PERFORMANCE AND EGG QUALITY OF LAYING HENS IN AN AVIARY SYSTEM

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Primary Audience: Egg Producing Companies, Egg Producing Managers, Researchers, Advisors, Teachers

SUMMARY

Laying hens were kept in an aviary system on a practical scale under Swedish conditions during five entire production cycles. All hens were non beak-trimmed, since this is prohibited in Sweden. The aviary type used, Marielund, is a three-tiered aviary with litter. About 4700 hens kept in four pens were housed in each batch. Lohmann Selected Leghorn (LSL) layers were used in all five trials. In addition to LSL, the Lohmann Brown (LB) was used in Trial 3 and an experimental cross (SLU-1329) was used in Trial 5. The performance of the hens from 20 until 80 wk (18.6 to 22.5 kg/hen housed), as well as mortality (4.0 to 20.9%), varied between years. This variation was greater than could be expected in cage systems and was possibly the result of unpredictable cases of cannibalism, in the medium heavy brown hybrid especially, and/or parasitic disorders like Red mites or coccidiosis. The proportion of misplaced eggs (floor eggs) seemed to be influenced by rearing, but was also observed to vary between different pens within batch. The total range during the five trials was between 0.7 and 18.4%. The proportion of dirty eggs was highly dependent on the proportion of misplaced eggs.

Key words: Aviary, egg production, egg quality, housing systems, laying hens
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DESCRIPTION OF PROBLEM

For several years concern has been raised both by the public and by scientists about the impact of battery cage housing on welfare of laying hens. Thus, battery cages have been criticized for increasing incidence of feather damage, foot lesions, and brittle bones [1, 2, 3, 4]. Moreover, conventional cages restrict the movements of hens and prevent certain behaviors, such as laying eggs in nests, scratching and bathing in sand or soil, and roosting on perches [5]. Aviaries have been identified as a possible alternative to cages, providing the hens with a larger total available area and access to nests, litter, and perches [6, 7]. Although production may be similar in aviaries and cages, it has often been reported to be lower in the former, since the risk for feather pecking, cannibalism, disease, and parasites increases [8, 9, 10]. Egg quality, as cracks or dirties, may also be affected since the hens do not lay the eggs on a wire floor in a cage, but instead on the wire floors of the tiers, in a nest, or even in the litter [10].

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In a comprehensive investigation from field data on a commercial scale, large aviary farms used beak-trimmed birds in the Netherlands [11, 12], In these situations production and mortality results were reported to be similar to that of birds in cages. However, medical treatment against parasitic disorders resulted in higher costs for aviary eggs. Similar results from smaller flocks, but with an increase in mortality and decrease in production and less predictability of production, were reported from Switzerland [13].

The present investigation studied performance and egg quality on a practical scale during five batches of birds in entire production cycles under Swedish conditions (climate and the use of non beak-trimmed birds). The project was handled by the Department of Animal Nutrition and Management at the Swedish University of Agricultural Sciences, Uppsala, Sweden. The project was carried out during the same period (March 1988 to June 1995) as studies in smaller experimental units such as at the research station at Funbo-Lövsta near Uppsala, where comparison with cages was included [7, 10]. Between cycles, modifications to the aviary were carried out in order to improve its function.

Materials and Methods

THE AVIARY SYSTEM

A room inside a barn was used measuring 53.0 × 5.6 m and 3.1 m high. In this room an aviary system was installed measuring 48.2 × 5.6 m. The aviary system (Marielund) was divided by wire netting walls into four pens of equal size (24.1 × 2.8 m). This aviary is a modified Swiss system, consisting of three tiers (Figure 1). The two lower tiers have feeders and the top resting tier has perches. All three tiers are equipped with water nipples. In Trial 2 spillage cups were installed under the water nipples. The litter area in this building comprised about 20% of the total available area, *i.e.*, litter floor, tiers, and platforms outside nests. The hens had not access to the floor under the lowest tier.

Nests in three tiers with automatic egg collection belts were attached to the walls of

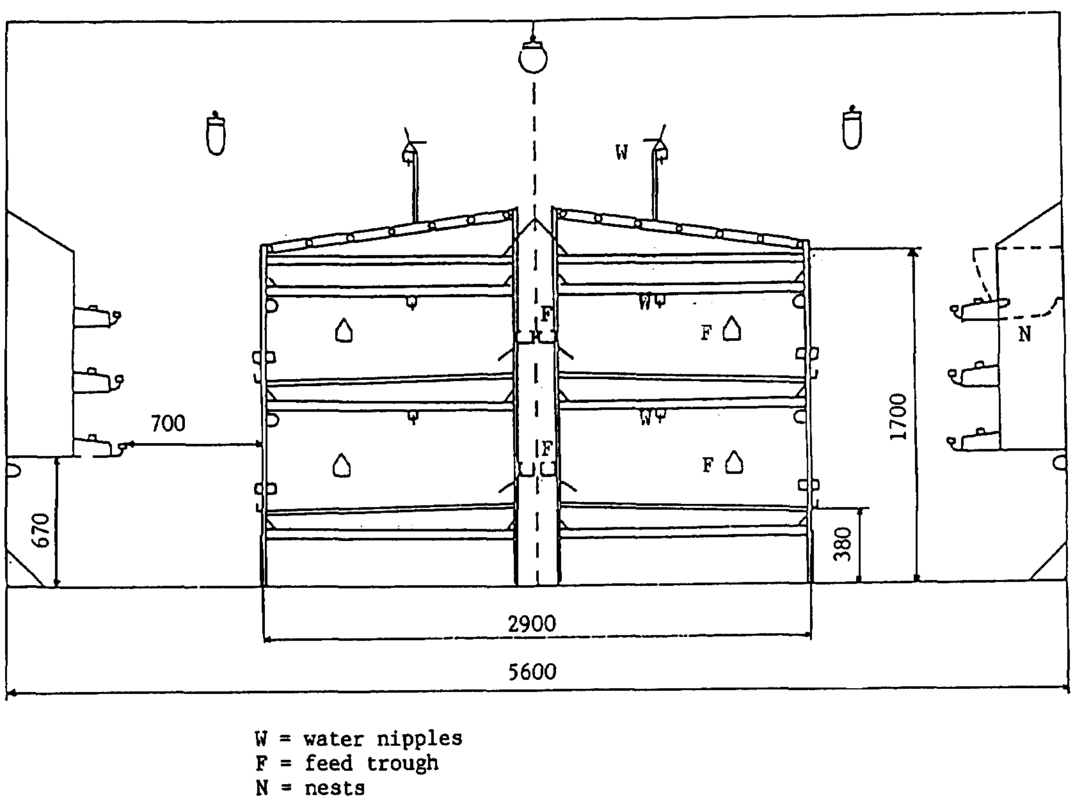

FIGURE 1. Section of the aviary house

the room opposite the aviary tiers. In Trial 1 a plastic bowl design with perforated bottom (Facco) was used. From Trial 2 and onwards, two designs of nests were used: the plastic bowl design and a nest lined with an artificial turf bottom. In Trial 3 the artificial turf was exchanged for turf with small holes. In order to reduce soiling, nests in two of the pens (Facco nests only) were equipped with a time monitored, one-way closing/folding and sloping metal plate, which prevented birds from entering the nests 30 min before dark until 30 min before light. When folded forwards, this plate also enabled old litter, accumulated during the day under the perforated nest bottom placed above, to slide and fall out into the litter bed. The metal plate also prevented light coming in from below through the perforated nest bottom in order to minimize disturbance to hens entering the nests. In the first trial, there were perches on the covers of the egg collection belts, but not in the following trials.

The system had belts for manure removal under each wire tier floor and automatic flat chain feeders. The feeders were run six times per day. Researchers used egg collection belts outside the nests, collecting eggs once a day. Misplaced eggs were collected five times a day until the number of misplaced eggs had declined to an acceptable level, and then a maximum of three times a day. Manure removal belts were run twice a week. The litter was kept in acceptable condition by adding some fresh wood shavings when necessary. Regular removal of litter was not necessary and hence, seldom carried out.

REARING, LIGHTING, AND FEEDING

No birds were beak-trimmed. The pullets were reared on farms 650 km from the laying house in Trials 1 and 2, 500 km in Trial 3 and 350 km in Trials 4 and 5. In Trial 1, the pullets were reared on litter with perches at 30, 60, and 90 cm above the floor with feed and water on the floor. In Trials 2 and 3, the pullets were reared in cages until they were 4 wk of age and thereafter on litter floor with manure bins covered with netting and with perches on top. Feeders and drinkers were located on the net. In Trial 4 the pullets were reared in cages until 4 wk of age, and thereafter on the floor with manure bins covered with netting with feed and water on the netting. In Trial 5, the pullets were reared on the floor during the first weeks, and thereafter on the floor with manure bins as in Trial 4.

At 16 wk the pullets were transferred from the rearing farms by truck to the laying house. In Trial 1 a total of 4632 Lohmann Selected Leghorns (LSL) were used (1158/pen). This placement implied 17 hens/m^2 of ground floor, 9.2 to 9.3 hens/m^2 of available area, and slightly more than 4 hens/nest. In Trial 2 a total of 4700 LSL pullets were housed, 1175 in each pen. In Trial 3, 1208 LSL hens per pen were housed in two pens. In the other two pens 1033 and 1034 Lohmann Brown (LB) were housed. In this trial, the number of hens was reduced at 20 wk to two pens with 1175 LSL hens per pen and two with 1000 LB. In Trial 4, a total of 4799 LSL hens were housed; at 20 wk the number of hens was reduced to 1175 hens per pen. In Trial 5, there were two pens with 1200 and 1199 LSL hens per pen. In the other two, 1210 and 1211 hens per pen were housed. They were of a Rhode Island Red × White Leghorn hybrid (SLU-1329), an experimental cross selected on diets with lower crude protein and energy contents. These hybrids were developed at the Department of Animal Breeding and Genetics, Swedish University of Agricultural Sciences.

At 16 wk the pullets were given 8 hr of light per day. Light was successively increased to 10 hr at 19 wk, 12 hr at 20 wk, and then by 30 min/wk to 16 hr/day at 28 wk. Lights were installed above the top resting tier, over the litter area, and at the vertical supports in the feeding tiers. In Trial 1 an artificial dawn and dusk of 16 min affected the whole aviary. In Trials 2 through 5, the light was turned on or off according to a special procedure in order to prepare birds for certain activities during periods of light and dark [14], *e.g.*, to facilitate the finding of food and water and to calmly find their way up to the perches on the resting top tier. Hence, in the morning, the light was first turned on instantly in the feeding tiers and over the litter area and then, 15 min later, the light over the top resting tier was gradually increased for 15 min. In the evening, the procedure was reversed, *i.e.*, the light was turned off first in the feeding tiers and over the litter, and then the light over the top tier was dimmed.

Until 18 wk the pullets were fed a grower's mash containing 15.0% crude protein (CP), 2600 kcal/kg ME, 1% Ca, and 0.7% P. During the following production period until slaughter at 80 wk, the hens were fed a commercial-type layer's mash meal containing 15.0% CP, 2700 kcal/kg ME, 3.5% Ca, and 0.6% P. Chicks reared for Trials 1, 2, and 3 were treated prophylactically with anticoccidials. Starter feed contained 125 ppm amprolium, and 8 ppm ethopabate, and grower feed 75 ppm and 5 ppm, respectively. No anticoccidials were given to birds in Trials 4 and 5 during rearing. Feed consumption was registered as a total average for the whole flock.

RECORDING AND STATISTICAL ANALYSIS OF DATA

Production, feed consumption, and mortality were recorded from 20 wk to 80 wk. The feed consumption was registered as a total mean for the whole flock and was not recorded per pen and thus the reported data is for each entire test without a breakdown of hybrid results. The weight of a sample of eggs was recorded on 1 day every week, 120 eggs per pen in Trials 1, 2, and 3, 270 eggs per two pens in Trial 4, and 180 eggs per pen in Trial 5. Samples of 2160 eggs from each pen were collected for candling at a commercial egg packing plant in order to record frequencies of cracked and dirty eggs corresponding to normal commercial egg grading procedures. In the five trials, the commercial egg grading was carried out on 15, 11, 9, 7, and 7 occasions, respectively.

At 36 and 72 wk, a sample of 20 eggs from each pen was collected for recording interior quality and shell strength, measured at the same day as collection. The traits recorded were albumen height, Haugh units, yolk color according to the La Roche scale (scores 1–15), blood spots, meat spots, shell percentage, and shell deformation [15]. Thickness of the shell [16] and shell weight (mg/cm^2) were also calculated [17]. Plumage condition, health, and causes of death were also recorded during the production period [18].

Statistical analyses were performed with an ordinary analysis of variance, using the General Linear Models of the Statistical Analysis System [19]. In Trials 3 and 5 effects of hybrid and nest design were tested, while in the other trials only effects of nest design could be tested. In the statistical model hybrid and nest design were considered fixed. No interaction effects could be included because this degree of freedom was used for the error term. If nest design was found non-significant, it was excluded from the model in order to increase the degree of freedom of the error term in the model. For exterior egg quality, the weighted means for the registration periods were used. Before analysis, the traits given in proportions (blood and meat spots, cracked and dirty eggs) were subjected to arcsin transformation [20].

RESULTS AND DISCUSSION

PRODUCTION AND MORTALITY

Since 1991 the Marielund aviary system has been tested at the Field Phase Testing program under the control of the Swedish Board of Agriculture [21]. Although not previously studied as closely as in this experiment, the system has shown similar results. However, production levels and mortality rates have been somewhat improved in white light hybrids, mostly the LSL as used in the present study.

The results of egg production, mortality, and feed consumption in the present trials appear in Table 1. Egg production within the LSL hybrid was rather similar in all trials, except in Trial 2 where it was considerably lower. In that trial there was high mortality mainly due to coccidiosis and leucosis as well as cannibalism [18], factors which influenced the overall performance of the birds. In Trial 3, LB had higher egg weight ($P < .05$) and higher mortality ($P < .05$) than did LSL, but egg production was not significantly different between the two hybrids. The high mortality in LB results from cannibalism [18]. A higher mortality in non beak-trimmed medium heavy brown hybrids than in light white birds in aviaries agrees with studies in the smaller experimental units [7, 10]. In Sweden, in contrast countries where beak trimming helps prevent cannibalism, one way to reduce this unwanted behavior in a flock is to lower light significantly. However, this practice may have other consequences, possibly increasing the number of misplaced eggs as well deteriorating the work-

TABLE 1. *Production, mortality, and feed consumption from 20 to 80 wk during five batches*

TRIAL	1	2	3		4	5	
HYBRID	LSL	LSL	LB	LSL	LSL	SLU-1329	LSL
Laying % (hen day)	82.3	80.4	76.0	79.9	84.6	75.0**	82.6**
Egg weight, g	60.4	60.6	65.1*	64.2*	64.8	65.4*	64.3*
Egg mass, kg/hen housed	20.5	18.6	18.8	20.6	22.5	19.5**	21.2**
Egg mass, g/hen/day	49.6	48.7	49.5	51.3	54.8	49.0***	53.1***
Mortality, %	4.0	15.6	20.9*	6.3*	6.0	7.2*	6.0*
Misplaced eggs, %	8.2	0.7	2.3	10.5	1.7	5.0	5.3
FCR, kg feed/kg egg	2.34	2.44	2.53		2.29	2.36	
Feed consumption, g/day	116	119	128		126	121	

*P < .05; **P < .01; ***P < .001.

ing environment for people working in the house.

The appearance of parasitic disorders and Red mite invasion in Trial 1 or coccidiosis in Trial 2 agrees with a similar situation in Dutch aviary housing on a commercial scale [11, 12]. The considerable level of unpredictability, where good results are mixed with unacceptable ones, agrees with Swiss results [13].

In Trial 5, SLU-1329 birds had a lower laying percentage ($P < .01$), higher egg weight ($P < .05$), and lower egg mass (kg/hen housed, $P < .01$; g/hen/day, $P < .001$) compared to LSL birds. A lower production for SLU-1329 agrees with results in a resent study in a Marielund aviary [22], but contrasts with results in traditional low density floor systems, where this university hybrid has actually produced better than some other commercial hybrids [23, 24]. The SLU-1329 birds were observed eating more of the misplaced eggs before collection than LSL, partly explaining the lower production recorded. The SLU-1329 also had higher mortality ($P < .05$) than LSL, but the mortality for both hybrids in that trial was considered acceptable.

The proportion of misplaced eggs was similar in all pens within year, except in Trial 3, where one LSL pen had 2.6% and the other 18.4%. This fact, together with considerable variation between batches, offers a good illustration of the large variation that an egg producer needs to include in a calculation when using floor systems. In Trial 1, the proportion of misplaced eggs was also high, whereas in the other trials it was considerably lower. The hens in Trial 1 were reared on litter with perches, but with food and water on the floor. The birds in the other trials had food and water on raised platforms and had obviously learned to move vertically to a larger extent, therefore finding nests more easily. Although no comparisons within batch between rearing systems were carried out, this factor may illustrate the importance of appropriate rearing. In other words, hens should be reared in a system similar to the one they will be housed in during the production period. This finding has been pointed out earlier [25, 26]. However, in Sweden it is still difficult for farmers to find birds optimally reared for aviaries.

EXTERIOR EGG QUALITY

The proportion of cracked eggs (Table 2) was higher in the last two trials than in the earlier ones. In Trial 5, SLU-1329 had more cracked eggs than LSL ($P < .05$). In Trial 1, the proportion of cracked eggs in nest eggs and misplaced eggs were similar. In Trial 2, however, floor eggs had a lower proportion of cracks than did nest eggs, possibly because an egg with a small crack laid on the floor has a greater risk of being broken when hens peck at it. Broken eggs will then be eaten very quickly and will not be recorded. All eggs laid in the nests will, instead, roll onto the egg collecting belt, where the hens cannot reach them.

The proportion of dirty eggs varied greatly between trials. Most of the eggs laid outside the nests were dirty (85.5 and 98.4% in Trials 1 and 2, respectively). Hence, due to a large proportion of misplaced eggs, the frequency of dirty eggs in Trial 1 was high in

TABLE 2. Exterior egg quality at candling in a packing plant during five batches

TRIAL	1	2	3		4	5	
HYBRID	LSL	LSL	LB	LSL	LSL	SLU-1329	LSL
CRACKED EGGS, %							
Total	3.3	3.5	3.4	3.3	4.4	7.9*	4.7*
Nest eggs	3.3	3.5	–	–	–	–	–
Floor eggs	3.4	1.6	–	–	–	–	–
DIRTY EGGS, %							
Total	18.5	9.2**	4.8	13.0	7.1	11.7***	13.6***
Nest eggs	12.9	8.5**	–	–	–	–	–
Floor eggs	85.5	98.4	–	–	–	–	–

*P < .05, hybrids; **P < .07, nest design; ***P < .10, nest design.

all pens. In Trial 2 the proportion of dirty eggs was 7.7% in the two pens with Facco nests (with the nest closing device), while in those with turf nests it was 10.7% (P < .07). Of eggs laid in nests, these proportions were 7.1 and 9.9%, respectively (P < .07). In Trial 3 the proportion of dirty eggs was about 5% in all pens, except in the LSL group with a high proportion of misplaced eggs, where it was 20%. These data give a good illustration of the importance of having a very low proportion of misplaced eggs. In Trial 4, pens with Facco nests had 5.4% dirty eggs and pens with turf nests had 9.0% (in this trial the two pens with different nest design were not separated when candled and therefore no statistical analysis could be carried out). In Trial 5, the proportion of dirty eggs from pens with Facco nests was 10.1% for both hybrids, whereas in turf nests it was 13.4% for SLU-1329 and 17.0% for LSL, respectively (P < .21 if hybrid is included in the statistical model and P < .10 if not).

It is important not only to provide an aviary with a good nest design that will attract hens but also to provide clean nests which do not cause damage to eggs when they roll out onto the egg collection belts. In this experiment, nest closing and nest bottom material were in fact confounded treatments. However, no clear differences were registered between presence or absence of a closing mechanism in Trial 1 with regard to cracked or dirty eggs, where all nests were of the plastic bowl design. Therefore, it may be concluded that dirty eggs in Trials 2 to 5 were more influenced by nest lining than by nest closing. Possibly the closing needs to eject the hens from the nests to be really effective since in the present study it was possible for hens to remain and defecate during the night in the nests when the closing device was folded down. Even though most hens left the nests, some stayed overnight.

INTERIOR EGG QUALITY AND SHELL STRENGTH

The results of the interior egg quality studies appear in Table 3. Apart from a falling trend of yolk color between successive trials within the LSL hybrid, there do not seem to be other trends. However, in Trial 3 at 36 wk, LB had thicker shells (P < .05) and greater shell weight (P < .05) than LSL did. At 72 wk, LB eggs had less shell deformation value (P < .05), thicker shells (P < .05), higher shell weight (P < .05), higher shell percentage (P < .001), and more blood spots (P < .05) than LSL. In Trial 5 at 36 wk, SLU-1329 had lower albumen height (P < .01) and lower Haugh units (P < .001) than LSL, a difference that remained at 72 wk (P < .05 for both values). There were no significant differences between SLU-1329 and LSL regarding shell deformation and shell percentage, but a slightly thinner shell in the former hybrid could explain some of the increased proportion of cracked eggs, a possibility which agrees with other experimental studies [22].

TABLE 3. Interior egg quality and shell strength at 36 and 72 wk during five batches

TRIAL	1	2	3		4	5	
HYBRID	LSL	LSL	LB	LSL	LSL	SLU-1329	LSL
36 WK OLD							
Albumen height, mm	8.36	7.39	7.47	8.00	8.40	6.75**	8.38**
Haugh units	90.5	85.7	85.0	88.2	90.2	80.5***	91.3***
Yolk color, points	9.6	9.3	7.4	7.2	6.3	6.2	6.0
Deformation, μm	22.6	22.8	21.1	21.9	21.7	22.3	21.8
Shell thickness, 10^{-2} mm	33.3	32.6	33.0*	32.7*	33.4	32.5	33.0
Shell weight, mg/cm^2	79.4	77.8	78.6*	78.0*	79.7	77.4	78.6
Shell %	9.4	9.3	9.2	9.1	9.3	9.1	9.4
Blood spots, %	3.7	2.5	5.0	2.5	0.0	2.5	0.0
Meat spots, %	1.2	2.5	7.5	2.5	2.5	0.0	0.0
72 WK OLD							
Albumen height, mm	6.44	6.58	6.10	6.63	7.24	5.63*	6.97*
Haugh units	77.5	78.4	72.5	77.9	82.3	69.4*	80.2*
Yolk color, points	9.5	10.4	7.4	7.3	7.6	6.6	6.4
Deformation, μm	25.7	23.9	23.0*	26.6*	25.5	25.9	24.9
Shell thickness, 10^{-2} mm	31.6	32.1	33.1*	31.2*	31.7	30.3	31.7
Shell weight, mg/cm^2	75.1	76.4	78.8*	74.1*	75.5	71.9	75.4
Shell %	8.7	8.9	9.0***	8.5***	8.7	8.2	8.6
Blood spots, %	2.5	2.5	20.0*	2.5*	1.2	5.0	0.0
Meat spots, %	0.0	0.0	12.5	12.5	7.5	2.5	7.5

*P<.05; **P<.01; ***P<.001.

Conclusions and Applications

1. The performance of layers in the aviary under Swedish conditions varies between years and more than can be expected in cage systems. The main reasons seem to be random outbreaks of cannibalism in non beak-trimmed medium heavy brown birds, especially, and in occurrences of coccidiosis. The proportion of misplaced eggs (tiers and in the litter) seems to be influenced by rearing, but can also vary between different pens within the same building.
2. The proportion of dirty eggs is highly dependent on the proportion of misplaced eggs, since most misplaced eggs are defecated.

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