[2], and John Feddes[1]

[1]**University of Alberta, Department of Agriculture, Food and Nutritional Sciences**, 2-14 Agriculture, Forestry Centre, Edmonton, Alberta T6G 2P5 [2]**Alberta Agriculture, Food and Rural Development**, Rm. 306 J. G. O'Donoghue Building, 7000-113 Street, Edmonton, Alberta, Canada T6H 5T6

Assessing the Welfare of Layer Hens Housed in Conventional, Modified and Commercially-Available Furnished Battery Cages

Michelle J. Jendral[1], John S. Church[2], John J. R. Feddes[1]

[1]Department of Agricultural, Food and Nutritional Science, University of Alberta,
[2]Alberta Agriculture Food and Rural Development, Edmonton, Alberta, Canada

Abstract
The purpose of this study was to modify conventional battery cages, and compare the adapted environments to conventional battery housing and furnished colony cages, by evaluating behavioural, physiological, production and condition differences. Conventional cages (CON) (30 cm x 45 cm) (n=84) and modified cages (MOD) (n=84) each housed 3 White Leghorn hens and provided 450 cm^2 of floor space per bird. MOD cages included a perch and an artificial turf-lined nest box (24 cm x 45 cm), providing an additional 360 cm^2 of nest area per bird. Furnished colony cages (COL) (120 cm x 110 cm) housed 26 hens and incorporated a perch and a nest box (60 cm x 50 cm). Dust baths (60 cm x 20 cm) were filled with peat moss daily in 12 of the 24 COL. COL provided 450 cm^2 of floor space and 115 cm^2 of nest box area per bird. Behavioural observation was conducted by analysing continuous video footage at 35 and 60 wks. Physiological measures of stress were assessed by corticosterone levels in blood, fecal matter and albumen samples collected at 29 and 59 wks, and blood heterophil/lymphocyte ratios. Production measures were evaluated by recording feed consumption at 26, 27, 28 and 64 wks, and body weight at 65 wks. Eggs were collected every 4 wks and egg weight, specific gravity, eggshell thickness and weight, the incidence of cracks and soiling and location of lay were recorded. Hen condition was evaluated at 31 and 65 wks by rating plumage, foot, claw and keel bone condition, as well as wounds to the head and vent region. Tibia, femur and humerus bones were collected at 65 wks to determine bone density, area, and breaking strength. Data were analysed using the General Linear Model for mixed effects. Treatment effects were significant at $P<0.05$. Preliminary results indicate that feed consumption per dozen eggs was significantly higher in COL than in MOD and CON. Feather cover was significantly higher in MOD and CON than in COL. The number of wounds to the vent region was significantly increased in COL and cannibalistic behaviour was highest in these cages. The proportion of eggs laid in the nest box ranged from 73 to 96% in MOD and 89 to 99% in COL. No difference in the proportion of soiled eggs was observed between cage types, however the incidence of cracked eggs was significantly higher in COL and MOD than in CON. These findings suggest that COL and MOD provide essential amenities yet group size also impacts hen welfare.

Keywords: layer, welfare, modified cages, furnished cages, behaviour

Introduction
The use of battery cages to house layer hens has stimulated considerable controversy. While cages promote hygiene, facilitate management and limit group size, thereby reducing aggressive and cannibalistic behaviour (Abrahammson and Tauson, 1995), it is widely acknowledged that housing layer hens in battery cages negatively impacts hen welfare. High stocking densities limit physical space and discourage the performance of innate behaviours (Nicol, 1987), and restriction of movement and exercise contributes to skeletal fragility (Knowles and Broom, 1990). In cages, birds are unable to escape from aggressive casemates and the absence of nesting facilities, perches and dust baths further prevents hens from performing natural behaviours (Appleby et al., 1993).

Concern for the welfare of layer hens housed in battery cages is increasing and is primarily reflected in the legislative changes occurring in Europe. The conventional battery cage has been banned in Switzerland since 1991 and in Sweden, cage housing is only permitted when a perch, nest box and litter box are provided (SFS, 1998). In 1999, a Directive was approved in the European Union that prohibits new investment in conventional cages beyond 2003 and bans their use as of 2012 (CEC, 1999). After 2012, all layer cages must provide a minimum of 750 cm^2 per hen, a nest box, a litter area, a perch and a claw shortening device.

In North America, the conventional battery cage is considered an acceptable housing system for layer hens. Although legislation regulating cage enrichment does not exist, recent changes in European welfare legislation, increased public concern for animal welfare, and pressure from animal rights groups have motivated some corporations to voluntarily implement changes to stocking density standards (Mayer, 2002). In the United States, for example, McDonald's and Burger King now require suppliers to provide layer hens with a minimum of 464 cm^2 and 484 cm^2 floor space, respectively. By 2008, the United Egg Producers, a proactive commodity group, will only certify producers that provide hens with a minimum of 432 cm^2 floor space (Mayer, 2002). In Canada, the Recommended code of practice for the care and handling of pullets, layers and spent fowl (2003) recommends that white and brown layers be provided with 432 cm^2 and 484 cm^2 floor space, respectively. Only two provinces, Quebec and Alberta, regulate stocking density, requiring producers to follow the recommendations of the code of practice in order to acquire new egg quota.

Aside from these recent changes in minimum space requirements, little consideration has been dedicated to finding alternative layer housing systems in North America (Duncan, 2001). In the future, North American producers will likely also begin to adopt modifications to cage systems to remain consistent with changes that are occurring worldwide and improve the welfare of layer hens housed in battery cages. In the present study an, experimental cage which made use of a conventional 6-hen battery cage was designed based upon the findings of previous modified cage research. The objectives of this study were to develop a cost effective modification to the conventional cage that would allow producers to make use of existing capital, and to compare the adapted environments to conventional battery cages and commercially available, furnished colony cages. We hypothesized that modifications to conventional battery cages would enhance hen welfare and improve production in a comparable manner to furnished colony cages, at a minimal cost.

Materials and Methods

Stocks and Management

White Leghorn layer chicks obtained from a commercial supplier were housed at the University of Alberta Poultry Research Centre, Edmonton, Alberta, Canada. Chicks were raised on floor litter and received a commercial layer diet and water ad libitum. All chicks were beak trimmed at one wk of age. At 19 wks, birds were randomly allocated to one of four cage treatments housed within the same room. Day length was increased from 10 h at 20 wks to 14 hrs at 24 wks. One additional hour of light from midnight to 0100 h was introduced at 30 wks and continued until the end of the trial.

Cage Design

Conventional (CON)

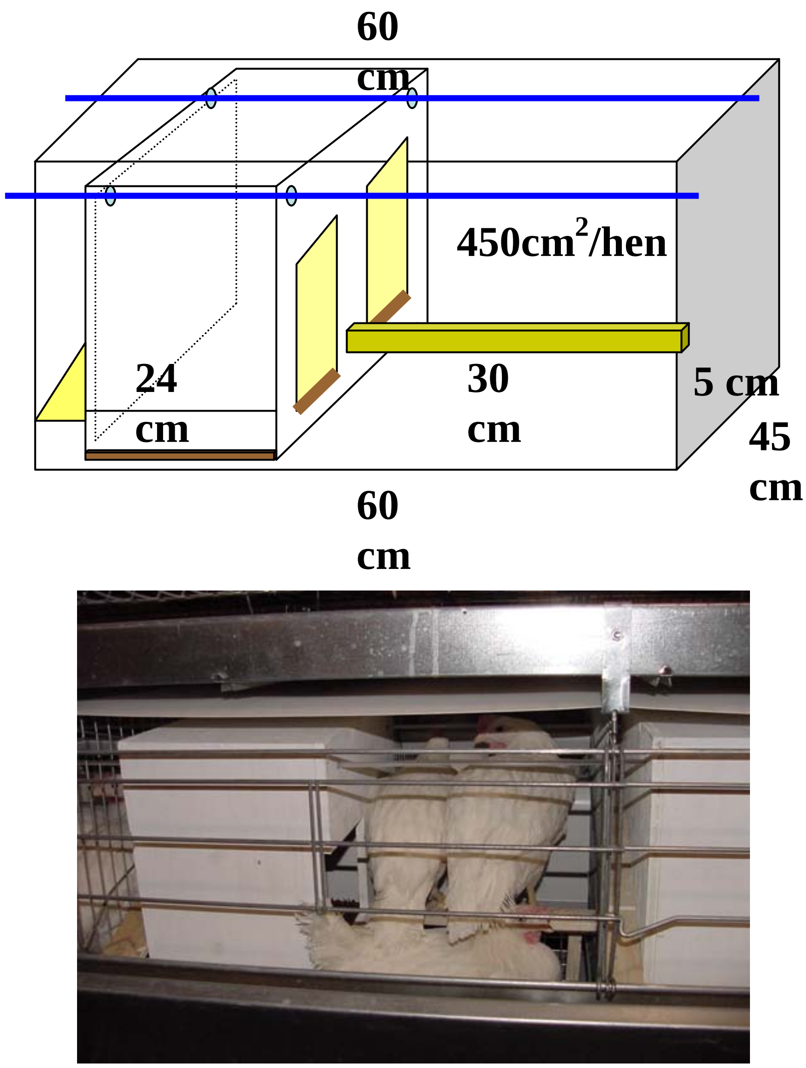
The CON group consisted of 3 tiers of 14 standard 6-hen laying cages measuring 60 cm wide, 45 cm deep and 40 cm high at the rear. A vertical bar partition was installed in the CON cages to divide each 6-hen cage into 2, 3-hen cages, giving 3 tiers of 28 cages. A total of 84 CON cages provided each hen with 450 cm^2 of floor space (Figure 1).

Figure 1: Conventional Battery Cage (CON)

Modified (MOD)

Three tiers of 28 standard 6-hen layer cages were modified by addition of an artificial turf-lined, wooden nest box (NB) measuring 24 cm wide, 45 cm deep and 35 cm high at the rear. Two entrances measuring 12 cm wide, 15 cm high and raised 5 cm from the floor were available, one at the rear of the cage and one at the front. A lightweight door inside each nest box opened and closed 30 minutes before lights on and off, respectively (Figure 2). A softwood perch of dimensions 5 cm deep, 2.5 cm high and 30 cm long extended from the nest box to the opposite wall of the cage. The perch was positioned 12.5 cm from the back of the cage and 32.5 cm from the front of the cage, at a height of 10 cm above the floor. Each hen in the MOD cages was provided with 450 cm^2 of floor space and an additional 360 cm^2 of nest space during the day.

Figure 2: The Modified Cage (MOD)



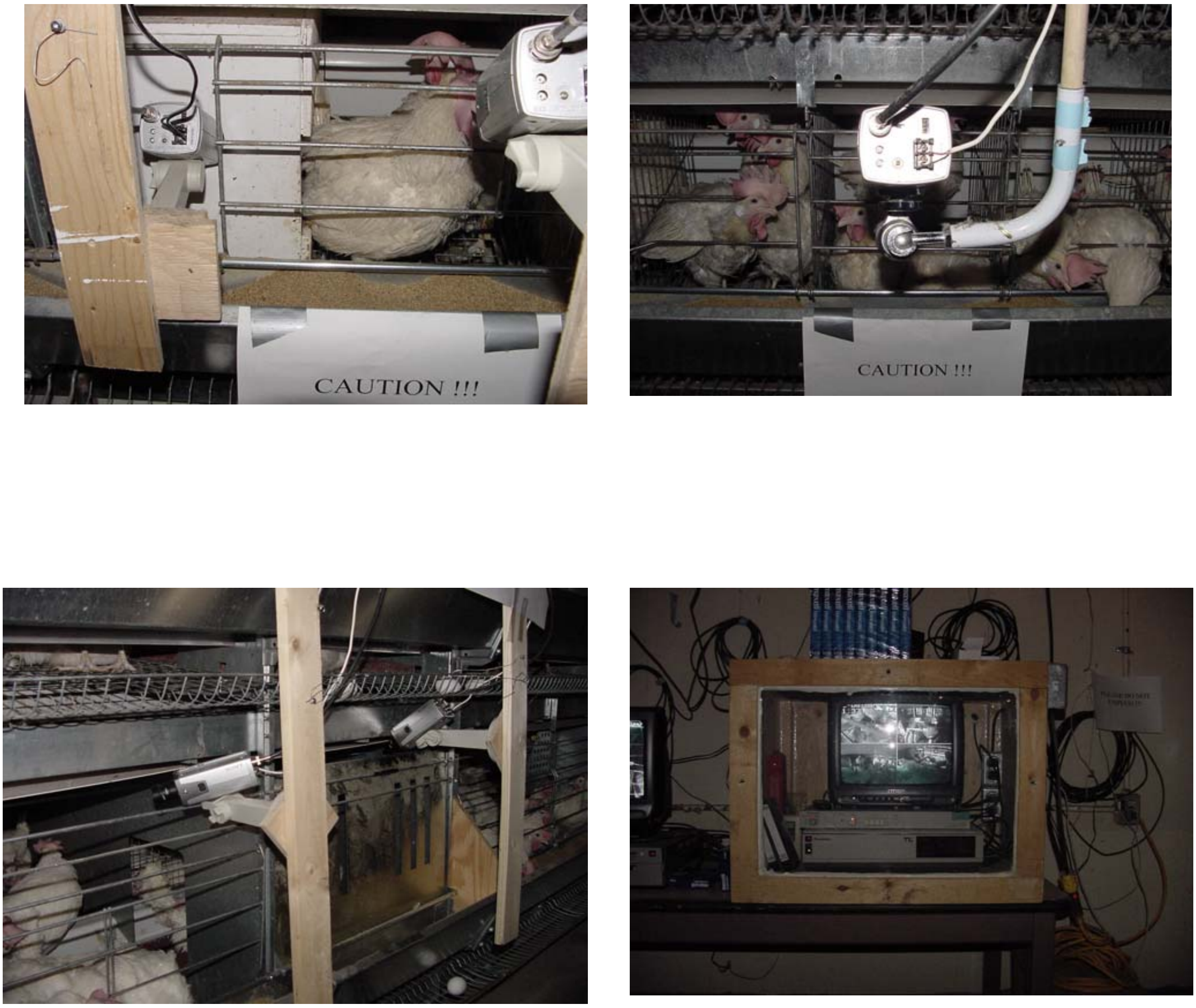
Commercially available, furnished colony cages (COL)
The COL battery consisted of 2 tiers of 12 cages, totalling 24 furnished cages. Cages, which were 120 cm wide and 110 cm deep, housed 26 birds and provided 450 cm^2 of floor space per bird. A metal dust bath (DB), measuring 60 cm wide by 20 cm deep, was present in 12 randomly selected cages, 6 per tier (COLWDB). In the remaining colony cages, the DB was not made available for hen use (COLWODB). To deter hens from nesting in the DB, the facility was opened daily at 1300h, was filled with peat moss and was closed one hour before lights were turned off. Nest boxes were constructed of metal and were 60 cm wide and 50 cm deep, providing an extra 115 cm^2 per bird. A single doorway measuring 20 cm wide, allowed entry into the artificial turf-lined NB. Softwood perches measuring 5 cm deep and 2.5 cm high extended the length of the cage on the side opposite the NB. In all of the cage systems, the cage and NB floor were sloped at an angle of 7° (Figure 3).

Figure 3: Commercially available, furnished colony cage (COL)

Behavioural Observations and Physiological Measurements
Video footage was recorded in continuous mode from 0630h to 1600h. Eight cages were randomly selected from each treatment and 2 cages per treatment were filmed each day at 35 and 60 wks. Video footage was analyzed from four, 1h periods including prelay (0630 h), 0900 h, 1300 h and 1500 h, using the focal animal sampling technique from the Observer 4.1 Behaviour Recording Program (Noldus Information Technology, The Netherlands, 2002). Prelay and nesting activities, roosting, preening, dustbathing, stereotypes and aggressive and avoidance behaviours were recorded, and frequencies and durations calculated. For cages housing 26 hens, videos were analyzed on a per cage basis and data presented as a mean per hen. Durations and frequencies were quantified as a percentage of the 1h period and as a percentage of the total behaviours observed, respectively (Figure 4).

At 29 and 59 wks, blood samples were collected from the brachial vein of 24 randomly selected birds per treatment. Plasma was analyzed for corticosterone using a commercial diagnostic kit (Immunodiagnostics Systems Ltd., UK). Microscope slides prepared from whole blood were stained with Wright-Giemsa stain and heterophil/lymphocyte ratios were determined. At 29 and 30 wks, and every 4 wks thereafter, albumen from 12 randomly collected eggs per treatment, and fecal samples from 10 cages per treatment were analyzed for corticosterone concentrations. At 65 wks, oviducts and ovaries were examined for regression.

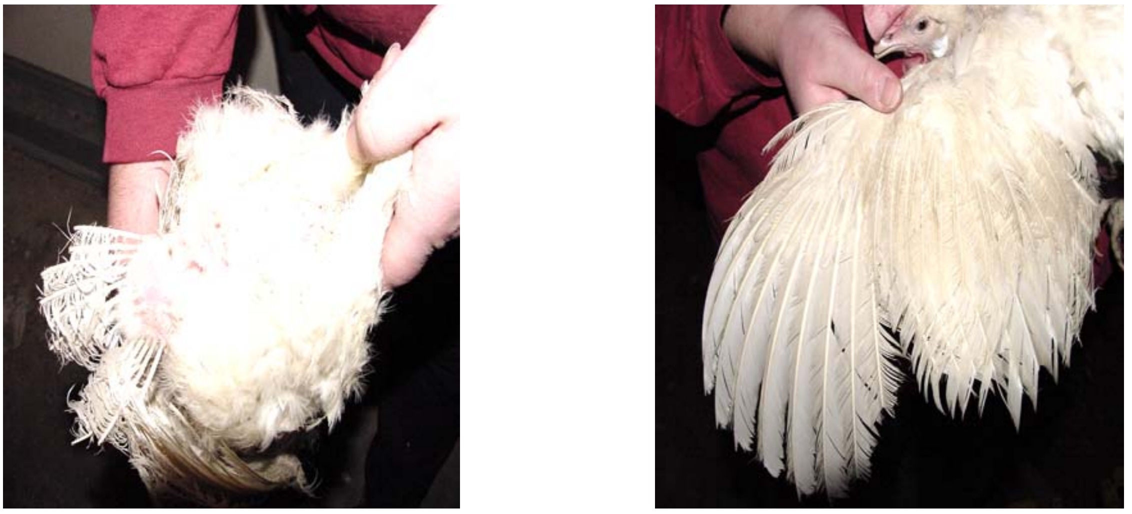
Figure 4: Behavioural Observations



Condition and Production Measurements

The exterior appearance of all birds from 12 randomly selected cages per treatment was evaluated at 31 and 65 wks. Plumage condition of the head, neck, breast, belly, back, wings, and tail was assessed on a scale of 4 (very good) to 1 (severely damaged). Scores for each bird were added to give an overall total condition score out of 28 (Figure 5).

Figure 5: Plumage Condition



Foot condition was measured on a scale of 4 (good) to 1 (very poor) by assessing lesions, hyperkeratosis in the distal toe pad, and abscesses in the footpad. Claws were measured for excessive growth and rated between 4 (short, normal) and 1 (extremely overgrown) (Figure 6).

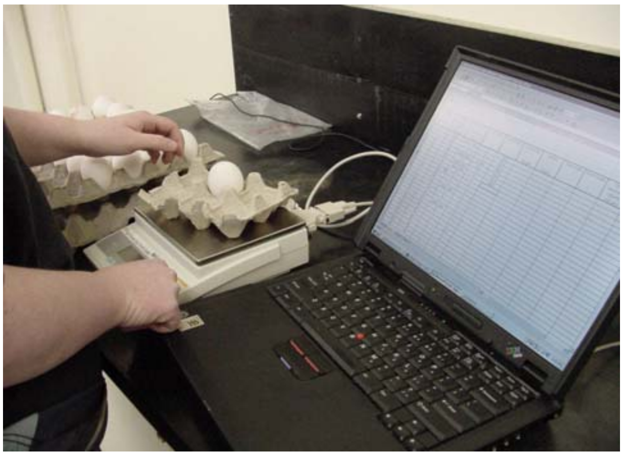
Figure 6: Foot Condition

Keel bone deformations and wounds on the comb and around the tail/ cloaca were assessed a score of 1 to 4 (no deformation or wounds). At 65 wks, right tibia, femur and humerus bones were removed from 108 hens per treatment and stored in plastic bags at -20°C. Bone density was measured using a Norland XCT scanner and the Norland XCT software version 5.40 (Norland Corp., Fort Atkinson, Wisconsin, USA) and total cortical and trabecular bone density and area were calculated. Bones strength was measured using an Instron Materials

Tester and the accompanying software, version 8.09 (Model 4411, Instron Corp., Canton, Ma, USA).

Each day, total egg numbers from the CON and MOD cages, and each COL cage were recorded. Eggs were collected for 2 consecutive days every 4 wks, were assessed for location of lay and soiling frequencies, and were candled for cracks and weighed. Specific gravity measurements were conducted on eggs from 30 CON and MOD cages, and all of the eggs from the COL treatments using the flotation method (Figure 7). Feed consumption was also monitored between 26 and 28 wks of age, and at 64 wks. Bird weights were obtained at 65 wks.

Figure 7: Egg Quality Measures

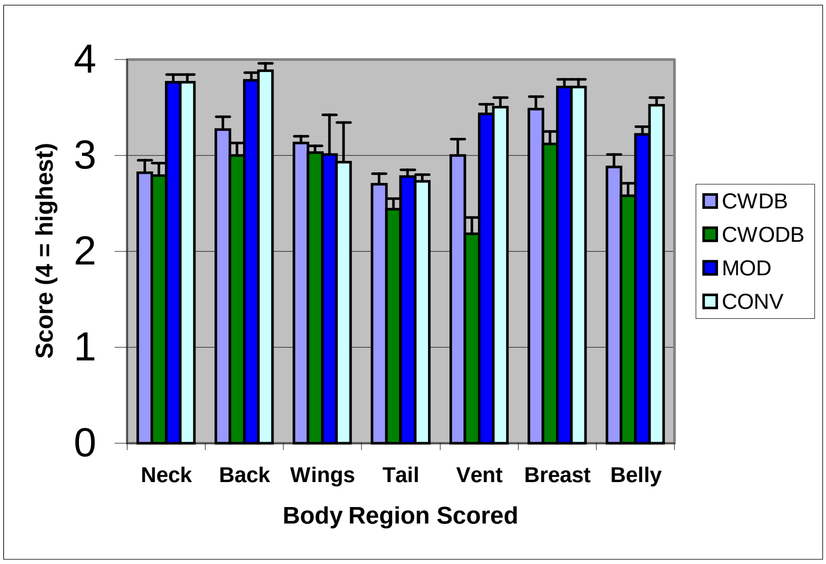


All data was analysed for statistical significance using the GLM procedure for mixed models in SAS (SAS Institute, 1999), with cage as the random effect. When the effect of treatment was found to be significantly different, means were separated using the least significant means comparison. Unless otherwise stated, the level of significance was assessed at $P < 0.05$.

Results and Discussion

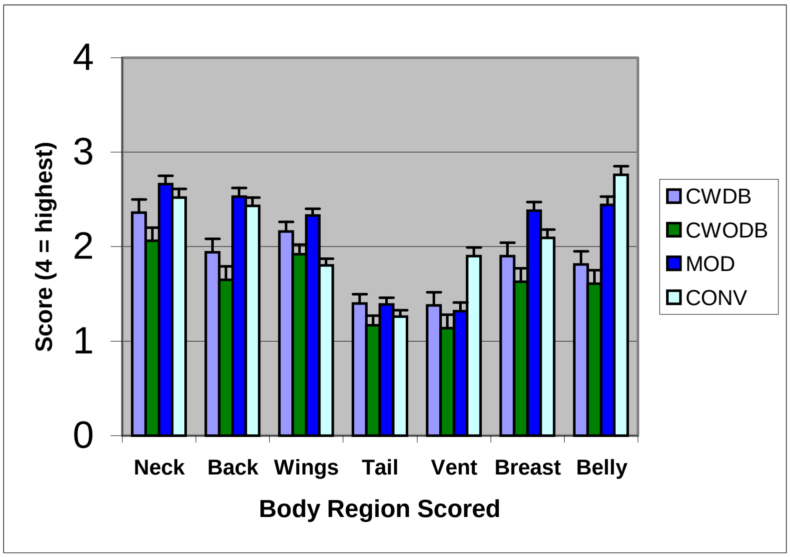
Preliminary findings from this study indicate that total feather condition scores at 31 wks of age were significantly higher for hens housed in CON and MOD than hens housed in COLWDB or COLWODB (Figure 8).

Figure 8: Feather Condition at 31 Weeks



Abrahammson et al. (1996) observed similar findings for hens housed in smaller groups when comparing cage types that housed different hen numbers, and feather pecking tendencies are believed to be influenced by group size (Hughes and Duncan, 1972). Significantly higher individual scores for neck, back and vent regions for hens housed in CON and MOD would also suggest a higher occurrence of aggressive and feather pecking in the colony cages. Significantly lower vent scores in COLWDB and COLWODB may have contributed to the high incidence of cannibalism observed in these cage types since poor vent cover may result in exposure of a partially prolapsed uterus during oviposition thereby encouraging vent pecking, the most severe precursor to cannibalism (Hughes and Duncan, 1972). Notably, feather condition was consistently higher in COLWDB than in COLWODB and vent cover was significantly higher in COLWDB than in COLWODB (Figure 8)(Figure 9).

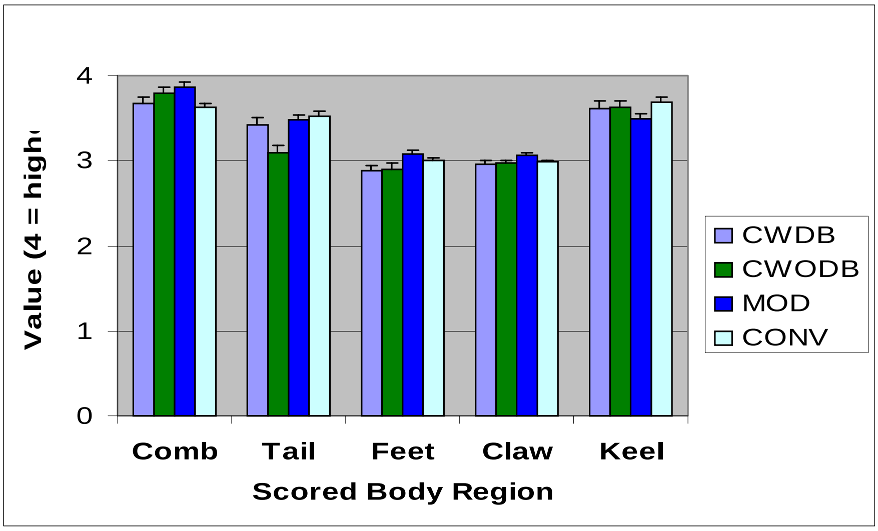
Figure 9: Feather Condition at 65 Weeks



This finding supports the belief that feather pecking results from the use of feathers to dust bathe in the absence of substrate (Vestergaard, 1989) and provides evidence that provision of a dust bath can contribute to hen welfare. Belly condition score was significantly lower in both of the COL cages than in CON or MOD. Dust bathing activity has previously been observed to occur on cage floors as well as in dust baths (Lindberg and Nicol, 1997) and may contribute to feather damage. Although sham dust bathing was observed in all cage types, it is possible that the activity was easier to perform in COL cages if hens occupying the nest box or dust bath freed floor space.

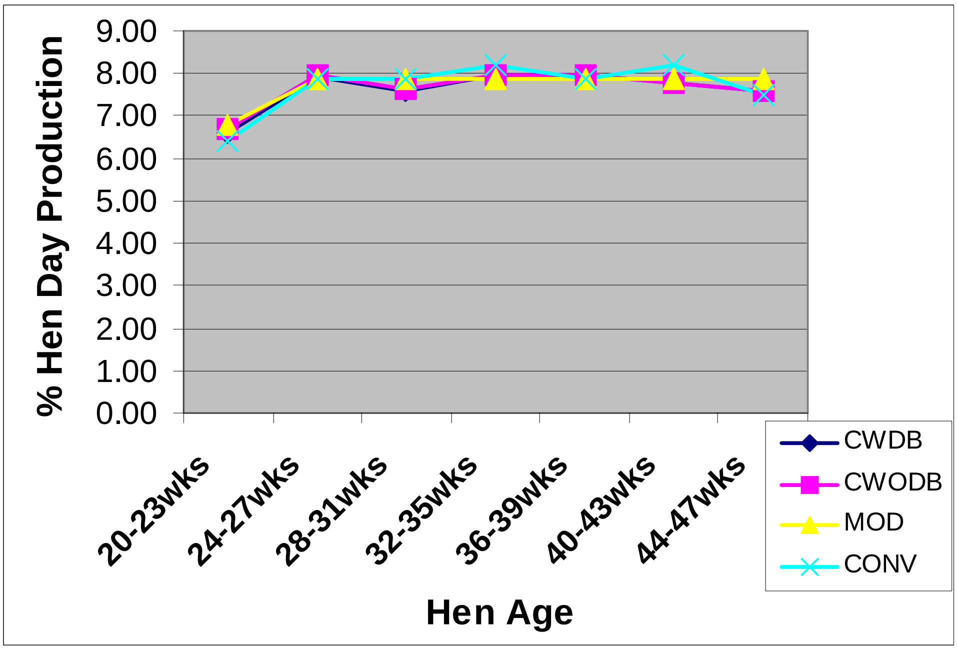
Wounds to the tail and cloaca region resulted in a significantly lower score ($P<0.05$) for COLWODB than for any other treatment at 31 wks, as might be expected from the significantly lower vent condition scores for this region. Foot and claw condition were significantly higher in MOD than either COLWDB or COLWODB at 31 weeks ($P<0.05$). Since foot problems may be reduced when a perch is present (Hughes and Appleby, 1989), these findings may reflect the increased opportunity for hens in MOD cages to perch than in COL cages, where perch space was limited. Keel bone scores were also lowest in the MOD cages and differed significantly from CON. Deformation of the keel bone has previously been observed in layer hens when a perch was provided in the cage (Abrahammson et al., 1996) (Figure 10).

Figure 10: Wounds and Feet, Claw and Keel Condition at 31 Weeks



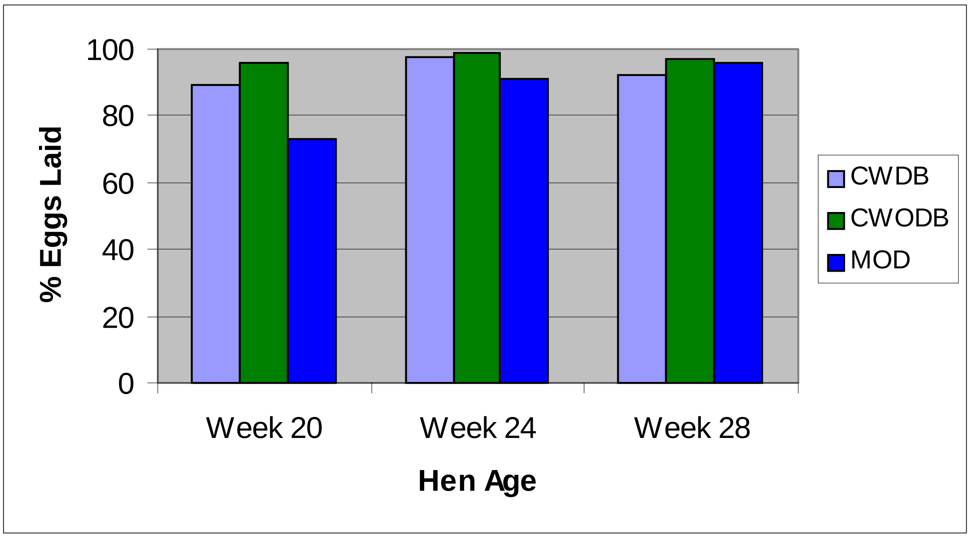
Egg production, measured as dozen eggs produced per hen, did not differ significantly between treatments from 20 to 47 wks. Peak production was achieved between weeks 24 and 27, and began to decline gradually until midnight lighting was introduced at wk 30. It is interesting to note that the incidence of cannibalism in the COL cages followed a similar pattern. Occurrences were highest at 27 and 30 wks (Figure 11).

Figure 11: Egg Production



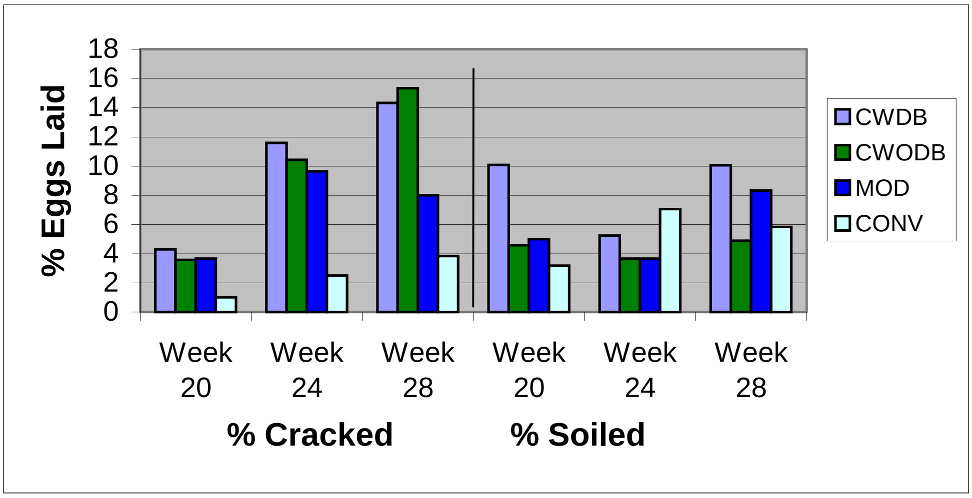
By wk 20, one wk after hens had been moved to the cage environments, 96% of eggs laid in COLWODB, 89% of eggs laid in COLWDB and 73% of eggs laid in MOD were laid in the nest box. By wk 24, these percentages had increased to 99%, 98% and 91%, respectively. In wk 28, 97% of COLWODB eggs, 92% of COLWDB eggs and 96% of MOD eggs were laid in the nest box (Figure 12).

Figure 12: Percentage of Eggs Laid in Nest Box



The high proportion of eggs laid in the nest box is consistent with the findings of previous studies (Appleby and Hughes, 1995) and reiterates the importance of providing a nesting site. Hens in COLWDB that did not oviposit in the nest box were more likely to lay their eggs in the cage than in the dust bath. The percentage of eggs laid in the dust bath was low, ranging from 0.1 to 4% over the 8-wk period, suggesting that the delayed opening of the dust bath was successful in reducing the number of eggs laid therein. The percentage of cracked eggs did not differ significantly between treatments at 20 wks, but was significantly higher in COLWDB, COLWODB and MOD than in CON at 24 wks, and was significantly higher in COLWDB and COLWODB than CON in wk 28 (Figure 13).

Figure 13: Percent Eggs Cracked and Soiled

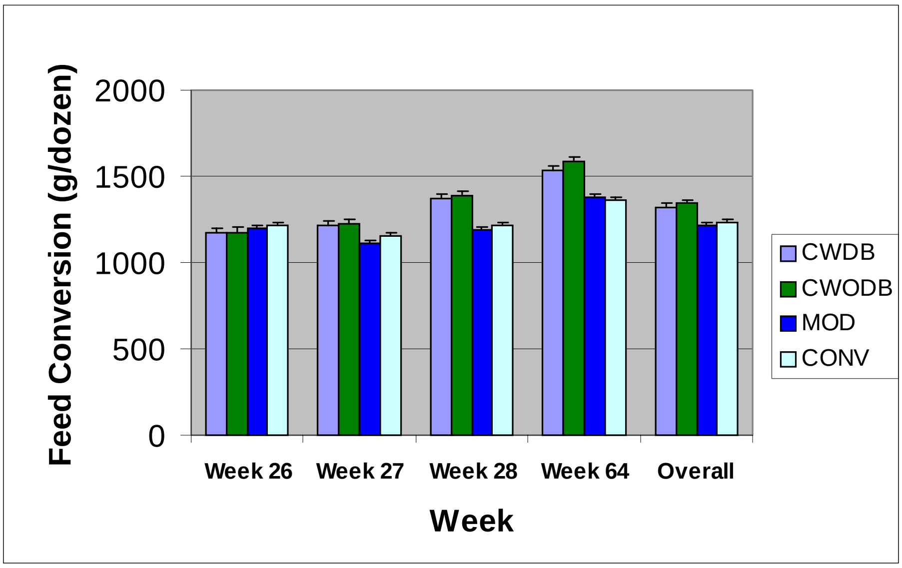


Appleby et al. (2002) observed similar findings for eggs laid in furnished cages. It is possible that since the eggs in this trial were hand collected, eggs rolling out of the nest box would come in contact with eggs in the collecting tray, resulting in a higher incidence of cracking. Although the percentage of soiled eggs was significantly higher in COLWDB cages than all other cages, these differences did not persist beyond wk 20.

No significant differences in egg weight were observed between treatments in wk 20. By wk 24, CON and MOD birds were laying heavier eggs and by wk 28, egg weights were significantly higher in CON and MOD cages than the COL cages. This may suggest that birds in small groups lay larger eggs. Specific gravity and shell weight were significantly higher for COL cages than for CON and MOD cages at week 24, but did not differ significantly at 20 or 28 wks. No significant differences in shell width were observed.

Feed consumption measures between 26 and 28 wks indicated that overall, feed consumption per dozen eggs was higher in COL cages than in CON or MOD cages. Birds in COL cages consumed higher amounts of feed during each weekly period, showing significant differences in wk 27 and highly significant differences in wk 28. These results are consistent with the data obtained for condition scores, since more poorly feather covered birds would require higher feed intake to counter heat loss. Tauson and Svenson (1980) determined that poorly feathered layer hens had a 46% higher maintenance energy requirement due to heat loss, which translated into a 27% larger feed consumption requirement (Figure 14).

Figure 14: Feed Conversion



The preliminary findings from this study suggest that amenities provided in the MOD and COL cages are important for improving the welfare of hens housed in cages. The presence of a dust bath may improve feather condition in a large COL unit, and hen foot and claw condition may be improved by provision of a perch. Hens clearly prefer the secluded environment of a nest box for oviposition, and use of a conveyor system to collect eggs at regular intervals may reduce the number of downgraded eggs observed in MOD and COL cages. MOD cages appear to provide a possible alternative system that provides welfare benefits for layer hens, maintains small group size, and allows producers to modify existing capital.

Summary

•In a large group unit, the presence of a dustbath may improve feather condition
•Hens housed in MOD cages appear to have better plumage condition and consume less feed
•Hen foot and claw condition may be improved by provision of a perch
•Hens prefer the secluded environment of a nestbox for oviposition
•Cannibalism is a problem in colony units

Conclusions

•The amenities provided in the Modified and Commercial cages are important for improving the welfare of hens housed in cages
•Modified cages appear to provide an alternative housing system that:
–provides welfare benefits for hens
–maintains small group size
–allows producers to modify existing capital

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