Distracting laying hens with a 'toy' : Does it work?

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Intensively housed animals may become mutually destructive, with resulting detrimental effects on production. The use of a commercially available plastic device, intended to distract laying hens, was investigated and found not to have the claimed effect. The means to plan a future experiment are supplied.

Intensief-behuisde diere kan onderling vernietigend wees, met nadelige gevolge vir produksie. Die gebruik van 'n kommersieel-beskikbare plastiese voorwerp wat lêhenne se aandag aftrek is ondersoek. Daar is bevind dat die voorwerp nie die beweerde uitwerking het nie. Die middele om 'n toekomstige eksperiment te beplan word verskaf.

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Introduction

Modern practice includes the housing of animals in close proximity. The result may be that certain natural behavioural patterns in these animals are transmuted into behaviour detrimental to production. In response to such situations, animal scientists have developed management practices intended to negate the disadvantageous effects of other practices. (For a discussion of this topic, see Wegner, 1990.) In the case of laying hens housed in multi-hen cages, a recent development is the use of a plastic 'toy' (hung from the roof of a cage) to relieve stress amongst the birds housed in that cage. The toy is claimed to have a calming effect on the hens by deflecting the attention of dominant individuals from the weaker ones to the toy and hence improving productivity.

To our knowledge, no scientific investigation of the efficacy of the toy has been conducted. A brochure put out by the company manufacturing the toy reports on 'trials' conducted in various places in the world, but neither these trials nor the report can be described as being scientific:

- It has been understood since the beginning of the era of modern Statistics (see Fisher, 1926) that systematic designs are an inappropriate tool in scientific investigation because a valid estimate of error is not available. The *trials* can therefore not be described as being scientific because a systematic experimental design was apparently used in all cases.
- Since a statistical analysis is not possible, standard errors for differences in production observed between treatment and control cannot be calculated. The absence of standard errors in the *report* implies that it is impossible to determine whether the differences reported must be attributed to a systematic treatment difference, or simply to the differences normally observed in biological material.

Materials and Methods

Two strains of commercial layer were used in the experiment, viz. a white strain (Lohmann Silver) and a red strain (Lohmann Brown). The white birds were housed at five birds per cage, and the red at four per cage. For this reason, separate analyses were performed. An analysis will be given below which justifies separate analyses. All analyses were done using the General Linear Model procedure (PROC GLM) of the Statistical Analysis System (SAS, 1989).

The battery cages used in the experiment were arranged in rows of 12 cages, with 4 rows forming a pyramid and 7 pyramids in the house (Figure 1). The white birds were housed in pyramids 1 through 3, and the red birds were housed in all but one row of the remaining 4 pyramids. Thus, $12 \times 12 \times 5 = 720$ white hens, i.e. (rows) $\times$ (cages/row) $\times$ (hens/cage), and $15 \times 12 \times 4 = 720$ red hens, were housed.

A randomized block design was used to eliminate potential sources of variation. The possibility of differences between upper and lower rows of cages was thus taken into account in the design, as was the possibility of differences between cage rows facing north and south, along with the possibility of differences on the outside of a row and the inside of a row. The result was an experimental unit of two adjacent cages, and blocks of size 2 (toy vs. no toy). The field plan is given in Figure 2. The letters 'TT' symbolize the two adjacent cages of an experimental unit which contained the toy and the letters 'NN' symbolize an experimental unit which did not contain the toy. Thus, each section in a row formed a block.

The data collected were the number of eggs laid from 15 October 1991 to 27 January 1992, i.e. over a period of 15 weeks (105 days). The data were analysed every week, but only summary analyses (for the whole period) are reported below.

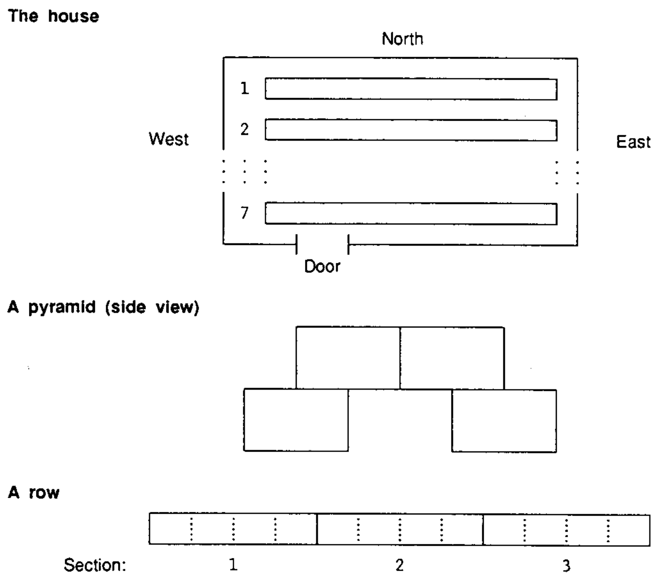

Figure 1 The physical facilities.

Hens	Row	Section 1		Section 2		Section 3	
	1	TT	NN	TT	NN	TT	NN
	2	NN	TT	NN	TT	NN	TT
	3	TT	NN	TT	NN	TT	NN
	4	NN	TT	NN	TT	NN	TT
	5	NN	TT	TT	NN	TT	NN
	6	TT	NN	NN	TT	NN	TT
White	7	NN	TT	TT	NN	TT	NN
	8	TT	NN	TT	NN	TT	NN
	9	TT	NN	NN	TT	TT	NN
	10	NN	TT	NN	TT	TT	NN
	11	TT	NN	NN	TT	NN	TT
	12	TT	NN	NN	TT	TT	NN
	14	TT	NN	NN	TT	NN	TT
	15	NN	TT	TT	NN	TT	NN
	16	NN	TT	NN	TT	NN	TT
	17	NN	TT	TT	NN	NN	TT
	18	NN	TT	NN	TT	NN	TT
	19	NN	TT	NN	TT	NN	TT
	20	NN	TT	TT	NN	TT	NN
Red	21	NN	TT	NN	TT	NN	TT
	22	TT	NN	NN	TT	TT	NN
	23	NN	TT	TT	NN	NN	TT
	24	TT	NN	NN	TT	TT	NN
	25	NN	TT	NN	TT	NN	TT
	26	TT	NN	NN	TT	NN	TT
	27	TT	NN	TT	NN	NN	TT
	28	NN	TT	NN	TT	NN	TT

Figure 2 The field plan.

Results

The results for the white birds are given in Table 1 and those for the red birds in Table 2. These tables supply the information needed to test the hypothesis:

H_0 : there is no treatment difference;

versus H_a : there is a treatment difference.

Table 1 ANOVA[1] table for the white birds, 15 week egg production

Source of variation	df[2]	SS[3]	MS[4]	F ratio	SL[5]
Blocks	35	67627.61	1932.22		
Treatments	1	1233.39	1233.39	0.7104	0.4050
Error	35	60767.61	1736.22		
Total (corrected)	71	129628.61			

[1] ANOVA = Analysis of variance.
[2] df = Degrees of freedom.
[3] SS = Sum of squares.
[4] MS = Mean square.
[5] SL = Significance level (see Kempthorne & Folks, 1971).

Table 2 ANOVA[1] table for the red birds, 15 week egg production

Source of variation	df[2]	SS[3]	MS[4]	F ratio	SL[5]
Blocks	44	35599.60	809.08		
Treatments	1	700.01	700.01	0.5907	0.4463
Error	44	52144.49	1185.10		
Total (corrected)	89	88444.10			

[1–5] See Table 1 for explanation of superscripts.

There is no evidence against H_0 in the case of the white birds, nor in the case of the red birds. Another means of presenting this fact is to display the treatment means. On the basis of 1 050 bird-days (10 birds housed for 105 days), the means for the white birds were:

Without Toy, 943 eggs; With Toy, 935 eggs.

The standard error of the difference between these means is 9.82. On a single-bird basis (bird housed basis), the 15-week averages are thus 94.3 and 93.5 with a standard error of a difference equal to 0.982. Hence, the observed difference of 94.3 – 93.5 = 0.8 is indistinguishable from experimental error. In this comparison the mean Without Toy exceeds the mean With Toy, but this was not a consistent result from week to week. The latter observation is consistent with the null hypothesis, i.e. that there is no systematic difference between the two groups, the weekly observed difference being positive or negative purely owing to chance.

The results for the red birds can be expressed on the basis of 8 × 105 = 840 bird-days:

Without Toy, 749 eggs; With Toy, 755 eggs.

The difference is 6 with a standard error of 7.26. On the basis of a single bird housed the means are 93.7 and 94.4 and the standard error of the difference, –0.7, is 0.907.

The decision to perform separate analyses depending on the strain of hen was based on evidence suggesting that the error variance for the white hens is larger than that of the red hens. In the first week these were 17.2678 and 7.8773, respectively. The red hen error variance was numerically smaller than the white hen variance in 14 of the 15 weeks. The exception was in week 6, when the values were 8.9821 and 11.1657, respectively. In the fifteenth week the values were 26.8270 and 14.4278, respectively, which translates to a significance level of 0.0260. This is strong evidence against the hypothesis of no difference between the experimental errors. (The variance estimates for the fifteen weeks cannot be combined by a simple rule since they are correlated.) Note that the decision to perform separate analyses favoured the toy, since separate analyses will allow one to show up a smaller systematic difference than would a combined analysis.

Criticisms of the experiment

The experiment can be criticized on two grounds:

Firstly: The toys were installed in the cages *after* the birds had come into lay (when they were 28 weeks old). The potential for an effect was appreciated, but the possibility of postponing the experiment was excluded by the company commissioning the experiment.

Secondly: After the experiment had run for about two months, the arrangement of the experimental units was criticized. The manufacturers of the toy felt that there should have been intervening cages between the experimental units, to prevent the birds in an experimental unit not receiving the toy being influenced by the toys in the adjacent experimental unit. (Recall that an experimental unit consisted of two adjacent cages.) This criticism may be answered by pointing out that the design used in the investigations reported in the manufacturer's brochure made no such arrangements; birds in cages without an installed toy would have been able to see the toy in adjacent cages. Moreover, the objection can only be based on the assumption that hens do not actually need contact with the toy, that it is sufficient that they only need to *see* it somewhere in their environment. The logical conclusion of such an argument would be that one could hang one oversize toy from the middle of the roof of the battery house. However (and more constructively), the present experiment can be used to obtain information to answer this criticism. Figure 2 shows that a limited number of *single* cages are 'protected' by an adjacent cage which was treated in exactly the same way. For example, all the cages on the outsides of the rows have this property. Within a row, two such cages arise every time the sequence such as 'NN TT' is followed by the reverse sequence, i.e. 'TT NN' in the example. The right-most cage of the first pair and the left-most cage of the second are so 'protected'. Beginning with week 8 (i.e. for a total of 8 weeks, 56 days), a second analysis was performed for each new week's data; the numbers of eggs laid by the hens in 'protected' cages was extracted from the raw data, and analysed. These analyses are summarized in Tables 3 & 4. On the basis of the previous analyses and for technical reasons, no attempt was made to take account of blocking in these analyses.

Table 3 ANOVA[1] table; egg production of 'protected' white hens

Source of variation	df[2]	SS[3]	MS[4]	F ratio	SL[5]
Treatments	1	6.10	6.10	0.0409	0.8408
Error	40	5966.38	149.16		
Total (corrected)	41	5972.48			

[1-5] See Table 1 for explanation of superscripts.

Table 4 ANOVA[1] table; egg production of 'protected' red hens

Source of variation	df[2]	SS[3]	MS[4]	F ratio	SL[5]
Treatments	1	7.98	7.98	0.0273	0.8694
Error	50	14603.46	292.07		
Total (corrected)	51	14611.44			

[1-5] See Table 1 for explanation of superscripts.

The treatment means for the white hens (on the basis of 5 hens per cage, a total of 280 hen-days) were 252 (no toy) and 251 (with toy) eggs. Since there were 21 cages of each type, the standard error of a difference is 3.77 eggs. Since the observed difference is well within experimental error, there is no basis for a claim of superiority (or inferiority) as a result of the use of the toy. For the red birds (on the basis of 4 hens per cage, a total of 224 hen-days) the averages are 195 (an average over 24 cages without toy) and 194 (28 cages with toy). The standard error of the difference between two such means is 4.75 eggs. Once again, the observed difference is well within experimental error.

Planning a future experiment

Using the results for the white hens as example, one can ask: 'How large a difference could one show up if one were to run exactly the same experiment (so far as numbers are concerned) for (say) 10 months?'

To get an answer to this question, the simplifying assumptions of a constant variance from week to week and of a constant correlation between any two weeks are useful. Then the variance for the total production in n weeks is

$$\mathrm{Var}\left[\sum_{i=1}^{n} x_i\right] = ns^2\left[1 + (n-1)r\right] = v, \quad \text{say,}$$

in which x_i is the production of an experimental unit (10 birds) in the i^{th} week, s^2 is the common variance and r is the common correlation. To estimate these unknown values, the average of the observed variances in the 15 weeks yields

$$s^2 = 18.4382.$$

Solving the above formula after substituting s^2 and equating it to the 15-week observed variance, 1736.22, yields

$$r = 0.3770.$$

Now, taking n at various values (but assuming 36 blocks of 10-bird experimental units), one can calculate the standard error of the difference between the two treatment means, $\sqrt{2v/36}$. The results, divided by 10 to express them on a single-bird basis, are given in Table 5.

This table warns that the 'typical' difference between the single-bird means of two groups of hens which were treated identically will be 2½ eggs after 10 months. If the two groups were treated differently, there would have to be a difference of at least 5 eggs before one had evidence that there is a systematic difference in egg production as a result of the treatments. However, the aim of the experiment should not be to merely show up a difference, but to show up a profitable difference. Hence, if the cost of the toy for a hen housed for 10 months is

Table 5 Extrapolated standard errors

n weeks	Months	Standard error
20	5	1.29
24	6	1.54
40	10	2.54

the equivalent of say 2 extra eggs laid, then one would have to observe a difference of 7 eggs before one could claim that the use of the toy is advantageous.

Alternatively, one could ask: 'How large an experiment (how many blocks) would be needed to show up a difference of say ($\delta =$) 3 eggs in an experiment lasting say two months?' The above information and the recipe in section 6.14 in Snedecor & Cochran (1989) will allow one to answer this question.

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