RURAL INDUSTRIES RESEARCH
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EVALUATION OF PERFORMANCE OF HENS FED HIGH NUTRIENT DENSITY DIETS POST-MOULT

A report for the Rural Industries Research and Development Corporation

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Figure A illustrates the potential for post-moult egg production performance (data obtained from Donald Bell, 1997). First cycle production was over 90% for 23 weeks while post-moult production was over 90% for 5 weeks and was still at about 80% after 100 weeks.

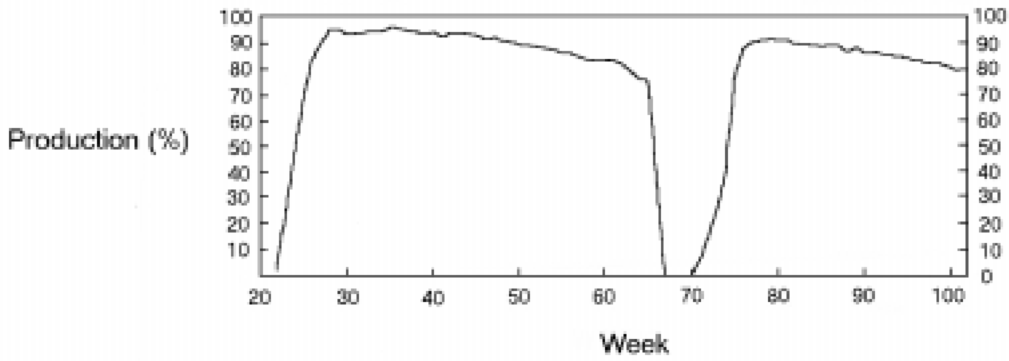

Figure A: Production Results from Californian Layer Flock Hatched July 1986 (40,000 housed)

Project Title: Evaluation of Performance of Hens Fed High Nutrient Density Diets Post-Moult.

Project Number: EGG 23

Organisation: University of Melbourne, Agriculture Victoria

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Location of Research Work: Longerenong College, University of Melbourne

Start Date: September, 1996

Completion Date: March, 1997

Project Objectives:

1. Evaluate the flock performance on 5 Victorian egg farms practicing moulting programs
2. Propose reasons for flock mortality and poor post-moult performance on commercial egg farms.
3. Develop a laboratory model of a moulting program at Longerenong College and investigate the responses to high density diets in the refeeding/repletion stage.
4. Study the changes in skeletal density and calcium reserves during a moulting program.
5. Develop improved management practices to optimise both post-moult growth rates and tissue reserves in laying hens subject to moulting programs.
6. Achieve post-moult peak production performance within 5% of the pre-moult peak performance.

Summary

The ability of moulted flocks to achieve rapid repletion growth rates has been hypothesised to be the critical factor in ensuring effective post-moult egg production, and this may be linked to the question of flock body weight variation and the rejuvenation of tissues required for sustained egg production.

An experimental model was established which utilised calcium supplementation during the period of tissue catabolism, and high density diets during the repletion phase. These strategies could then be tested as approaches to improve both repletion growth rates and post moult egg production performance.

In summary the use of a low level of calcium supplementation (1/ gram/bird/day) in the moulting or catabolism phase appears to produce sustained improvements in post-moult performance (3-5%). The use of high density layer diets produced significantly

enhanced rejuvenation of body weight and the enhanced growth rates produced a peak production 3-4 weeks earlier than the conventional diet.

The most important findings that can be derived from this research are that there is potential to shorten the duration of the non-productive period during the moult, and secondly, under weight flocks that have experienced some mismanagement can potentially be rejuvenated by careful attention to the extent of the body weight loss.

The more recent research undertaken on a commercial farm has begun to illustrate the problems of rejuvenating over weight flocks, and the limitations that excessively obese birds may represent to moulting programs.

Clearly the research described in this project illustrates many of the deficiencies of first cycle flocks, and illustrates the need to experiment with moulting programs in flocks that have achieved elite performances in the first cycle of production rather than sub-optimal performances.. At this stage the adoption of more sophisticated body weight management practices and the use of calcium supplements during the tissue catabolism phase are clear gains to the industry from this research.

In the longer term, however, the biological responses to moulting and the interaction with management will need to be continually re-evaluated. The economic gains to the industry of effective second cycle production will be substantial and are worthy of long term strategic research..

Background:

Moult induction is increasingly being used in Australia as a means of extending production of laying flocks by restoration of shell quality and egg production levels. Economic advantages to the producer and industry come from the reduced pullet depreciation cost, increased flexibility in capturing sudden changes in egg supply and improvements in cash flow management.

Recent analysis of the biological information available on moulting indicates that the ovulation rates and rates of lay on a hen housed basis should be within 5% of first cycle performance. Optimally, moulted flocks should lose 25-30% of their body weight in a two week period, and this should be followed by an almost linear increase in live weight gain following the moult. It is important that the flocks regain their initial mature body weight as rapidly as possible following the moulting program. The duration of the entire moult from commencement to attainment of peak production should only be 10-12 weeks which equates to the period between point of lay and peak production in first cycle flocks.

A number of farms have been contracted to the Victorian Egg Industry Co-operative Ltd. to produce eggs for product from moulted flocks. The performance of these flocks has not met the production standards expected, and the performances have been significantly below the biological optimums described. The potential of moulting programs has been illustrated in the US where flocks have reached up to 93% production post-moult following a pre-moult peak of 95% (D. Bell, personal communication). Presently in Australia, peak production rates of up to 20% below the

first cycle peak and increased mortality (5-10%) are commonly observed in commercially moulted flocks.
It is clear that the performance of these flocks has been influenced by the pre-moult condition of the flock and that this factor has been poorly understood by the egg industry. Factors such as body weight uniformity, average body weight and skeletal density/calcium reserves are likely to be important factors influencing the response to moulting. These factors require clarification and standardised guidelines within the industry to lift the overall response to moulting programs. The potential gains are very large if these responses can be consistently achieved and the economics of the egg industry may be dramatically altered.

Preliminary Research - SIRO CB Moulted Flock

In 1996 a flock of SIRO CB's that had previously been used in a nutrient density trial was moulted to provide some preliminary data for this research initiative. Approximately 2000 birds housed at Longerenong College were moulted at 69.5 weeks of age. The moulting procedure involved feeding the birds 40 gm of barley per day for 22 days, followed by 25 gm of barley per day for three days (barley was approximately 13.5% protein). Birds were then refed (*ad lib.*) on a diet containing 18% protein and 12.1 MJ/kg ME. Average body weight, femur calcium content and production results were recorded for both pre and post-moult periods (Table 1).

Table 1: Average Body weight, Production and Femur Calcium of Experimental Flock of SIRO CB's (standard errors indicated in parentheses)

Age (weeks)	Body weight	Production (%)	Calcium (gm's) in Femur
20	1.67	0	1.10 (0.034)
33	*	89 (peak)	*
40	1.92	85	0.96 (0.025)
50	2.03	82	1.15 (0.029)
69	1.99	66	1.19 (0.058)
73	1.55	0	0.86 (0.062)
80	2.17	76	1.00 (0.028)
107	2.18	62	1.27 (0.045)

* data not available

The post moult production results are indicative of the problems experienced in the commercial sector. The post moult peak production was 78% at 82 weeks, which is 11% below the peak reached in the first cycle. It is interesting to note that although average body weight rebounds to 2.17 kg at 80 weeks of age, 180 gm's heavier than pre-moult, the total amount of femur calcium in the same period rebounds to only 83% of the pre-moult figure. However, by 107 weeks femur calcium has rebounded to well above the pre-moult figure, whilst body weight remained constant. This result indicates that although body weight may return quickly to pre-moult figures following refeeding, the birds reserves of calcium do not rebound as quickly.

Field Models

In 1996 five farms were contracted to the Victorian Egg Industry Co-operative for moulting programs using 65-75 week old spent hens purchased from various commercial egg farms in Victoria. All farms use whole barley as the single grain feed to induce the moult, but barley allocation per flock differed between the farms. The moulting process and subsequent performance of the flocks were monitored at regular intervals.

Two the contract farms were visited and broad estimates of flock growth rates and production determined. These preliminary studies indicate that the two most significant problems appear to be the moulting of flocks with low average body weights and large variations in post-moult growth rates. Several of the flocks experienced significant mortality (5%) and egg production in some of the flocks was 20-30% below acceptable standards. These performances are clearly uneconomic and represent serious welfare problems for the egg industry. The establishment of reasonable flock body weight standards for moulting programs is a clear priority for the industry and has already been communicated to the Egg Producers Co-operative in Victoria.

Apart from the obvious questions of flock body weights and repletion growth rates it seems probable that carcass composition and tissue reserves may also be important in sustaining production of both first cycle and moulted flocks. This area of research needs more development with some systematic long term models.

Additional Experimental Models

Introduction

Based on some of the observations made in the preliminary research an experimental model was established to compare the effect of implementing a post-moult refeeding program using either a conventional layer diet or a high energy diet. The high energy diet was expected to produce rapid weight gain to levels higher than pre-moult body weights with beneficial effects on productivity, shell quality and skeletal calcium reserves of birds during post-moult production. In addition, birds were divided into two treatments during the moulting phase, one treatment was fed a calcium supplement, the other was not. It was hypothesised that feeding a calcium supplement during the moulting phase would buffer the birds from excessive skeletal calcium depletion, and this may assist in rejuvenating egg production in the post-moult period.

In early 1997 the Egg Producers Co-operative phased out their moulting program on the five farms described, but a commercial model was able to be established on one of Victoria’s largest farms that has maintained a commitment to moulting as a husbandry tool. The commercial model was established to evaluate some of the approaches taken in the laboratory model, and to increase the information of the problems associated with commercial moulting programs.
Fortuitously the two models of moulting represented two extremes, both under weight and over weight flocks, and it seems likely that these models will represent the divergent patterns confronting the industry.

Methods

Part (A)

Laboratory Model (WL X NH, Under weight flock)

A total of 960 White Leghorn x New Hampshire hens, purchased from a commercial producer at 79 weeks of age, were housed in the Longerenong College cage unit at 4 birds per cage. The flock initially weighed 1875 grams upon arrival and was maintained on a conventional layer diet for two weeks prior to the moulting program. During this acclimatisation period the flock gained 82 grams, reaching a flock average weight of 1957 grams.

Following the acclimatisation period the flock was subsequently moulted using 25% of normal daily protein and energy intake (40 grams of feed barley per day) for a period of 22 days. The moulting period was maintained for 22 days , because the magnitude of the weight loss achieved in the conventional 10-14 days was significantly less than expected. Both the quality of the barley and the amount of allocated per day probably moderated the extent of the tissue catabolism.

During the moult period, half of the flock (480 birds) were supplemented with calcium in the form of marble chips at a rate of 1 gm calcium/day, while the remainder had no calcium supplement. At the completion of the moult the 2 flocks were further subdivided into 2 treatments (240 birds) and refed with either a conventional layer diet (16.5% protein and 11.5 MJ/Kg M.E.) or a high density diet (20% protein and 12.35 MJ/Kg M.E.) to 10 weeks after refeeding commenced. After 10 weeks all treatments were fed the conventional layer diet (*Appendix 1.*) All dietary vitamin and mineral specifications were maintained over the four treatments. In the refeeding phase all groups were fed a conventional level of calcium. Each of the 4 treatments consisted of 5 replicates of 48 birds.

All treatments were monitored weekly for body weight and production over 13 weeks following refeeding. The flock was sampled twice during the trial, once before the moult, and again 12 weeks post-moult. At each sampling, femur were removed from 10 birds of each treatment for subsequent analysis of calcium content.

Part (B)

Commercial Trial (Lohmann Brown, Over weight flock)

A 15,000 bird flock of Lohmann brown hens housed in controlled environment shedding was moulted for 25 days on a barley diet. The initial body weights of the flock in the first cycle of egg production and egg production are illustrated in Figure (1.) and Appendix (3)

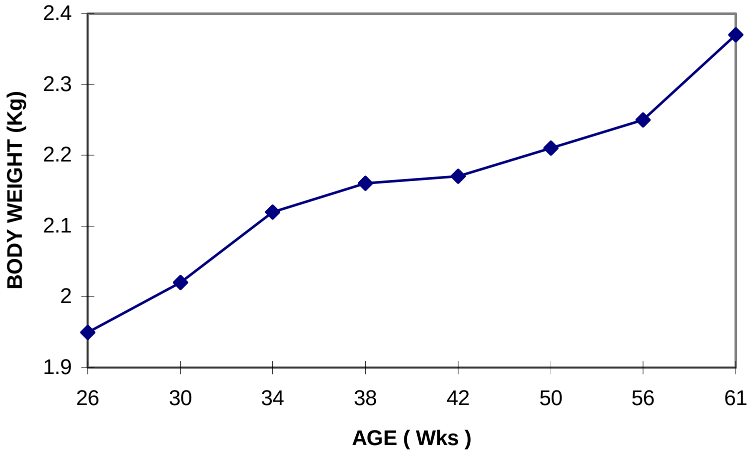


Figure 1: Body weight of Lohmann brown during first cycle. Flock moulted at 61 weeks of age. (Note large average body weight 2.37 kg).

Randomised within the shed 3 rows of birds (1500 birds) from a total of 32 rows (15,000 birds) were allocated 1 gram calcium /bird/day (shell grit) in addition to the barley.

On day 26 (64-65 weeks of age) both flocks, (calcium supplemented and control) were fed the conventional layer diet containing 3.8% calcium, 17% Crude protein and 11.4 mj/kg M.E. (Appendix 1.)

At the commencement of the moult 20 birds were post mortemed and the femur calcium determined on a grams/bone basis. On day 14 of the moult, and at 20 weeks after re-introduction of the layer diet, 10 birds from the control and 10 birds from the calcium supplemented diet were post mortemed and the femur calcium levels determined.

Egg production of the flock in the first cycle is illustrated in Appendix (3) and post moult egg production was monitored between 1 to 21 weeks after the re-introduction of the layer diet.

Results

Part (A)

Laboratory Model (WL X NH, Under weight Flock)

Note: HD = High Density Diet, CD = Conventional Diet

Body weight

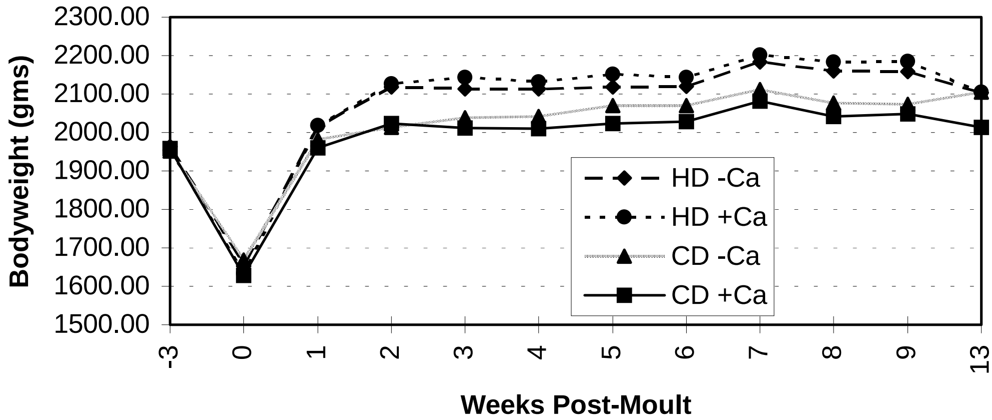


Figure 2: Average Body weight - Pre and Post-Moult

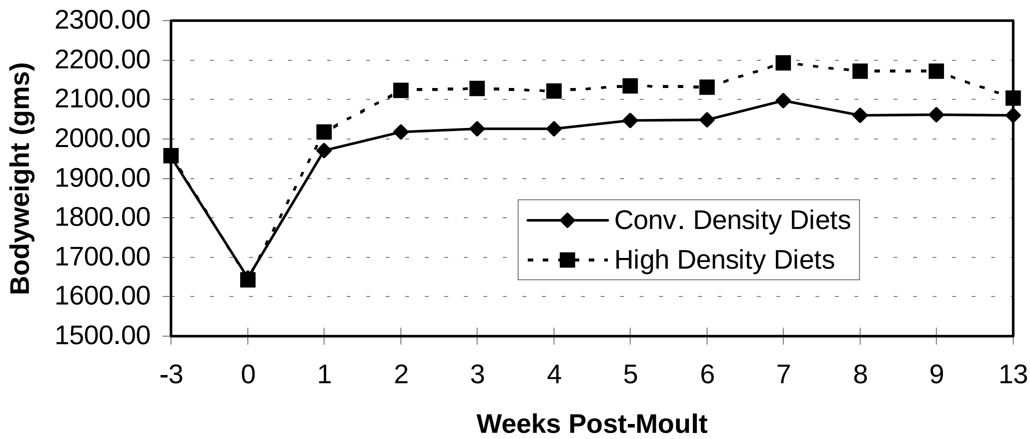


Figure 3: Average Body weight - High vs Conventional Density Diet

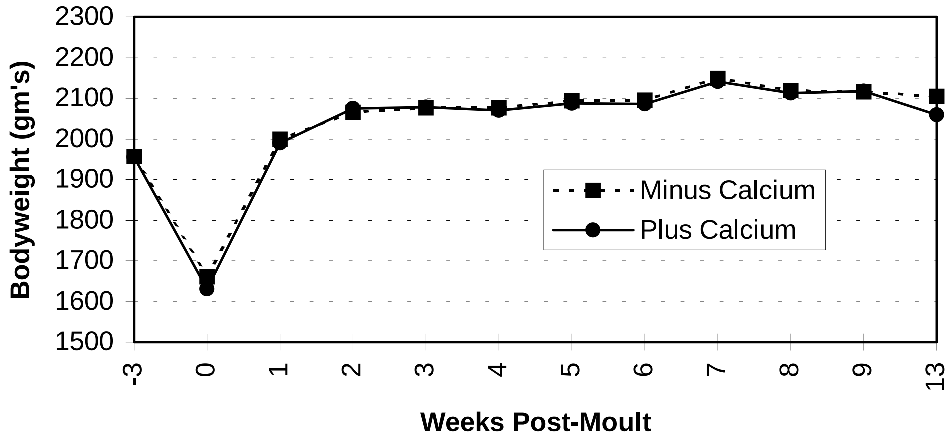


Figure 4: Average Body weight - Calcium Supplemented vs Non-supplemented

The average initial weight of the flock was 1957 grams, which was reduced by 16% to an average weight of 1646 grams at the completion of the moult (Figure 2). Following refeeding, birds in all treatments rebounded to their pre-moult weight after only 1 week. All treatments body weight peaked 7 weeks post-moult, with the highest body weight (2.2 kg) achieved by birds fed the high density diet with calcium supplementation (Figure 2). It is of interest to note that when the high density diet was replaced by a conventional diet 10 weeks following refeeding, body weights of both high density treatments dropped considerably.

Birds from the 2 high density diet treatments had a significantly higher ($p<0.01$) body weight than birds fed the conventional diet (Figure 3). No significant differences in body weight were observed between those treatments with or without calcium (Figure 4).

Egg Production

First cycle egg production of the sister flock is illustrated in Appendix 2(a) and 2(b). Appendix 2(b) illustrates the sister flock productivity following a conventional moulting program.

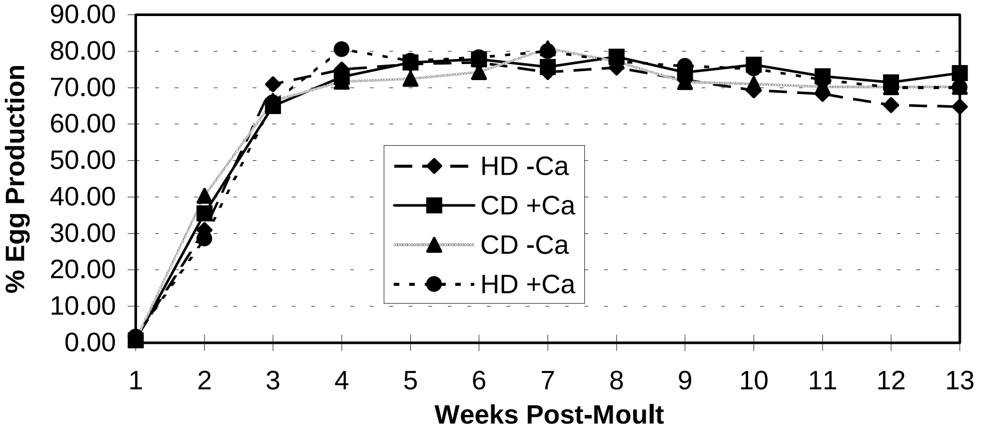


Figure 5: Percentage Egg Production Following Moult Program

Figure 6: Percentage Egg Production Following Moult Program - High (●) vs Conventional (■) Density Diet (standard error bars included)

Figure 7: Percentage Egg Production Following Moult Program - Calcium Supplemented (•)vs Non-supplemented (■) (standard error bars included)

Egg production peaks range from just over 80% for the high density plus calcium treatment down to 77% for the high density minus calcium treatment (Figure 5). Peaks for all four treatments occurred between 4 and 7 weeks post moult, with the highest average peak (combining all 4 treatments) of 77.7% occurring at 7 weeks post-moult (Figure 5). Importantly birds fed high density diets attained peak production earlier than their conventionally fed counterparts. As illustrated with the body weight data the removal of the high density diet at 10 weeks post-moult has an adverse effect on egg production.

No significant difference ($P>0.05$) was observed between high and conventional density dietary treatments (Figure 6). The 2 treatment groups fed the calcium supplement during moulting had significantly higher ($P<0.05$) egg production than those birds without the supplement (Figure 7).

Feed Consumption

No clear trends emerge when feed consumption is analysed and there is no treatment that is consistently higher or lower than any other throughout the entire experimental period. The average feed consumption was 128 grams per day for the first 2 weeks post-moult. and ranged from 112-118 grams per day for the remainder of the trial..

There is no significant difference in feed consumption between birds fed high or conventional density diets, or between those birds supplemented with calcium and those without.

Average Egg Weight

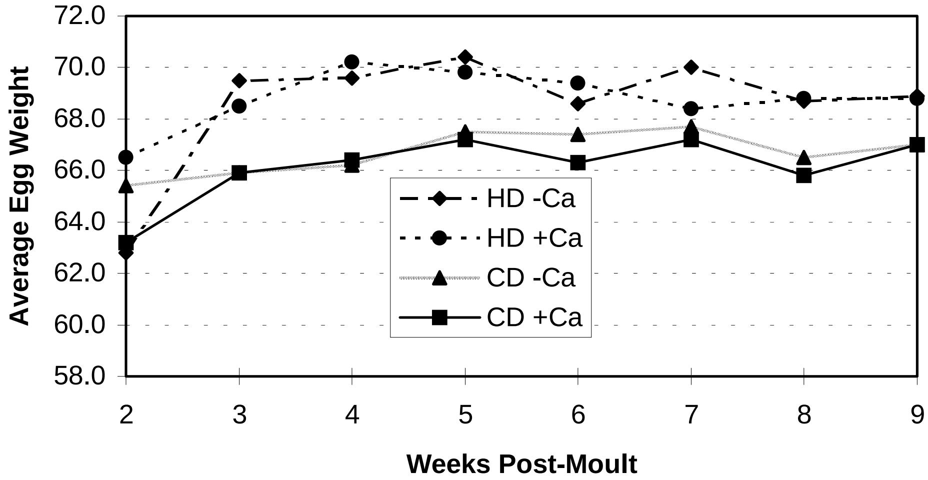


Figure 8: Average Egg Weight

Both the high density dietary treatments have a higher egg weight than the conventional dietary treatments, regardless of whether birds were supplemented with calcium or not (Figure 8.). There is no significant difference between the two high density dietary treatments, or between the two conventional dietary treatments. There is a significant difference between the two combined high density diet treatments and the two conventional dietary treatments (P<0.01). No significant difference was observed between those birds supplemented with calcium during the moult and those without.

Femur Calcium Content

Table 2: Average Body weight and Total Femur Calcium Content of 10 Birds per Treatment, Sampled 12 Weeks Post-Moult (standard error in parentheses)

	Treatment			
	HD + Ca	HD - Ca	CD + Ca	CD - Ca
Body weight (gms)	2081	2056	2001	2039
Femur Calcium (gms)	1.19 (0.065)	1.23 (0.076)	1.14 (0.078)	1.26 (0.054)

There is also no significant difference in femur calcium contents or body weights between birds fed the different diets (Table 2.). This may reflect the small sample size (10 birds) or perhaps the results are confounded by the convergence of the body weights in the treatment groups transferred from the high density diet to the conventional diet at 10 weeks of age.

Part (B)

Commercial Trial

Lohmann Model (Over weight Flock):

The Lohmann brown flock experienced a relatively poor early growth (22-30 weeks of age) (Figure 9.) and this was associated with a relatively low peak production of 88-89 % at 28-34 weeks of age (Appendix 3). Between 42-50 weeks of age the body weight began to increase significantly as production began to decline. The net result was an average weight of 2.37 kg at 61 weeks of age with egg production below 80 % (Figure 9 , Appendix 3). Approximately 28% of the flock was estimated to have body weights in access of 2.5 kg (Table 4.).

Using the barley method of moulting the flock average weight declined from 2.37 to 1.9 kg. over a 3-4 week period, but 4% birds still had body weights ≥ 2.5 kg (Tables 3, 4.) . After 2-3 weeks of refeeding the layer diet the average weight had increased to 2.18 kg and approximately 17% of birds had body weights ≥ 2.5 kg (Tables 3, 4.).

Body weight

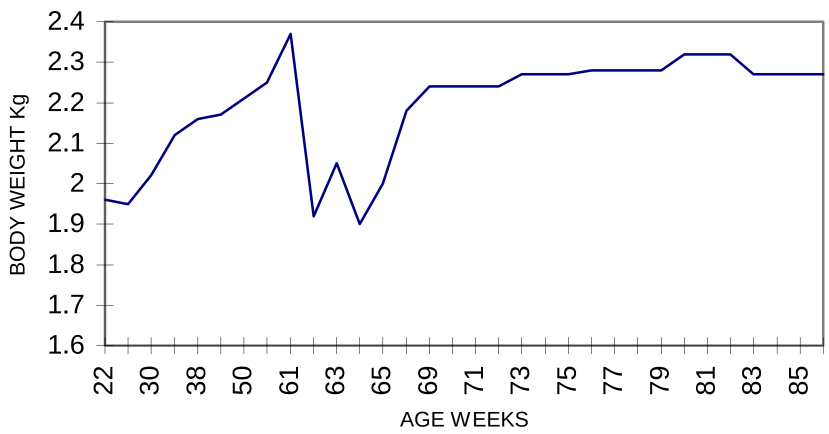


Figure 9: Estimated body weight of Lohmann Brown during first cycle, moult and repletion phase

Table 3: Average body weight (kg) and standard error of Lohmann brown during and following moulting program (-3 weeks commencement of moult in 61 week old birds, 0 weeks commence refeeding in 64 week old birds)

Weeks		Control	Calcium Supplemented
-3	61 weeks of age	2.37 ± 0.05	
-1	63 weeks of age	1.98 ± 0.06	2.09 ± 0.05
0	64 weeks of age	1.90	
2	66 weeks of age	2.24 ± 0.06	2.08± 0.06
7	71 weeks of age	2.24 ± 0.06	
21	86 weeks of age	2.27 ± 0.08	2.44± 0.11

Table 4: Estimated percentage of flock with body weights equal to or exceeding 2.5 kg during moulting program.

Weeks		Percentage ≥ 2.5 kg
-3	61 weeks of age	28
-1	63 weeks of age	4
2	66 weeks of age	17

Egg Production

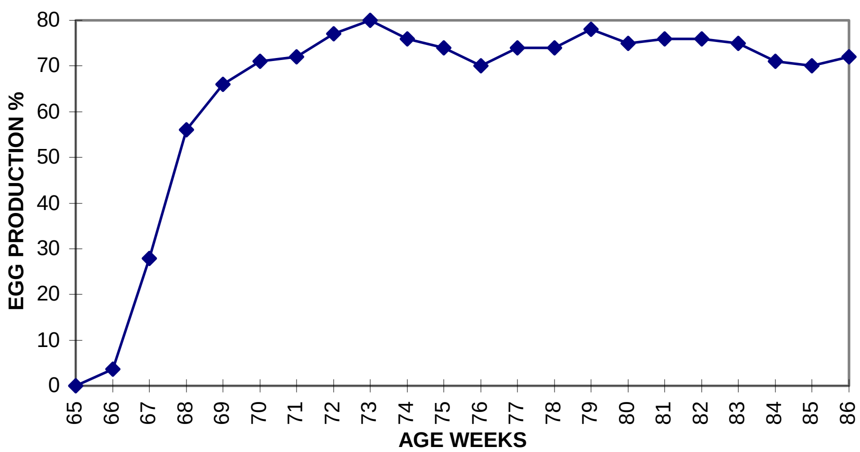


Figure 10: Egg production from Lohmann Brown commercial flock following refeeding at 0 weeks or 64-65 weeks of age.

Post moult egg production appears to be peaking at only 78% which is well below the first cycle peak of 89-90% (Figure 10.). Clearly a significant number of birds have not been rejuvenated into production. The increase in live weight between 75 to 80 weeks of age (Figure 9.) is associated with an improvement in egg production and the loss of body weight between 80-86 weeks of age (Figure 9.) is assocated with a decline in egg production.

Estimates of egg production from the group fed the shell grit and the non-supplemented group at 3 weeks, 6-7, 10 and 20 weeks post moult indicate that the egg production is about 5% higher in the shell grit supplemented group. At 10 and 20 weeks post moult an estimation of egg production in the shell grit treated group averaged 75% production, whilst the control group averaged 71%. These findings are consistent with the earlier research undertaken at the University of Melbourne, Longerenong campus.

Mortality

Mortality during the moulting process averaged 0.1% for the 3-4 week period and was maintained at a low level during the repletion phase. Total mortality between 61-86 weeks of age was only 2.7%. Presumably this low level of mortality achieved during this moulting program occurs because the body weights of even the smallest birds in this flock are significantly above the survival thresholds estimated at 1.0 to 1.2 kg . The smallest birds recorded had a body weight of about 1.6 kg.

Femur Calcium

The provision of the calcium during the moulting process appears to have increased the femur calcium content by some 20% during the moulting process, and the values are consistent with previous research findings (Table 5.).

Table 5: Femur calcium content (g/bone) in Lohmann browns prior to, during and following the moulting program

Weeks		Control	Calcium Supplemented
-3	61 weeks	1.12 ± 0.04	
-1	63-64 weeks	0.80 ± 0.04	0.97 ± 0.05
20	85 weeks	1.00 ± 0.05	1.06 ± 0.05

Discussion

Overall the research undertaken in this project has begun to identify some of the major constraints to efficiency of the moulting process and the post-moult egg production performance. The most significant findings were the variation in the quality of the pre-moult flocks (Figure 11.) Some flocks had pre-moult weights that were almost at the initial pullet weights of 1.6-1.7 kg and appear incapable of being moulted without significant mortality . At the other extreme, it has become evident that there may also be flocks at the end of lay that are significantly over weight and these flocks will require special management approaches to achieve high post-moult egg production.

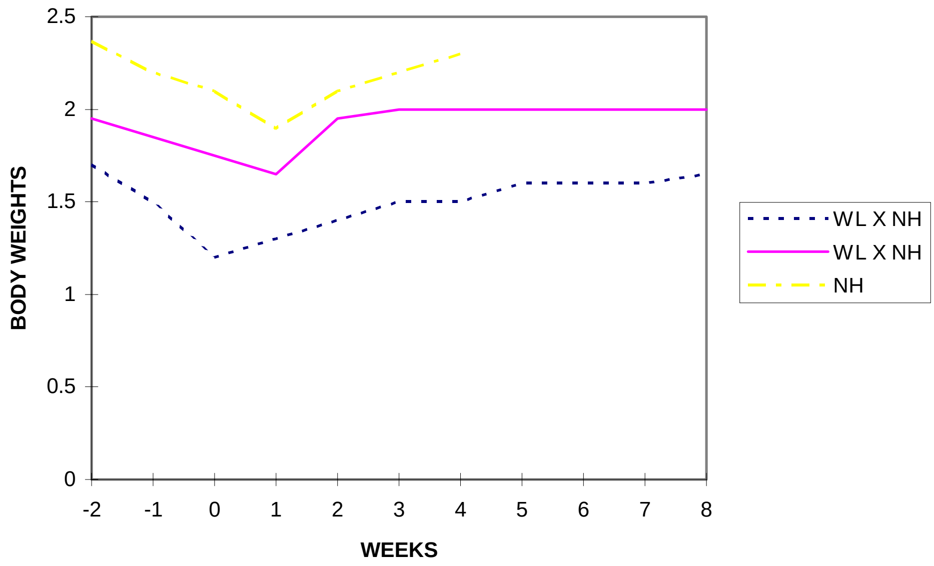


Figure 11 : Body weight patterns of three different moulting programs with divergent initial body weights and different repletion growth rates used in these experimental models

It is clear that there are large numbers of first cycle laying flocks that have body weights which reflect productive capacities well below optimum. These flocks may be able to be rejuvenated using different moulting practices, but the long term solution is to achieve first cycle flocks which have the correct balance of body weight, feed intake, and egg production and to then fine tune moulting practice using this initial platform. Certainly it appears from this research, that there are probably large numbers of under weight flocks which should not be moulted.

An analysis of the moulting performance of a moderately under weight flock and an over weight flock has been developed, to illustrate some of the approaches which can be taken to improve post-moult performance across a range different commercial flocks

Part (A) Under weight flock

This initial experiment has shown that, as expected, in under weight flocks the high density diet resulted in moulted hens regaining weight more rapidly, and achieving a higher body weight, than those birds fed a conventional diet. Additional benefits gained by using the high energy diet was the earlier peak in production, which was 3 weeks prior to that seen in the hens fed the conventional diet. There was however, no significant difference between the two diets in terms of egg production over the 13 week period. This response in growth and production needs to be examined again in flocks with lower initial body weights and lower nutrient densities to more precisely define the economics of the biological responses.

The important findings derived from this experiment is that there is likely to be responses in repletion growth rates to the supply of a bolus of additional nutrients that can be exploited to rejuvenate under weight flocks. It is difficult to extrapolate from theses studies on nutrient density to all situations, and it is important that the response to nutrients are titrated or evaluated closely on a case by case basis using carefully controlled experiments.

Although calcium supplementation had no significant effect on body weight, it did significantly improve production. Calcium supplemented birds maintained production at over 70% for 9 weeks (4 to 13 weeks post-moult), while non-supplemented birds only maintained production above 70% for 6 weeks (4 to 10 weeks post-moult).

The femur calcium levels (1.14-1.26 g/bone) in the WL x NH 12 weeks after the moulting process were surprisingly high for birds of this strain and weight. The moulting process appears to have regenerated the calcium reserves in this flock to relatively high levels, but this may also be linked to the relatively low rate of egg production (70%) in the 85 week old hens.

If the apparent improvement in persistency of production achieved with the use of calcium supplementation during the moulting process can be reproduced, it will be important to more systematically quantitate the changes in the skeletal calcium reserves.

Earlier research had illustrated that during the moulting process skeletal calcium reserves declined by about 30%, and it was hypothesised that a poor repletion of skeletal calcium following the moult may compromise egg production. More specifically, the moulting of flock with sub-optimal skeletal calcium reserves may deplete the calcium pool to such an extent that the ability to replete the pool is compromised.

Aggregating the studies undertaken on skeletal calcium reserves in this project and previous research on project DAV 31E, a model is beginning to be consolidated. The model suggests that flocks in high levels of production have femur calcium contents of 0.9 to 1.0 g/bone, as the drain of production diminishes in older flocks this level increases to between 1.1 to 1.2 g/bone. Once flocks are moulted it appears that the femur calcium declines from 1.1-1.2 to about 0.8 g/bone.

The current model therefore suggests that 0.8 g/femur in the average bird will be associated with the cessation of ovulation. The ability of moulted hens to replete their skeletal calcium reserves upon re-feeding will be critical in re-initiating ovulation. Based on the data for first cycle flocks a femur calcium content of 0.9 to 1.0 will be requires to re-initiate egg production.

The hypothesis underpinning this research is that a proportion of the flock may have the skeletal calcium reserves depleted to levels below 0.8 g/bone and these birds may struggle to replete the calcium reserves to the levels required for sustained egg production. The provision of the additional calcium during the moulting process is hypothesised to buffer the birds from excessively low levels of skeletal calcium, and enables birds to more effectively replete the skeleton to levels at which sustained ovulation can occur.

Part (B) Over weight Flock

In the second model an important contrasting pattern has been illustrated with a moulting program undertaken on large, presumably obese birds. This may represent another important challenge for the Egg Industry in the development of management techniques which either modify the pre-moult weights or take into account the requirements of flocks that have been allowed to accumulate tissue reserves to this extent.

One of the other important questions in this model is, what is the trigger for a significant proportion of the flock to begin accumulating body weight (fat ?) between 42 to 60 weeks of age. It seems probable that the cessation of egg production or a lowering of egg production in individual birds, may not be accompanied by the commensurate reduction in feed consumption. Consequently in these birds the excessive nutrient intake is partitioned to accumulating tissues.

Unpublished data obtained from a 100 bird flock of Australian brown egg layers aged between 70 to 75 weeks of age suggests that these very large birds (> 2.5 kg) are likely to be producing at a lower level (Parkinson, 1996) (Figure 12.).

Figure 12: Relationship between body weight and egg production in an Australian brown egg layer flock assessed between 70-75 weeks of age (n=100 birds in single bird cages)

Furthermore, the relationship between body weight and egg production indicates that both under weight and over weight birds are laying below the potential. The physiological/metabolic explanation for these effects are likely to be markedly different.

Clearly the moulting program practiced in this model did reduce the body weights of these large birds, but the absolute weights were still heavy and well above the target weights of 1.7-1.8 kg.
Approximately 40% of the flock still had body weights > 2.0 kg. following the 25 day moulting program. The provision of the repletion diet to these large birds appears to result in a rapid accretion of body weight and fat, and it seems likely that the birds may remain unproductive despite the moulting program. This hypothesis needs to be evaluated as an explanation for moderate post moult performance

The most obvious strategies for further improvement are superior weight control of the first cycle flock and more attention to the duration of the moult to achieve the appropriate extent of weight loss (Rose and Campbell, 1986).

In the commercial trial the use of the calcium supplement (1 gram Ca/bird/day) during the moulting program, again produced an enhancement of the post moult egg production (5%). These finding when combined with the results from the experiment at Longerenong, provides strong evidence for a role of diminished skeletal calcium reserves in constraining egg production in moulted flocks.

If the calcium supplement had been provided to the whole flock of 15,000 hens then the peak production may have approached 83-84% which compares more favouably with the first cycle peak of 89-90%.

The important findings derived from this research is the need to continue to develop an understanding of the effects of both calcium and fat reserves on ovulation potential in both first cycle and moulted flocks..

Concluding Comments

1) The three models presented in this research are likely to represent almost the complete divergence of management problems associated with poor post-moult performance.

2) Clearly one of the keys to achieving effective moulting programs is superior body weight management in the first cycle of egg production. Flocks should attain the genetically defined equilibrium of body weight, feed intake and production for a superior post-moult performance.

3) Given that many flock are still likely to deviate from the ideal metabolic equilibrium there are some managerial refinements which can be used to improve the production performance.

4) In under weight flocks higher body weights post-moult were achieved by using the high density diets. This response is worthy of more investigation using a broader range of nutrient densities and pre-moult body weights..

5) Calcium supplementation during the moult resulted in improved sustainability of production by about 3-5%, and it will be important to evaluate the consistency of this response in additional larger scale experimentation. The response to calcium supplementation during the moulting process is consistent with the hypothesis that the skeletal calcium reserves have important effects on post-moult ovulation rates

6) This research indicates that underweight flocks can be regenerated to a certain extent, and that careful management of the extent of weight loss and the repletion process could be used to rejuvenate flocks that have experienced significant mismanagement.

8) One of the most promising results from this experiment is that peak production post-moult was 80% within 7 weeks of the commencement of the moult, in a flock

that had only achieved after a first cycle peak of 88%. This experiment has indicated that it is possible to reduce the difference between pre and post-moult peaks in Australian flocks and it may be possible to rejuvenate badly mismanaged flocks using the approaches described in this research.

9) In the under weight flock model, an important question that remains to be answered is what is the relationship between the extent of the body weight loss (ie 16% verses 25%) to the compensatory appetite and growth response.

10) The research on the over weight flocks indicates that a more severe moult may be required to shift very fat birds to the physiological state for effective post-moult production. It is not clear at this stage, whether birds with body weights of >2.8 kg can be rejuvenated into effective production.

11) The two important questions that flow from this work are, 1) can these excessively large birds be effectively rejuvenated into production and 2) does the accumulation of fat reserves inhibit birds from re-initiating ovulation or is this linked to calcium metabolism.

Additional Research

Assessments of femur calcium content have also been made on flocks diagnosed with Vitamin D deficiency and the values of 0.6 g/bone associated with severe under mineralisation and pathology in the skeleton is consistent with the models presented in the research project and in project DAV 38E.

Implications

Given the findings presented in project DAV111A and their inter linkage to this research there are large gains in productivity to be achieved by the Australian Egg Industry if it can increase the management acumen of the technologically advanced producers. Educational systems are required to train the technologically advanced producers to understand objective modelling, and the application of these approaches to management refinement.

Clearly the body weight management of flocks in the first cycle will have a profound influence on the moulting program and the potential post-moult performance. The relatively poor standard of moulting management within Australia belies its true economic potential, and the industry should be cognisant of the commercial interests that may argue against this management approach on economic grounds.

It still remains however for commercial models to be established that demonstrate the superior biological performance in moulted flocks described in other countries and research models. There is little doubt that these performances can be achieved, but it is evident that the managerial/environmental interactions are very large.

Finally it is interesting to note that a large proportion of the United States Egg industry practices moulting, in an economic environment were margins are low by

Australian standards. Given the biological potential and the likely adoption rates if moulting can be improved, there are large gains for the Egg Industry which should be able to be realised within a 5-10 year period. In the future, it may be important to identify strains or genotypes which can be efficiently moulted, and it seems likely that stocks derived from North America or lines that have been specially adapted for second cycle production will obtain a dominant market position.

Intellectual Property

N/A

Achievement of Objectives

1. Evaluate the flock performance on 5 Victorian egg farms practicing moulting programs
   Two flocks from two farms undertaking moulting programs have been analysed comprehensively, and on another two farms indicative data has been obtained.

2. Propose reasons for flock mortality and poor post-moult performance on commercial egg farms.
   Under weight flocks that are moulted to body weights to low to sustain survival can produce significant mortalities.

   Poor repletion growth rates following moulting programs, compromises peak production and persistency of production.

   Excessive depletion of skeletal calcium reserves may compromise ability of a significant proportion of the flock to re-initiate ovulation following moulting.

   A conventional moulting program may be unable to rejuvenate egg production in obese birds in the flock.

   Flocks with excessive average body weights may respond poorly to conventional moulting programs

   Severely obese birds may be incapable of rejuvenation into egg production following a conventional moulting program.

3. Develop a laboratory model of a moulting program at Longerenong College and investigate the responses to high density diets in the refeeding/repletion stage.

   Model completed and analysed using a tinted egg laying strain

4. Study the changes in skeletal density and calcium reserves during a moulting program.

Preliminary model of alterations in skeletal calcium reserves has been developed, but needs refinement with more detailed sequential studies

5. Develop improved management practices to optimise both post-moult growth rates and tissue reserves in laying hens subject to moulting programs.

   Management strategies for improving moulting performance in both under and over weight flocks have been developed, but these ideas require additional communication at seminars or conferences.

6. Achieve post-moult peak production performance within 5% of the pre-moult peak performance.

   Last objective is contingent on improving the body weight management of elite flocks in Victoria and then applying some of the strategies that have been developed in these models

Recommendations

1. Markedly superior post-moult performances will be achievable in layer flocks that have a better equilibrium of body weight, feed intake and production. Under weight and over weight flocks will inevitably compromise the economics of moulting.

2. There are clearly significant gains in production to be achieved in moulted flocks by improving the management of the extent of the tissue catabolism and the repletion growth rates.

3. For both under weight and over weight flocks the extent of the tissue catabolism is probably best defined by a threshold body weight rather than a percentage weight loss (25-30%).

4. A calcium supplement provided to flocks during the period of tissue catabolism seems likely to improve the persistency of post-moult egg production by buffering flocks from excessive calcium depletion.

5. The duration of the non-productive period in a moulting program may be able to be reduced by applying more analysis of the flock repletion growth rates.

6. Assuming that the response to calcium supplementation during moulting can be reproduced, then more systematic analysis of the changes in skeletal calcium reserves will be required in both first cycle and moulted flocks.

7. The egg industry needs to move away from rules of thumb and recipes if bird welfare is to be improved during moulting programs.

8. Body weight standards should be developed by all hatcheries or an independent research groups to assist in moulting management. These standards should have well researched threshold body weights and repletion growth rates patterns, and there should be advice for producers attempting to rejuvenate under weight or over weight flocks.

9. The causal reason(s) for the induction of under weight laying flocks are beginning to be understood and rectified by the industry. The new challenge appears to be in understanding the reasons for the development of laying flock with excess weight gain toward the end of lay.

Communication

Some of the basic findings which have been clarified by this research need to be promoted to the Egg Industry at producer forums. In the first instance the variability in the pre-moult flock condition is likely to be unrecognised in the bulk of the Egg Industry. Forums such as the Poultry Information Exchange and the Victorian Egg Industry Seminar Day may provide the appropriate environment to promote these issues. Following on from this approach model flocks need to be developed on commercial farms that can test the thresholds of performance, and validate the original hypothesis that post-moult egg production can almost model first cycle production.

Publications and seminars

1. An abstract will be prepared for publication in the Australian Poultry Science Symposium which describes the potential role of skeletal calcium reserves in the maintenance of egg production.

2. A producer orientated seminar was undertaken in October 1997 and the illustration of the divergence of flock body weights highlighted.

3. In 1998 the Victorian Egg Industry Seminar will include a paper to illustrate the problems and opportunities for moulting

References

Parkinson, G. B. (1996). Unpublished data.

Rose, S.P., and Campbell, V. (1986). Fatness of laying hens and induced moulting regimes. Brit. Poult. Sci. 27: 360-377.

Appendix 1.

Nutrient specifications of experimental diets used in the Laboratory model for refeeding of moulted hens.

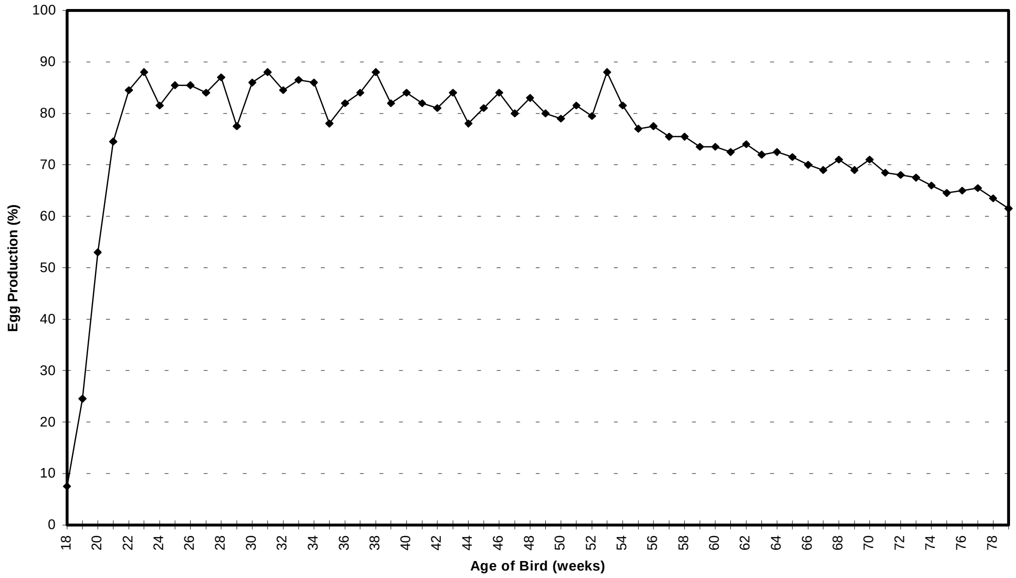
	High Density Diet	Conventional Diet

	%	%
Crude Protein	19.90	16.50
Fat	8.00	5.30
Fiber	2.75	3.34
ME (Mj/kg)	12.35	11.51
Cal	3.75	3.75
Phos	0.83	0.77
Avphos	0.65	0.55
Meth	0.45	0.35
M+C	0.72	0.60
Lys	1.20	0.84
Thre	0.74	0.56
Leuc	1.54	1.13
Isol	0.66	0.57
Trypt	0.21	0.17
Linoleic Acid	3.00	1.64
Sod	0.17	0.15
Chl	0.17	0.17

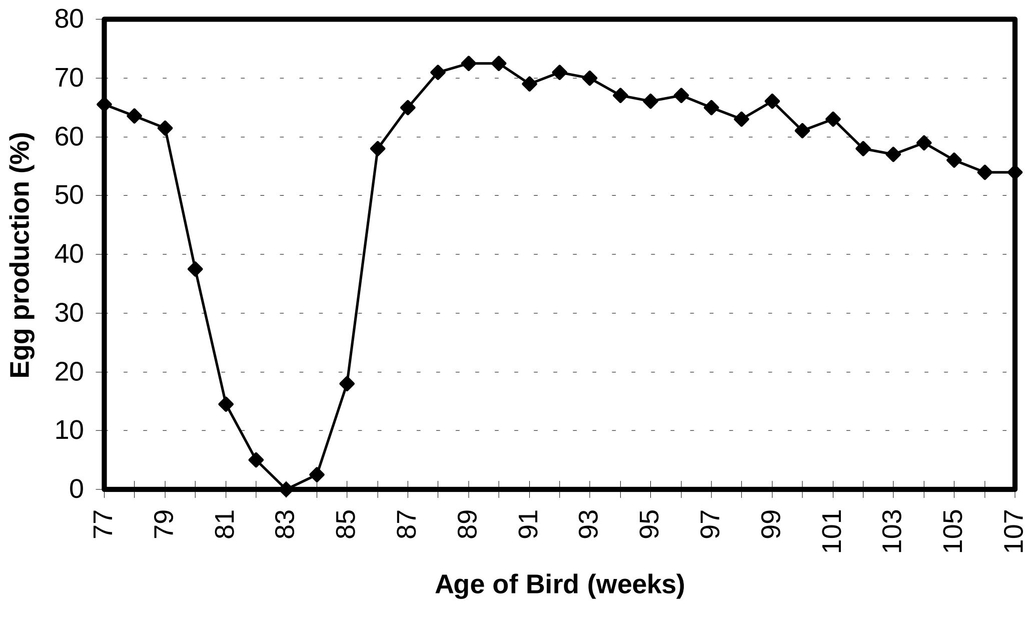
Nutrient specification of commercial diet used in farm trial to refeed moulted hens.

	Commercial Diet %
Crude Protein	17.00
Fat	2.80
Fiber	
ME (Mj/kg)	11.40
Cal	3.89
Phos	
Avphos	0.48
Meth	0.33
M+C	0.63
Lys	0.80
Thre	0.58
Leuc	1.17
Isol	0.61
Trypt	0.16
Linoleic Acid	0.81
Sod	0.11
Chl	0.10

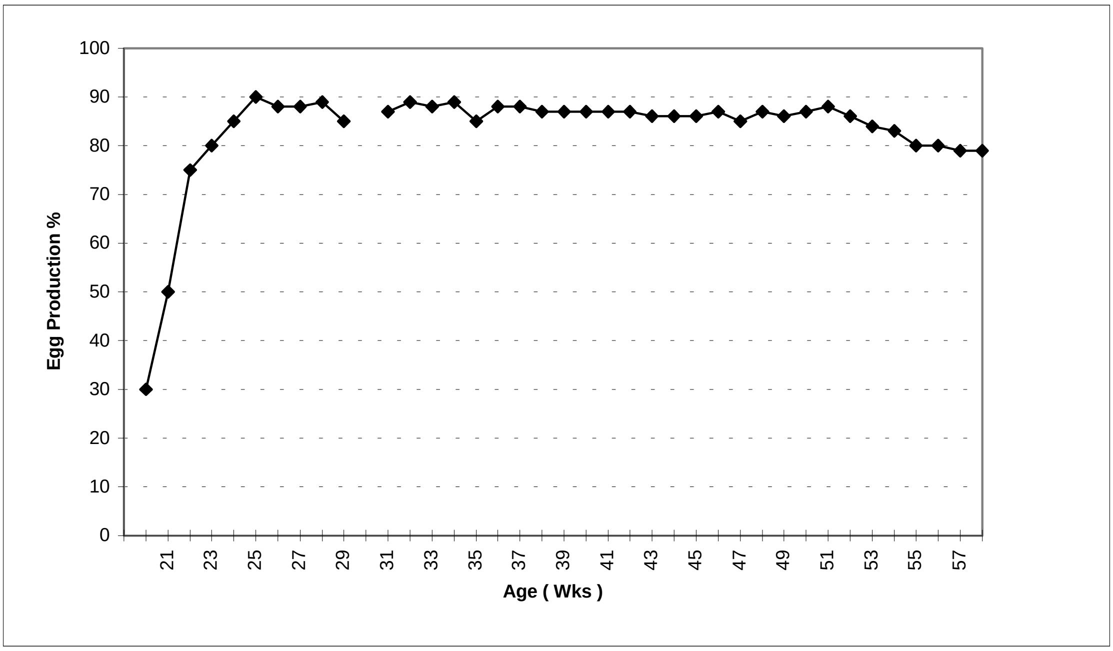
Appendix 2(a): First Cycle Production of Sister flock (WL x NH) to that used in the laboratory model.



Appendix 2(b): Post-moult Egg Production from Sister Flock of that used in laboratory model (WL X NH)



Appendix 3. Egg production from Lohmann Brown commercial flock



Egg Production %
100
90
80
70
60
50
40
30
20
10
0
21
23
25
27
29
31
33
35
37
39
41
43
45
47
49
51
53
55
57
Age (Wks)