A System Approach to Determining the Feasibility of Forced Molting Commercial Layers

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ABSTRACT The economical and practical considerations in determining the feasibility of molting a commercial layer flock are based on several production and economical factors. This paper describes a computerized model used to predict: 1) the economic feasibility of molting when layers are in various production periods; 2) the net profit resulting from different molting procedures; and 3) the effect of increased feed cost on net profit.

On the basis of the application example and parameters in this study, forced laying hen molt resulted in higher net profit for two different molt regimens than for the no-molt alternative. However, based on the fixed inputs, the molt procedure employed resulted in different net revenues. The situation and assumed conditions evaluated represented several alternatives to commercial producers.

The model is designed to generally evaluate the feasibility of molting at various ages. The reliability of using a computer model to predict molt or no-molt alternatives is dependent on accurate data inputs.

(*Key words:* forced molting, laying hens, modeling, environmental temperature)

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INTRODUCTION

The management team of an economically sound commercial layer operation investigates any feasible technique to minimize costs or maximize revenue. Least-cost feed formulation is one such technique to minimize feed cost by taking advantage of the various feed ingredients available at economical prices at various times of the year. Another profit enhancing technique is the forced molting of cage layers, a management technique to avoid the cost of replacing pullets annually. This management technique may reduce investment cost and increase egg production during the layer's life span. Wakeling (1977) presented a review of forced molting. Many practical and experimental molting procedures are available. Two recent molting procedures presented in the literature were published by Savage (1976) and Brake *et al.* (1979).

Egg production is a complex system. Body size, strain, egg production, egg size distribution, feed consumption, environmental temperature, seasonal changes in egg prices, and feed costs are some of the important factors affecting the system performance. A mathematical model of the layer is beneficial, not only to study these factors, but also to use as a tool in the decision-making process of evaluating alternatives. An individual commercial egg company can use such a mathematical model with their specialized inputs to predict the feasibility of molting.

Brown *et al.* (1976) developed a mathematical model of a laying hen to predict performance in terms of eggs produced and feed consumed as functions of dietary energy, protein, and environment. Economics were not considered in this model. The model can be used to study the effects of feed ingredients on egg production but is too complicated for practical use in the commercial layer industry. Rahn (1977) developed a computerized budgeting procedure to evaluate layer programs. Factors considered in the model were mortality, body weight, feed consumption, egg production, and grade A egg yields. The model does

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not directly consider egg size distribution, price spreads between size categories, and temperature effect on feed consumption. The forced molting procedures outlined by Savage (1976) were assumed in Rahn's model.

The purpose of this paper is to study the feasibility of the forced molting as compared to a no-molt situation. The model considers hen-day production, body weight, feed consumption, feed cost, environmental temperature, forced molt, the time molting occurs, production period, and fixed and operating costs involved in producing and packing eggs.

MODEL DEVELOPMENT

The program written in FORTRAN IV language,[4] is a simulation procedure of the layer operation from the starting pullet age of 20 weeks through the sale of cull hens at 100 weeks. The base situation is one without molting, and the alternatives are compared with the base situation. The assumed 80 weeks laying hen production was used because of the production times used by Rahn (1977).

Body weight estimates, essentially a function of age, were based on data developed by Bell (1978). Hen-day production curves were developed according to Savage (1976) and Brake *et al.* (1979). Temperature effects on hen-day production were based on the following curvilinear relationships developed by Brown *et al.* (1976):

For temperature below 25 C:

$$THDP = .02808142 - .08979 \times HDP(J) + .071576 \times [HDP(J)]^2$$

$$AHDP(J) = HDP(J) \times (1.0 - THDP \times [TEMP(J) - 25.01])$$

For temperature above 25 C:

$$THDP = .03155985 - .107099 \times HDP(J) + .092831 \times [HDP(J)]^2$$

$$AHDP(J) = HDP(J) \times (1.0 - THDP \times [TEMP(J) - 25.01])$$

where:

THDP = correction factor due to temperature
HDP (J) = hen-day production per period as shown in Figure 1
AHDP (J) = actual hen-day production
TEMP (J) = temperature in °C
J = production period, J = 1 to 20

Body weight, egg production, and environmental temperature were considered the major factors affecting the feed consumption. Average house temperatures corresponding to calendar months are shown in the Application Example, section 8. The following equation, developed by Byerly (1941), was used to calculate feed consumption.

$$FIT(J) = .0523 \times (BWT[J])^{.653} + 1.126 \times DWT + 1.135 \times EGGWT(J)$$

where

FIT (J) = feed consumption in grams per hen during period J
BWT (J) = body weight in grams at start of period J
DWT = change in body weight in grams between period J-1 and J
EGGWT (J) = egg weight in grams produced during period J
J = production period, J = 1 to 20

Environmental temperature has the most pronounced effect of the factors altering feed consumption. The percentage of variations in feed consumption at various temperatures in the program were based on those of North (1979). The feed consumptions obtained from the above equation were adjusted upward or downward depending on temperature.

Egg weight produced during each period was calculated as follows:

$$EGGWT(J) = 28.0 \times AHDP(J) \times AEGGWT(J)$$

where

AHDP (J) = actual hen-day production
AEGGWT (J) = average egg weight
J = production period, J = 1 to 20

[4]The complete listing of the program is available from the author upon request.

The weighted average egg weight was the sum of average egg weight of each size.

The forced molting procedures outlined by either Savage (1976) or Brake *et al.* (1979) were followed. Each production period represents 28 days. The molting period is assumed to begin in production period 11 and requires 28 days. The feed consumption during the molting period is 7.7 kg per 100 hens per day. The loss in body weight during molting is assumed to be 25% of the starting body weight as indicated by Brake and Thaxton (1979). The body weight after molting is assumed to be 88% of the weight of the same age hen without molting. The inputs assumed in Savage's molting procedure were described by Rahn (1977). Alternatives are based on 20 production periods in Rahn (1977) used in excess of 20 production periods.

Production and packing costs including fixed and operating costs were based on data developed by H. E. Wildey (1979, personal communication). For a 25,000 caged layer unit with mechanical feeders and hand egg gathering, curtained sidewalls water flush manure removal system, the annual fixed cost is $.742 per bird. The operating cost is $.098 per bird. The labor cost is $.361 based on the basis of 8 hr per day at $3.10/hr. The total cost for packing and distribution is $.1519 per dozen. Total returns from the system are the sum of the egg value obtained by multiplying number of eggs produced in each size by price of each size and the hen salvage value.

In this program we use table look-up function TABEX, developed by Llewellyn (1965) to handle the functional relationships such as hen-day production, age-body weight, temperature-feed consumption, etc. No attempts were made to fit these relationships in a linear or curvilinear form.

INPUT AND OUTPUT PARAMETERS

The input parameters to the model are in the following order:

1. Hen-day production
2. Egg price of each size (extra large, large, medium, small, and undergrade)
3. Hen age at molting
4. Hen-day production after molting
5. Average egg weight of each size
6. Body weight and hen age relationship
7. Temperature effect on feed consumption
8. Environmental temperature of each period
9. Feed price

Other input parameters such as fixed and operating costs of egg production, packing cost, pullet cost, and total production period are considered to be constant for any particular system; therefore, they are not treated as input variables.

The output parameters of the model include number of eggs produced, egg value, body weight, feed consumption, feed conversion, feed cost, egg weights for each period, egg value, feed consumption, and total production and marketing cost such that a monthly cashflow is generated. For comparison, the program also calculates the total production and marketing costs resulting from an increase in feed price by 5, 10, 15, and 20%.

APPLICATION EXAMPLE

Input data expressed in this example may or may not be correct for certain breeds, season of the year, or area of the US. However, for illustration purposes, the following input data are used:

1. Hen-day production during each period as described by Brake *et al.* (1979) and Savage (1976).
2. Farm egg prices obtained from current market prices in January 1980 are 53, 51, 49, 47, and 30¢ per dozen for extra large, large, medium, small, and undergrades.
3. Hen ages at molting are considered at 68, 72, and 76 weeks of age and production periods of 13, 14, and 15.
4. Hen-day production after molting as described by Brake *et al.* (1979) and Savage (1976).
5. Average egg weights used were 67.3, 60.2, 53.1, and 46.0 g for extra large, large, medium, and small egg sizes, respectively.
6. Hen age (weeks) and body weight (kg) relationships are:

Hen age	Body weight
18	1.205
20	1.295
22	1.386
24	1.464
26	1.532
30	1.655
40	1.741
50	1.786
60	1.814
70	1.832

7. Temperature effects on feed consumption are:

Temperature (C)	Degree of influence on feed consumption (%)
4.44	115.6
10.00	112.4
15.56	107.1
21.11	100.0
26.67	91.6
32.22	76.9
37.78	62.2

8. Assumed environmental temperatures of each period are:

Production period	Temperature (C)
1	15.56
2	14.44
3	15.56
4	20.00
5	22.78
6	25.00
7	26.67
8	28.33
9	25.56
10	22.24
11	18.89
12	15.56
13	15.56
14	14.44
15	15.56
16	20.00
17	22.78
18	25.00
19	26.67
20	28.33

9. Four different feed prices are used:

Hen age (weeks)	Feed price ($/kg)
20–24	.15094
24–45	.14649
45–60	.14276
Above 60	.13660

Feed cost decreased because of decreased protein and/or amino acid requirements with increasing age.

10. Production and packing costs are given in the Model Development section.

RESULTS

Figure 1 shows the total cost and total revenue per layer per period when layers are housed for 13 and 20 production periods (4 weeks per period). Hen production is assumed to begin at 20 weeks of age. Only the last two periods show net profit when layers are producing 13 production periods. Within the 20 production periods, the longer the production period the higher the net profit, because the fixed cost is spread over more eggs and a lower dietary protein level is fed after 60 weeks. The net revenue (Fig. 1) is $1.12 per layer for 20 production periods and 57¢ for 13 production periods.

Tables 1 and 2 show several examples of production management alternatives with and without molting. Table 1 shows results when Brake's molting regimen was used. Table 2 shows results when Savage's molting regimen as reported by Rahn (1977) was used.

On the basis of budgeted summaries shown in the Application Example, forced molting resulted in higher net revenue for both Brake's (Table 1) and Savage's (Table 2) molting regimens than for the no-molt regimen. For illustration purposes, alternative 13-7 indicates 13 production layer periods and then 7 periods of forced molt cycle. With Brake's molting regimen, 8 more eggs were produced and layers ate more feed with alternative 13-7 than with alternative 20-0 in any temperature condition. This result of more production with less feed held for all molt alternatives. In practice, Brake's molting regimen may not produce more eggs, but the molting procedure was used to illustrate the model.

For temperature condition 1 and using Brake's molting cycle, the total egg value (Table 1) is $14.07, the cost is $12.59, and the net revenue is $1.48 per hen in alternative 13-7, which is 48¢ higher than that of alternative 20-0. The net revenue is about 30¢ less on every alternative with Savage's molting procedure (Table 2) as compared to Brake's molting

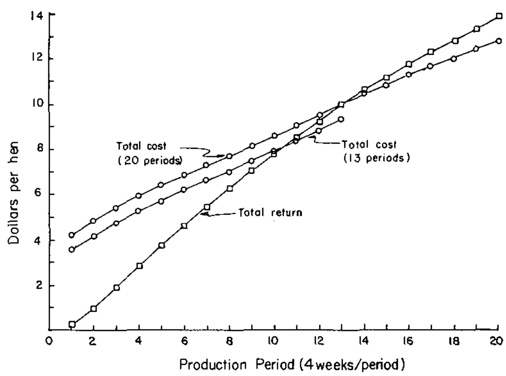

FIG. 1. Total cost and total revenue for layers housed 13 and 20 production periods.

TABLE 1. *Total number of eggs produced, feed intake, cumulative feed conversion, total feed cost, total cost, and net returns under different production alternatives comparing Brake's molting regimen per hen*[1] *and a no-molt regimen*

Alternative[2]	Temperature[3] condition	Total egg number	Total feed intake	Feed conversion	Total feed cost	Total egg value	Total cost	Net return
			(kg)	(kg/doz)	($)			
20-0	1	338	62.663	2.225	8.837	13.749	12.754	.995
13-7	1	346	62.468	2.166	8.810	14.066	12.592	1.474
14-6	1	347	62.406	2.158	8.801	14.100	12.583	1.517
15-5	1	347	62.278	2.154	8.784	14.091	12.566	1.525
20-0	2	338	62.029	2.202	8.744	13.750	12.651	1.099
13-7	2	346	62.128	2.148	8.758	14.107	12.540	1.567
14-6	2	348	61.993	2.138	8.740	14.141	12.521	1.620
15-5	2	348	61.784	2.130	8.711	14.132	12.493	1.639
20-0	3	340	63.915	2.256	9.016	13.830	12.934	.896
13-7	3	348	63.973	2.206	9.024	14.147	12.806	1.341
14-6	3	349	63.949	2.199	9.021	14.181	12.803	1.378
15-5	3	349	63.867	2.196	9.010	14.172	12.971	1.381
20-0	4	339	63.120	2.234	8.901	13.790	12.819	.971
13-7	4	347	63.091	2.182	8.897	14.107	12.679	1.428
14-6	4	348	63.007	2.173	8.886	14.141	12.667	1.474
15-5	4	348	62.854	2.167	8.865	14.132	12.646	1.486

[1] Brake *et al.* (1979).

[2] Each alternative corresponds to number of production periods (4 weeks per period) – period in which molting began.

[3] Temperature condition = 1, indicates the environnmental temperatures as shown in item 8 of input and output functions; i.e., temperature at period 1 is 15.56 C and so on. Temperature condition = 2, temperature in period 1 starts at temperature as shown in period 5; i.e., temperature at period 1 is 22.78 C. Temperature condition = 3, temperature in period 1 starts at temperature as shown in period 9; i.e., temperature at period 1 is 25.56 C. Temperature condition = 4, constant temperature at 21.11 C during all 20 periods.

TABLE 2. *Total number of eggs produced, feed intake, cumulative feed conversion, total feed cost, total cost, and net returns under different production alternatives using Savage's molting regimen per hen*[1] *and a no-molt regimen*

Variables	Alternative[2] 20-0	13-7	14-6	15-5
Total egg number	338	336	337	337
Total feed intake (kg)	62.663	61.749	61.675	61.564
Feed conversion (kg/doz)	2.225	2.205	2.196	2.192
Total feed cost ($)	8.837	8.712	8.702	8.686
Total egg value ($)	13.749	13.667	13.700	13.691
Total cost ($)	12.754	12.493	12.483	12.468
Net return ($)	.995	1.174	1.217	1.223

[1] Reported by Savage (1976) and discussed by Rahn (1977).

[2] The environmental temperatures as shown in item 8 of input and output functions were used; i.e., temperature at period 1 is 15.56 C and so on.

procedure (Table 1). On the basis of situations and parameters reported, these data suggest the need to pick carefully the molting procedure employed.

Using the data inputs presented in this paper, approximately 10 more eggs are produced during a laying cycle with the Brake's molting procedure than with the Savage's molting procedure. Using different data inputs or other molting regimens may have resulted in a different conclusion.

Rahn (1976) also shows that egg production relations vary significantly between housing seasons and that environmental temperatures influence net profit. The hen consumes more feed under temperature condition 3 (Table 1) than under other temperature conditions. The first of 20 production periods begins in late August or early September in the southeastern US under temperature condition 3; therefore, more cool months with more feed consumption are found under temperature condition 3 than under other temperatures studied. Consequently, net revenue is lower under temperature condition 3 than under other temperature conditions.

Table 3 shows net gain or loss due to feed cost increases of 5, 10, 15, and 20% with Brake's molting regimen and the other factors that generated Table 1. Forced molting resulted in higher net revenues with feed cost increases of 15% or less compared with net revenues of the no-molt alternative. However, a 20% increase in feed cost resulted in negative net returns in every temperature regimen illustrated.

CONCLUSIONS AND LIMITATIONS

On the basis of the application example and parameters in this study, molting resulted in more net revenue than the no-molt regimens. Net revenue was greater with Brake's than with Savage's molting regimen. The intent of the study was not to evaluate molting procedure techniques but to offer at least two molting techniques in evaluating the feasibility of molting based on data inputs. The situation and assumed conditions evaluated represent several alternatives available to commercial producers. However, this study did not encompass all alternatives such as another molt beyond the 20 period production cycle.

Although the estimates of net revenue clearly show that increases are available with the molt procedure, these values do not represent a present value or the current dollar value of these streams of return. Because the positive cash flow is interpreted for a total month, the current dollar value of all systems would show a smaller gain in net revenue. However, the spread will not disappear; thus, molting appears profitable based on data presented in this study.

The computer model presented in this study offers to the poultry industry a method of evaluating commercial layer production op-

TABLE 3. *Changes in net returns due to feed cost increases using Brake's molting regimen*[1]

Alternative[2]	Temperature[3] condition	% Increase in feed cost[4] 0	5	10	15	20
20-0	1	.995	.698	.256	−.186	−.627
13-7	1	1.474	1.034	.593	.153	−.288
14-6	1	1.517	1.077	.637	.197	−.243
15-5	1	1.525	1.086	.647	.208	−.231
20-0	2	1.099	.796	.359	−.079	−.516
13-7	2	1.567	1.129	.692	.253	−.184
14-6	2	1.620	1.183	.746	.309	−.128
15-5	2	1.639	1.204	.768	.333	.103
20-0	3	.896	.590	.139	−.311	−.762
13-7	3	1.341	.890	.439	−.012	−.464
14-6	3	1.378	.927	.476	.025	−.426
15-5	3	1.381	.930	.480	.290	−.421
20-0	4	.971	.671	.226	−.219	−.664
13-7	4	1.428	.984	.539	.094	−.351
14-6	4	1.474	1.030	.585	.141	−.303
15-5	4	1.486	1.042	.599	.156	.287

[1] Brake *et al.* (1979).

[2] Each alternative corresponds to number of production periods (4 weeks per period) – period in which molting began.

[3] Temperature condition = 1, indicates the environnmental temperatures as shown in item 8 of input and output functions; i.e., temperature at period 1 is 15.56 C and so on. Temperature condition = 2, temperature in period 1 starts at temperature as shown in period 5; i.e., temperature at period 1 is 22.78 C. Temperature condition = 3, temperature in period 1 starts at temperature as shown in period 9; i.e., temperature at period 1 is 25.56 C. Temperature condition = 4, constant temperature at 21.11 C during all 20 periods.

[4] Minus sign indicates negative revenue.

tions. The question of molting is an alternative that must be evaluated within each flock and an individual company. The reliability of using a computer model to predict molt or no-molt alternatives will depend upon accurate data inputs.

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