EFFECT OF LIGHT RESTRICTION AND AMINO ACID SUPPLEMENTATION ON PERFORMANCE AND AGONISTIC BEHAVIOR OF FORCE MOLTED HENS

by

DANNY JOE HEMBREE

B. S., Kansas State University, 1976

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Animal Sciences and Industry

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1978

Approved by:

Major Professor

TABLE OF CONTENTS

Page

INTRODUCTION. 1

MATERIALS AND METHODS 4

Experiment 1 5

Experiment 2 7

RESULTS AND DISCUSSION. 8

Experiment 1 8

Egg Production and Egg Quality 8

Behavior 13

Experiment 2 21

ACKNOWLEDGMENTS 27

REFERENCES. 28

APPENDIX. 30

INTRODUCTION

Forced molting is used by poultrymen to extend the productive life of laying flocks. A number of procedures have been devised to force molt hens. They can generally be placed into three basic categories: (1) the use of feed additives such as zinc (Scott and Creger, 1976) or anti-ovulatory drugs such as progesterone (Adams, 1955; Shaffner, 1955) and 2-amino, 5-Nitrothiazole (Pino, 1955; Robblee and Clandinin, 1955); (2) feeding low nutrient rations such as a low salt ration (Nesbeth et al., 1974), a low calcium ration (Douglas et al., 1972); Nevalainen, 1969), or a ground corn ration (Safi and Miller, 1969); and (3) the restriction of feed and/or water (Berg and Bearse, 1947; Hansen, 1960; Len et al., 1964; Noles, 1966). The latter is the most common procedure and normally involves the use of a restricted lighting program. Most of these procedures will result in a cessation of egg production, a decrease in the body weight of the hen and a complete or partial loss of feathers.

Important aspects involved with force molting are egg production, egg size, egg quality, shell strength and feed conversion. Berg and Bearse (1947) and Safi and Miller (1969) observed an overall increase in egg weight after force molting. Swanson and Bell (1974c) stated that "less than 6% of molted flocks' total production was in the medium or smaller categories as opposed to over 23% for the pullet flocks". In contrast Len et al. (1964) reported no difference in egg weight before and after a force molt. The general consensus is the cycle of production after force molting will have a higher percentage of large eggs than the pre-molt cycle.

As a laying flock ages, egg quality declines. Most reports agree that force molting will temporarily improve egg quality. Berg and Bearse

(1947) found an improvement in albumen quality after a force molt by hens which had been in production for 12 months prior to a force molt. No subsequent improvement in albumen quality was observed when hens had been in production for only 10 months prior to a force molt. Len et al. (1964) and Noles (1966) reported that the improvement in egg quality was temporary and had largely disappeared within three to five months of post-molt production. Associated with egg quality is shell thickness. Berg and Bearse (1947), Hansen (1960), and Len et al. (1964) observed that shell thickness increased temporarily after a force molt, which parallels the trend observed for interior egg quality.

Len et al. (1964) and Noles (1966) found that force molted hens tended to convert feed more efficiently than non-molted hens of the same age. The data of Swanson and Bell (1974c) indicate there is an improvement in feed efficiency, but overall, there is slightly inferior feed efficiency for each additional cycle of production.

A number of different rations have been fed during the recovery period. Swanson and Bell (1974b) compared the full-feeding of different cracked grains (barley, corn, milo, and oats) during the recovery period. They reported no overall differences in post-molt egg production. They also did not find any economic advantage in using recovery rations which were fortified with vitamins and minerals.

Brake and Thaxton (1977) observed that force molted hens fed a 16% protein pullet grower ration, during the recovery period, returned to production earlier and reached peak production four weeks earlier than force molted hens fed a ground corn ration. Overall, they noted that the hens fed the pullet grower ration had improved egg production and feed conversion, but found no advantage for egg size and shell quality over the hens fed ground corn. Since feathers have a higher content of some amino acids than eggs, (Appendix-Table A-1), Ouart (1977) postulated that feeding specially formulated amino acid supplemented rations would stimulate more rapid post-molt feather growth and a more rapid return to egg production.

Rider (1938) as cited by Wilson and Abplanalp (1956) indicated that pullets raised in darkness were not prevented from coming into egg production. Wilson and Abplanalp (1956) reported the minimum amount of light needed to maintain egg production was less than six one-minute photoperiods per day. They also reported that hens were more sensitive to light changes than pullets. Wilson and Woodard (1958) reported that hens kept in continuous darkness for five weeks continued to lay eggs.

Although much research has been reported on the production characteristics of force molted hens, little information is available describing hens' behavior during a force molt. Guhl and Ortman (1953) found that abrupt changes in the contour of an individual hen could result in a loss of recognition and a possible loss of social status to a subordinate. However, progressive changes associated with a molt or illness will not readily result in a loss of social status in small flocks. Allee et al. (1940) observed that the injection of hens with large doses of thyroxin induced a sudden and complete molt with an accompanying loss of social position to non-treated hens. Hansen (1976) reported that force molting was occasionally effective in relieving hysteria in hens, but a highly nervous state generally persisted.

The present investigations were conducted to determine: (1) the effects of amino acid supplementation on post-molt egg production and quality; (2) the agonistic behavior of hens during the force molting procedure, and (3) the effectiveness of total light restriction as a method of force molting.

MATERIALS AND METHODS

A commercial strain of White Leghorn hens (Hyline) from a previous nutrition experiment was used. They had been housed in floor pens with 80 birds per pen and exposed to 12 hr of light per day. They had been fed, ad libitum, 5 different 17% protein rations. Four of the rations were supplemented with either D-L methionine, zinc sulfate, D-L methionine and zinc sulfate or zinc proteinate (Zinpro-240^R)[1]. There were no significant differences in the production of the birds fed the different rations. At 68 weeks of age the hens were culled and randomly distributed into groups of 10. No more than 2 birds per group of 10 came from the same floor pen.

[1] Zinpro-240^R-zinc methionine sulfate. Zinpro Corporation, 303 Hazeltine Gates Office Park, Chaska, Minnesota 55318.

Experiment 1

The experiment was designed to study behavioral characteristics of force molted chickens and to determine if amino acid (a. a.) supplementation of the recovery diet would be beneficial to post-molt egg production and quality. The hens were placed in an environmentally modified, fan-ventilated, windowless, cage house. Groups of 10 hens were randomly assigned to colony cages (81.3 x 71.1 cm). The experiment consisted of three treatments, with six cages per treatment.

Hens in Treatments 1 and 2 (Table 1) were force molted by removing the feed for 10 days (stress period) and reducing the light period to 8 hr per day. Hens in Treatment 1 (no a. a. supplementation) were fed ground corn during the recovery period, while hens in Treatment 2 (a. a. supplementation) were fed ground corn supplemented with 86.26 g, L-cystine, 167.98 g L-glycine, 22.70 g L-serine, and 49.94 g L-threonine per 45.5 kg. The amino acids were supplemented to levels which were calculated to be equivalent to the N.R.C. (1971) requirements for replacement pullets from 6-14 weeks of age. After the 28-day stress and recovery period the hens were returned to the layer ration and 14 hr of light per day. Hens in Treatment 3 (control) were fed the layer ration, *ad libitum*, and exposed to 14 hr of light per day throughout the experiment. The post-molt egg production cycle consisted of five 28-day periods.

Table 1. SUMMARY OF TREATMENTS USED TO INDUCE MOLT IN 70-WEEK OLD HENS, EXP 1 AND 2

	Periods[1]		
Trt.	Stress (0-10 d)	Recovery (11-28 d)	Post-Molt (29-168 d)
		Exp 1[2]	
1	No feed 8 hr light	Ground corn 8 hr light	Layer ration 14 hr light
2	" "	Ground corn plus amino acid supplementation 8 hr light	" "
3	Layer ration 14 hr light	Layer ration 14 hr light	" "
		Exp 2[3]	
1	No feed 8 hr light	Cracked corn 8 hr light	Layer ration 14 hr light
2	Cracked corn No light	" "	" "

1 Numbers indicate days after start of force molting procedure.

2 Six cages per treatment, 10 hens per cage.

3 Forty-five cages per treatment, one hen per cage.

Egg and mortality records were recorded daily. Feed consumption data were collected from three cages per treatment. Wing badges were placed on individual hens in two cages per treatment for monitoring body weight. These hens were weighed at the time of housing, the end of the stress period, the end of the recovery period and the end of each 28-day post-molt period. Three eggs were randomly collected per cage for three consecutive days prior to the force molt and at the midpoint of each 28-day period after the hens reached 50% post-molt production to determine egg weight, specific gravity and Haugh units.

Behavioral Observations Four cages per treatment were each observed for four 10-min periods each week for an 8-week period beginning two weeks prior to the start of the stress period. Two observations were made in the morning and two in the afternoon during each week. The number of fights, pecks, threats, and avoidances were recorded for each period to determine the number of total aggressive acts.

Two cages per treatment were used to study the social inertia of the flocks by recording the specific individual interactions which occurred. These were the same cages in which wing badges had been placed on the individual hens. Each cage was observed for eight 15-min periods each week for 8 weeks, beginning two weeks prior to the start of the stress period. Four observations were made in the morning and four in the afternoon during each week.

Experiment 2

The experiment was designed to determine if total light restriction was an effective force molting method. Sixty hens per treatment were housed in single-cage batteries (30.5 x 45.7 cm) in a windowless, fan-ventilated room. A number of birds did not adapt to the water troughs and died from dehydration within two weeks after housing. As a result of the deaths, the number of hens per treatment was reduced to 45 before the force molting procedures began.

The experiment consisted of two treatments (Table 1). Treatment 1 (conventional method) followed the same procedures as those previously described for Treatment 1 in Experiment 1, except cracked corn was fed *ad libitum* instead of ground corn. The birds in Treatment 2 were subjected to 10 days of total darkness during the stress period, except for short periods each day when a flashlight was used to aid in gathering eggs and checking for mortality. The hens were fed cracked corn, *ad libitum*, during the 10 days of darkness. The remaining force molting procedures were the same as those previously described for Treatment 1.

Daily egg production and mortality records were maintained. Feed consumption data were collected for 2 groups of 10 birds per treatment. Nine birds per treatment were used for observing changes in body weight. Thirteen eggs per treatment were randomly collected for three consecutive days prior to the force molt and for each 28-day period after the hens reached 50% post-molt production to determine egg weight, specific gravity and Haugh units.

RESULTS AND DISCUSSION

Experiment 1 - Egg Production and Egg Quality. No significant difference in egg production was observed during the pre-molt period between the hens assigned to the three treatments (Table 2 and Fig. 1). The non-molted hens had significantly ($P < .05$) higher egg production than the force molted hens during the molting period and the first post-molt period, but significantly ($P < .05$) lower egg production for all the remaining post-molt periods. As the data show, amino acid

Table 2. EFFECT OF FORCE MOLTING METHODS ON EGG PRODUCTION, EXP 1

Period	Force molt - no a.a. suppl	Force molt - a.a. suppl	Non-molted Control
	% hen-day		
Pre-molt	51.4[1]	51.0	54.2
Molt[2]	4.9	4.9	56.2
Post-molt[3]	57.2	56.9	45.6

1 Common line indicates no significant difference ($P < .05$) between means.

2 Consists of the stress and recovery periods.

3 29-168 days post-molt.

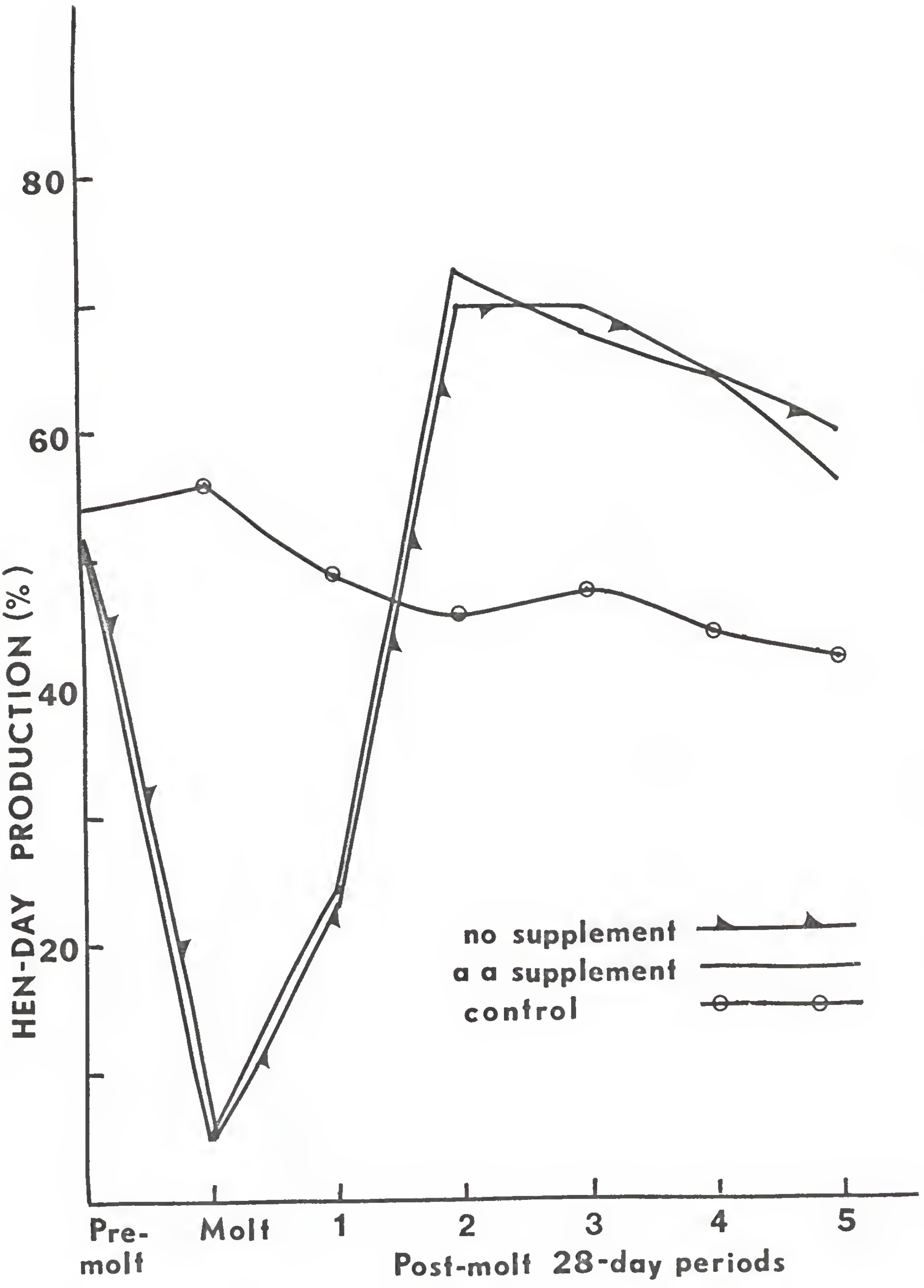

Figure 1. Effect of Force Molting Methods on Egg Production.

supplementation did not significantly improve post-molt egg production.

An increase in egg weight (Table 3) was observed for hens on all treatments during the post-molt period. The increase in post-molt egg weight for the force molted hens agrees with the findings of Berg and Bearse (1947) and Safi and Miller (1969). The increase in post-molt egg weight is probably due to the increase in age of the hens and not the effect of a force molt since the non-molted hens produced significantly ($P < .05$) larger eggs than the force molted hens during the post-molt period (68.9 g _vs_. 66.4 and 67.1 g). Amino acid supplementation did not significantly increase egg weight (67.1 g for a. a. supplementation _vs_. 66.4 g for no a. a. supplementation).

Shell thickness, as estimated from the average specific gravity (Table 3), of eggs laid by the force molted hens was significantly improved ($P < .05$) during the post-molt period which agrees with the findings of Berg and Bearse (1947), Hansen (1960) and Len _et al_. (1964). The non-molted hens experienced a significant decline ($P < .05$) in the average specific gravity for the post-molt period. The post-molt specific gravity of eggs was not improved with amino acid supplementation.

Post-molt egg quality, as measured by Haugh units (Table 3), of the force molted hens was significantly superior ($P < .05$) to the pre-molt levels. This is in agreement with the findings of Len _et al_. (1964) and Noles (1966). The non-molted hens experienced a significant decline ($P < .05$) in average Haugh unit values. No advantage in post-molt egg quality was observed for amino acid supplementation.

The nonsupplemented and amino acid supplemented hens lost 16.8 and 10.6% of their body weight, respectively, during the force molting period (Table 4). They attained or surpassed their pre-molt weight by

Table 3. EFFECT OF FORCE MOLTING METHOD ON EGG WEIGHT AND QUALITY, EXP 1

	Force molted- no a.a. supplement	Force molted- a.a. supplement	Control (non-molted)
Egg weight (g)			
Pre-molt	62.4[1]	64.0	63.3
Post-molt	66.4*	67.1*	68.9*
Specific gravity			
Pre-molt	1.082	1.083	1.083
Post-molt	1.085*	1.085*	1.080*
Haugh units			
Pre-molt	67.7	66.3	67.3
Post-molt	72.0*	71.8*	60.8*

1 Common line indicates no significant difference ($P < .05$) between the means.

* Indicates significant difference ($P < .05$) between pre-molt and post-molt values.

the end of the first 28-day post-molt period. This agrees with the results reported by Swanson and Bell (1947c). Amino acid supplementation did not result in significant changes in body weight.

In most of the post-molt periods there was a trend for the hens that were force molted to consume more feed per hen per day (Table 5) than the non-molted hens. This would be expected because of the higher egg production rates of the force molted hens than the non-molted hens during those periods. Feed conversion (Table 5) was inferior for the force molted hens as compared with the non-molted hens during the first post-molt period. This would be expected since the force molted hens had just come back into production during this period. The force molted hens tended to have superior feed conversion during the later post-molt periods, which agrees with the findings of Len et al. (1964) and Noles (1966). No differences were found, between the nonsupplemented and amino acid supplemented hens, for feed consumption or feed conversion during any of the post-molt periods (Table 5).

Mortality was 1.5, .2, and .5% for the nonsupplemented, amino acid supplemented, and control hens, respectively. Mortality was not found to differ significantly (data not shown).

Behavior. The behavioral data for aggressive acts were divided into 4 time periods: (1) pre-molt - 2 weeks prior to the force molting period when all hens were treated the same, (2) stress - the 10 days during which the force molted hens went without feed, (3) recovery - the 18 days after the stress period when the force molted hens were fed either ground corn or ground corn supplemented with amino acids, and (4) post-molt - the first 2 weeks after the force molting procedures were completed and during which all hens were treated the same.

Table 4. EFFECT OF FORCE MOLTING METHOD ON BODY WEIGHT, EXP 1

Days	Percent Change[1]		
	Force molted- no a.a. supplement	Force molted- a.a. supplement	Control (non-molted)
28	-16.8[2]	-10.6	11.8
56	4.3	5.6	5.2
84	9.9	11.6	6.2
112	11.7	11.1	9.9
140	11.6	11.9	9.5
168	9.7	11.3	10.3

1 Deviations from pre-molt weight=100 $\pm$ (weight at specific day/pre-molt weight x 100).

2 Common line indicates no significant difference ($P < .05$) between the means.

Table 5. EFFECT OF FORCE MOLTING METHODS ON POST-MOLT FEED CONSUMPTION AND CONVERSION, EXP 1

Period	Force molted- no a.a. supplement	Force molted- a.a. supplement	Control (non-molted)
	Feed consumption (g/bird/day)		
1[1]	99.8[2]	103.0	104.0
2	119.1	114.3	102.2
3	110.9	109.7	103.1
4	116.7	115.8	107.1
5	100.2	98.2	83.5
	Feed conversion (kg feed/dz eggs)		
1	6.1	5.4	2.8
2	2.0	1.9	2.8
3	1.9	1.9	2.4
4	2.1	2.1	3.1
5	1.9	2.1	2.6

1 Each number represents a 28-day post-molt period.

2 Common line indicates no significant difference ($P < .05$) between the means.

Analyses of variance of data for aggressive acts are shown in Table 6 and the Appendix (Table A-2). No significant differences in aggressive acts were found between the force molted hens and the non-molted hens during the pre-molt period (Fig. 2, 3 and 4).

The force molted hens tended to have less ($P < .10$) aggressive acts in the afternoon than the non-molted hens during the stress period (Fig. 2). Further division of the data into severe acts (fights and pecks) and non-severe acts (threats and avoidances) reveals that the force molted hens had significantly less ($P < .01$) non-severe acts in the afternoon (Fig. 4). Al-Rawi and Craig (1975) reported aggressive acts were most frequent during feeding. The decrease in activity of the force molted hens during the afternoon observations was possibly a result of the feed deprivation and/or the hens' lack of energy due to the time of day.

During the recovery period the force molted birds had significantly more severe ($P < .05$), non-severe ($P < .001$) and total ($P < .05$) aggressive acts than the non-molted hens. The time of day had an effect. The force molted hens exhibited significantly more aggressive acts in all aggressive categories during the morning while only being significant in the non-severe category for the afternoon observations.

An observation of considerable interest is the force molted hens tended to act more possessive toward the feeders during the recovery period than in the other periods. The degree of possessiveness tended to decrease as the recovery period progressed. Similarly, Andrew (1957) reported an increase in aggressive encounters for flocks of yellowhammers after fasting. Duncan and Wood-Gush (1971) reported that frustration in chickens resulted in an increase in aggressive acts. For an increase in aggressive acts to occur during frustration a subordinate must be present.

Table 6. ANALYSIS OF VARIANCE OF AGGRESSIVE ACTS

Source	df	Total MS	Severe MS	Non-severe MS
Treatments (T)	2	642.83*	69.62	311.49*
Cage/T	9	145.14	31.93	48.26
Time periods (P)	3	2221.67*	321.13	923.5**
AM, PM	1	153.77	29.26	48.88
PX AM, PM	3	121.79	58.14	18.64
Remainder 1	8	418.4	178.25	66.84
TxP	6	463.15**	75.62**	186.34***
TxAM, PM	2	278.96*	95.51*	57.36*
TxPxAM, PM	6	129.27	47.52	23.33
Remainder 2	343	64.27	25.28	15.31

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

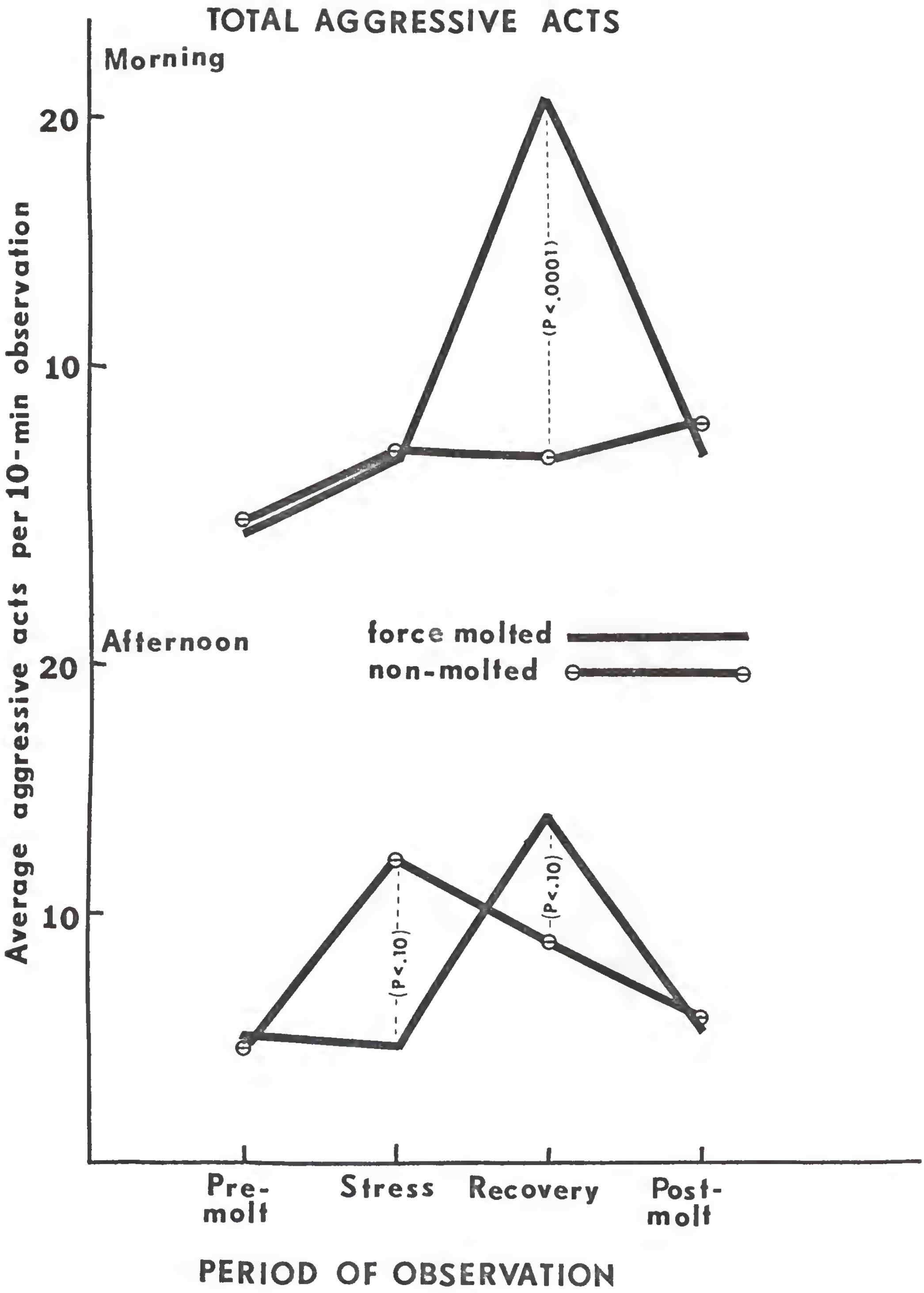

Figure 2. Effect of Force Molting on Total Aggressive Acts.

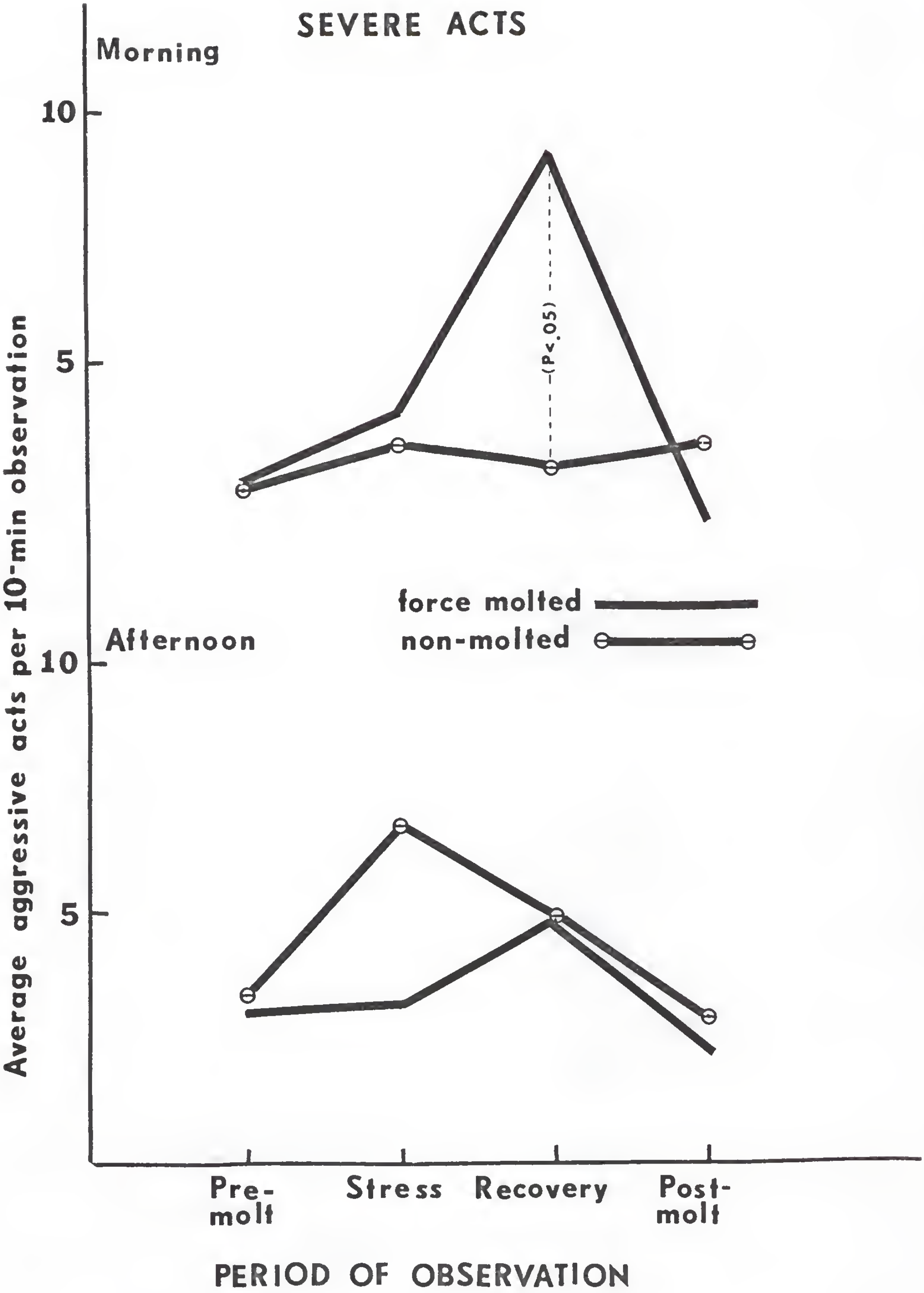

Figure 3. Effect of Force Molting on Severe Aggressive Acts.

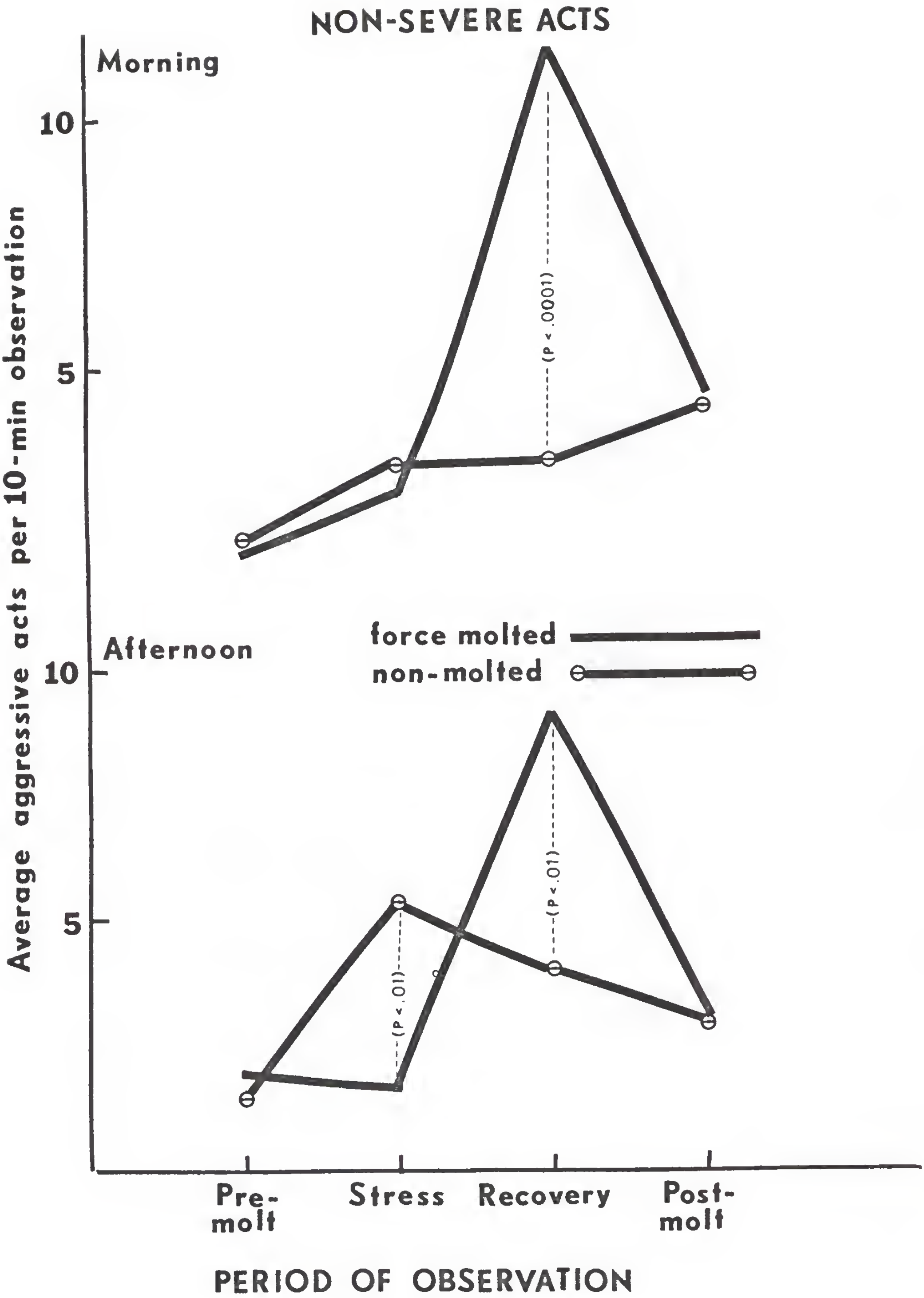

Figure 4. Effect of Force Molting on Non-Severe Aggressive Acts.

Hens at the top of the peck order might have prevented hens near the middle of the peck order from feeding. The frustrated hens near the middle of the peck order may have increased the number of aggressive acts toward the subordinate hens near the bottom of the peck order. Additionally, the force molted hens consumed an average of 170.2 g/bird/day during the recovery period while the non-molted hens consumed an average of 97.2 g/bird/day. Since the force molted hens consumed nearly twice as much feed as the non-molted hens it may be possible to deduce the force molted hens spent more time feeding. As previously stated, aggressive acts are most frequent during feeding (Al-Rawi and Craig, 1975). The frustration the force molted hens experienced along with the increased time spent feeding during the recovery period may be responsible for the increase of aggressive acts.

No differences for aggressive acts were found between the force molted hens and the non-molted hens during the post-molt period.

As a measure of social inertia, the number of peck order violations which were committed during the recovery and post-molt periods were compared to the number of "correct" peck order interactions (Table 7) which occurred. No differences were found as the force molted hens fed ground corn and ground corn supplemented with amino acids, and the non-molted hens exhibited 2.1, 2.8 and 1.7% peck order violations, respectively. These values are in general agreement with the 3% tendency toward peck order violations reported by Holabird (1955).

Experiment 2. Egg Production and Quality. Egg production (Table 8) was not found to differ significantly between treatments for any of the periods. The hens force molted by total light restriction required 8 days to cease production while the hens force molted by the conventional

Table 7. NUMBER OF PECK ORDER VIOLATIONS DURING THE RECOVERY AND POST-MOLT PERIODS

Treatment		Number of Interactions Observed: Correct	Violations	Total	Percent Violations[1]
1. No supplement	observed	1022.00	22.00	1044	2.1
	expected	1020.65	23.35		
	difference	1.35	-1.35		
2. a.a. supplement	observed	413.00	12.00	425	2.8
	expected	415.49	9.51		
	difference	-2.49	2.49		
3. Control	observed	226.00	4.00	230	1.7
	expected	224.86	5.14		
	difference	1.14	-1.14		
Total		1661.00	38.00	1699	

$X^2 = 1.0054$ $P > .50$ d.f. = 2

1 Percent violations = violations divided by total.

Table 8. EFFECT OF FORCE MOLTING METHOD ON EGG PRODUCTION, EXP 2

	Percentage hen-day production	
	Conventional	No light
pre-molt	56.5[1]	56.3
molt	6.5	8.1
post-molt[2]		
1	12.0	13.8
2	71.9	72.3
3	70.9	69.3
4	65.9	66.8
5	64.6	62.1

1 Common line indicates no significant difference ($P < .05$) between the means.

2 Each number represents a 28-day period.

Table 9. EFFECT OF FORCE MOLTING METHOD ON EGG WEIGHT AND QUALITY, EXP 2

	Conventional	No light
Specific gravity		
pre-molt	1.082[1]	1.083
post-molt	1.088*	1.086*
Egg weight (grams)		
pre-molt	63.3	63.8
post-molt	65.5*	67.6*
Haugh units		
pre-molt	67.4	66.2
post-molt	73.9*	74.2*

1 Common line indicates no significant difference ($P < .05$) between the means.

* Indicates significant difference ($P < .05$) between pre-molt and post-molt values.

method ceased production in 5 days. Both groups of hens were out of production for 34 days.

Shell thickness, as estimated from average specific gravity (Table 9), was significantly improved ($P < .05$) for the post-molt period for both groups of hens. The hens which were force molted by the conventional method had a significant advantage ($P < .05$) over the no light force molted hens (1.088 vs. 1.086).

Post-molt egg weight (Table 9) was significantly greater ($P < .05$) than the pre-molt egg weight for both groups of hens. During the post-molt period the hens force molted by exposure to no light laid significantly larger eggs ($P < .05$) than the hens force molted by the conventional method (65.6 vs. 67.6 g).

Egg quality, as measured by Haugh units (Table 9), was improved ($P < .05$) during the post-molt period for both groups of hens. No difference was found between the treatments for post-molt egg quality.

During the molting period the hens force molted by the conventional method and the no light force molted hens lost 25.8 and 27.0% of their body weight, respectively (Table 10). It required about 8 weeks for the hens to return to their pre-molt weight. No differences between the treatments were observed for changes in body weight for any of the post-molt periods.

Feed consumption and feed conversion (Table 11) did not differ significantly. Additionally, during the 10 days of total light restriction the hens consumed an average of 59.3 gm of feed per bird per day.

No significant differences in mortality were observed between treatments for all test periods (data not shown). Both groups of hens had less than 1% mortality throughout the entire experiment.

Table 10. EFFECTS OF TREATMENTS ON PERCENTAGE CHANGE IN BODY WEIGHT[1]

Days	Conventional	No light
28	-25.8	-27.0
56	-10.3	- 6.4
84	- 2.0	2.0
112	8.1	9.2
140	5.7	4.4
168	1.9	3.2

1 Deviations from pre-molt weight = 100± (weight at specific day/pre-molt weight x 100).

Table 11. EFFECTS OF FORCE MOLTING METHOD ON FEED CONSUMPTION AND CONVERSION, EXP 2

	Conventional	No light
	Food consumption (g/bird/day)	
Post-molt periods		
1	94.3[1]	98.1
2	103.3	103.4
3	103.9	103.8
4	109.2	105.9
5	107.2	104.4
	Feed conversion (kg feed/dz eggs)	
Post-molt periods		
1	9.9	13.7
2	1.7	1.8
3	1.8	2.1
4	1.9	2.0
5	2.0	2.2

1 Common line indicates no significant difference ($P < .05$) between the means.

In conclusion, no advantage in subsequent post-molt performance was observed when hens were fed corn supplemented with cystine, glycine, serine, and threonine. Total light restriction with full feeding of cracked corn did not result in superior post-molt production when compared to a conventional force molting procedure. Force molted hens experienced an increase in aggressive acts after a period of feed deprivation. Data suggest the social inertia of a small flock can withstand the pressures of a force molt.

ACKNOWLEDGMENTS

I would like to give thanks to my major professor, A. W. Adams, for the guidance and constructive criticism he offered throughout my stay at Kansas State. Sincere thanks are extended to Professor J. V. Craig for inspiration and numerous opportunities to develop my talents. Additional thanks are extended to A. D. Dayton, Head, Department of Statistics, for his assistance and supervision in the statistical analyses of the data. Last, but not least, my thanks are extended to Mrs. Claudia Phillips for her help in gathering the egg quality data and always being willing to lend a helping hand.

REFERENCES

Adams, J. L., 1955. Progesterone-induced unseasonable molt in Single Comb White Leghorn pullets. Poultry Sci. 34:702-707.

Allee, W. C., H. E. Collias, and E. Beeman, 1940. The effect of thyroxin on the social order in flocks of hens. Endocrinology 27:827-835.

Al-Rawi, B., and J. V. Craig, 1975. Agonistic behavior of caged chickens related to group size and area per bird. Appl. Anim. Ethol. 2:69-80.

Andrew, R. J., 1957. Influence of hunger on aggressive behavior in certain buntings of the genus Emberiza. Physiol. Zool. 30:177-185.

Berg, L. R., and G. E. Bearse, 1947. The changes in egg quality resulting from force molting White Leghorn yearling hens. Poultry Sci. 26:414-418.

Brake, J., and P. Thaxton, 1977. Post-molt effect of high protein vs. low protein diets during a force molt. Poultry Sci. 56:1347.

Cotterill, O. J., W. W. Marion, and E. C. Naber, 1977. A nutrient re-evaluation shell eggs. Poultry Sci. 56:1927-1934.

Douglas, C. R., R. H. Harms, and H. R. Wilson, 1972. The use of extremely low dietary calcium to alter the production pattern of laying hens. Poultry Sci. 51:2015-2020.

Duncan, I. J. H., and D. G. M. Wood-Gush, 1971. Frustration and aggression in the domestic fowl. Anim. Behav. 19:500-504.

Guhl, A. M., and L. L. Ortman, 1953. Visual patterns in the recognition of individuals among chickens. Condor 55:287-297.

Hansen, R., 1960. The effects of methods of forced molting on reproductive performance of chickens. Poultry Sci. 39:1257.

Hansen, R. S., 1976. Nervousness and hysteria of mature female chickens. Poultry Sci. 55:531-543.

Harrap, B. S., and E. F. Woods, 1964. Soluble derivatives offeather keratin. 1. Isolation, fractionation and amino acid composition. Biochem. J. 92:8-15.

Holabird, C., 1955. Social organization in flocks of light Brahma hens as compared with other breeds. Physiol. Zool. 28:239-255.

Len, R. E., H. Abplanalp, and E. A. Johnson, 1964. Second year production of force molted hens in the California random sample test. Poultry Sci. 43:638-646.

National Research Council, Nutrient requirements of poultry, 6th ed. 1971. National Academy of Sciences, Washington, D. C.

Nesbeth, W. A., C. R. Douglas, and R. H. Harms, 1974. Response of laying hens to a low salt diet. Poultry Sci. 53:1961.

Nevalainen, T. J., 1969. The effect of calcium deficient diet on the reproductive organs of the hen. Poultry Sci. 48:653-659.

Noles, R. H., 1966. Subsequent production and egg quality of force molted hens. Poultry Sci. 45:50-57.

Ouart, M. D., 1977. Unpublished literature review.

Pino, J. A., 1955. Force molting in W. L. hens by the use of Enheptin. Poultry Sci. 34:540-543.

Robblee, A. R., and D. R. Clandinin, 1955. The use of 2-amino, 5-nitrothiazole for the induction of moult in yearling hens. Poultry Sci. 34:991-995.

Safi, L. M., and B. F. Miller, 1969. Inducing and controlling reproduction pauses in laying hens. Poultry Sci. 48:1865.

Scott, J. T., and C. R. Creger, 1976. The use of zinc as an effective molting agent in laying hens. Poultry Sci. 55:2089.

Shaffner, C. S., 1955. Progesterone induced molt. Poultry Sci. 34:840-843.

Swanson, M. N., and D. D. Bell, 1974. Forced molting of chickens. Cooperative Ext. Ser., University of California, Berkely.
(a) I Introduction AXT-410
(b) II Methods AXT-411
(c) III Performance Characteristics AXT-412

Wilson, W. O., and H. Abplanalp, 1956. Intermittent light stimuli in egg production of chickens. Poultry Sci. 35:532-538.

Wilson, W. O., and A. E. Woodard, 1958. Egg production of chickens kept in darkness. Poultry Sci. 37:1054-1057.

APPENDIX

Table A-1. COMPARISONS OF AMINO ACID CONTENT OF FEATHERS AND WHOLE EGGS[1]

Amino Acid	Percent Total Protein: Hen Feathers[2]	Percent Total Protein: Whole Egg[3]	Difference
Ala	6.65	5.36	+1.29
Arg	3.77	6.41	-2.64
Asp	5.32	9.96	-4.64
Cys/2	7.30	2.28	+5.02
Glu	6.82	12.37	-5.55
Gly	11.51	3.27	+8.24
His	0.21	2.32	-2.11
Ile	3.20	4.99	-1.79
Leu	6.95	8.30	-1.35
Lys	0.62	7.08	-6.46
Met	0.13	3.23	-3.10
Phe	3.10	4.76	-1.66
Pro	9.41	5.56	+3.85
Ser	13.10	7.66	+5.44
Trp	0.61	4.97	-4.36
Thr	3.86	1.44	+2.42
Tyr	1.36	4.39	-3.03
Val	7.01	6.50	+0.51

1 Adapted from Quart (1977).

2 Calculated from Harrap and Woods (1964).

3 Cotterill, et al. (1977).

Table A-2. ANALYSIS OF VARIANCE OF AGGRESSIVE ACTS

Total Aggressive Acts
Daily Average

Source	df	Pre-molt MS	Stress MS	Recovery MS	Post-molt MS
Treatments	2	142.45	75.06	1806.59***	8.20
T_1, T_2 vs T_3	1	0.13	150.00	3003.13**	16.34
T_1 vs T_2	1	284.76+	0.12	610.04+	0.06
Cage/treat.	9	62.74	70.38	126.69	91.00

Severe Acts
Daily Average

Source	Pre-molt MS	Stress MS	Recovery MS	Post-molt MS
Treatments	81.65+	12.65	186.97*	15.22
T_1, T_2 vs T_3	0.75	25.01	302.17	24.80
T_1 vs T_2	162.56*	0.29	71.77	5.64
Case/tret.	24.28	28.84	34.29	14.95

Non-Severe Acts
Daily Average

Source	Pre-molt MS	Stress MS	Recovery MS	Post-molt MS
Treatments	8.64	26.27	831.72***	3.89
T_1, T_2 vs T_3	0.26	52.51+	1400.08***	0.88
T_1 vs T_2	17.01	0.03	263.35*	6.89
Case/treat.	11.99	13.08	38.84	32.99

+ $P < .10$ * $P < .05$ ** $P < .01$ *** $P < .001$

Table A-2 (cont.). ANALYSIS OF VARIANCE OF AGGRESSIVE ACTS

Total Aggressive Acts
Morning

Source	df	Pre-molt MS	Stress MS	Recovery MS	Post-molt MS
Treatments	2	37.94	2.00	1651.35*	8.59
T_1, T_2 vs T_3	1	0.84	0.00	3296.68***	16.67
T_1 vs T_2	1	75.03	4.00	6.02	0.50
Cage/treat.	9	25.35	86.33	216.14	102.19

Severe Acts
Morning

Source	Pre-molt MS	Stress MS	Recovery MS	Post-molt MS
Treatments	25.00	3.04	310.51*	12.89
T_1, T_2 vs T_3	0.00	2.09	620.84*	25.01
T_1 vs T_2	50.00+	4.00	0.19	0.78
Cage/treat.	10.83	43.93	59.93	25.38

Non-Severe Acts
Morning

Source	Pre-molt MS	Stress MS	Recovery MS	Post-molt MS
Treatments	1.69	1.05	532.29**	1.69
T_1, T_2 vs T_3	0.84	2.09	1056.24***	0.84
T_1 vs T_2	2.53	0.00	8.34	2.53
Cage/treat.	4.08	12.26	53.98	16.97

+ $P < .10$ * $P < .05$ ** $P < .01$ *** $P < .001$

Table A-2 (cont.). ANALYSIS OF VARIANCE OF AGGRESSIVE ACTS

Total Aggressive Acts
Afternoon

Source	df	Pre-molt MS	Stress MS	Recovery MS	Post-molt MS
Treatments	2	115.65	153.13	729.01**	1.40
T_1, T_2 vs T_3	1	0.17	300.00^{+}	403.34^{+}	2.67
T_1 vs T_2	1	231.12	6.25	1054.68**	0.13
Cage/treat.	9	69.33	74.21	86.16	29.60

Severe Acts
Afternoon

Source	Pre-molt MS	Stress MS	Recovery MS	Post-molt MS
Treatments	60.81	40.04	77.09*	5.14
T_1, T_2 vs T_3	1.50	72.52	0.11	4.17
T_1 vs T_2	120.13^{+}	7.57	154.08*	6.12
Cage/treat.	28.51	47.05	32.46	6.04

Non-Severe Acts
Afternoon

Source	Pre-molt MS	Stress MS	Recovery MS	Post-molt MS
Treatments	10.34	38.79*	409.68***	2.34
T_1, T_2 vs T_3	2.67	77.52**	416.84**	0.17
T_1 vs T_2	18.00	0.06	402.52**	4.50
Cage/treat.	12.40	7.31	128.02	12.51

$^{+}$ $P < .10$ * $P < .05$ ** $P < .01$ *** $P < .001$

EFFECTS OF LIGHT RESTRICTION AND AMINO ACID SUPPLEMENTATION ON PERFORMANCE AND AGONISTIC BEHAVIOR OF FORCE MOLTED HENS

by

DANNY JOE HEMBREE

B. S., Kansas State University, 1976

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Animal Sciences and Industry

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1978

ABSTRACT

Two experiments were conducted to determine the effects of several force molting procedures on the performance and agonistic behavior of W. L. hens force molted at 70 weeks of age. Experiment 1 consisted of 3 treatments with hens housed in colony cages: (1) force molted - stress period (no feed and 8 hr light/day for 10 days), recovery period (ground corn and 8 hr light/day for 18 days), and post-molt period (17% layer ration and 14 hr light per day for five 28-day periods), (2) force molted - same as 1 except ground corn was supplemented with the amino acids cystine, glycine, serine, and threonine, and (3) non-molted (control) - 17% layer ration and 14 hr of light/day throughout the experiment. Experiment 2 consisted of 2 force molting procedures with hens housed in single-cage batteries: (1) force molted - same as Treatment 1 of Experiment 1 and (2) force molted - stress period (cracked corn and no light for 10 days) and the recovery and post-molt periods were the same as Treatment 1.

Force molted hens fed ground corn supplemented with amino acids during the recovery period did not experience a significant advantage over the hens fed ground corn with no amino acid supplement for post-molt egg production, egg weight, specific gravity or Haugh units. Absence of light as a method of force molting did not show a significant advantage over the conventional method (feed and light restriction) for post-molt egg production or Haugh units. The eggs laid by the hens force molted with the conventional method had superior ($P < .05$) post-molt specific gravity (1.088 <u>vs</u>. 1.086) than the hens force molted with no light. During the post-molt period the hens force molted with no light produced significantly ($P < .05$) larger eggs (65.6 <u>vs</u>. 67.6 g) than the hens force molted with the conventional method. Force molted hens exhibited a significantly higher ($P < .01$) frequency of agonistic acts per 10-min observation during the 18-day recovery period than hens not force molted (17.2 vs. 7.5). Data suggest the social inertia of a small flock can withstand the pressures of a force molt.