EFFECT OF JUVENILE DIETARY REGIME AND TIME OF BEAK TRIMMING ON PULLET GROWTH, SUBSEQUENT EGG PRODUCTION AND INCIDENCE OF PROLAPSE IN LEGHORNS

by

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Thesis submitted to the Faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of Master of Science in Poultry Science

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(ABSTRACT)

Beak trimming at two different ages, Week-1 and Week-8, under four dietary regimens, varying in percent crude protein (CP) and metabolizable energy (ME) were compared. The dietary regimens were conventional high energy (CHE), conventional medium energy (CME), conventional low energy (CLE) and step-up protein regimen (SUP). At 20 weeks of age, 192 birds from each beak-dietary treatment were housed in laying cages for 24 weeks of egg production. One-half of the birds were provided with high light intensity ranging from 20 to 70 lux and one-half with low intensity from 2.5 to 22 lux.

Cumulative feed intake through 20 weeks of age for the CHE fed birds was significantly lower than that for the CLE fed birds but did not differ from that of the CME or the SUP fed birds. The feed intake of the CME and CLE groups did not differ from each other; however, both were significantly greater than that of the SUP fed birds. Birds reared on CME had the lowest protein consumption with no difference in protein consumption between CHE, CLE and SUP fed birds. Birds reared on the SUP regimen had the lowest ME intake followed by the CLE group with no
significant difference between CHE and CME groups. By 20 weeks of age, there was no significant difference in body weight for CHE, CME and CLE birds with those on SUP being significantly lower than all other treatments. Livability for the 20-week growing phase did not differ among dietary treatments. The influence of age when beaks were trimmed (Week-1 or Week-8) on feed, protein, and energy intake, body weight or livability for the 20-week growing period did not differ between the two beak treatments.

By 44 weeks of age, there were no significant body weight differences among any of the juvenile dietary treatments. Age at 50% production, hen-day and hen-housed egg production, egg weight, shell quality, feed per egg, livability and mortality due to prolapse per se did not differ significantly among juvenile dietary treatments for the six 28-day production period. Birds reared on SUP regimen laid a significantly higher number of pee-wee eggs (< 42.5 g) and a significantly lower number of extra-large eggs (63.8 - 70.8 g) than those fed the other diets. Age at beak trimming and level of light intensity did not influence any of the parameters evaluated during the laying period.
DEDICATION

This thesis is dedicated in the memory of my late Uncle
ACKNOWLEDGEMENTS

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Special thanks to for his encouragement and moral support throughout my graduate program.

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## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>v</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>vi</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>viii</td>
</tr>
<tr>
<td>LIST OF APPENDIX TABLES</td>
<td>x</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xi</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>REVIEW OF LITERATURE</td>
<td>2</td>
</tr>
<tr>
<td>Description</td>
<td>2</td>
</tr>
<tr>
<td>Low-Protein Diets</td>
<td>4</td>
</tr>
<tr>
<td>Step-Up Protein</td>
<td>9</td>
</tr>
<tr>
<td>Energy</td>
<td>10</td>
</tr>
<tr>
<td>Protein:Energy</td>
<td>12</td>
</tr>
<tr>
<td>Prolapse</td>
<td>13</td>
</tr>
<tr>
<td>Beak Trimming</td>
<td>16</td>
</tr>
<tr>
<td>Light Intensity During Laying Phase</td>
<td>18</td>
</tr>
<tr>
<td>GROWING PHASE</td>
<td>22</td>
</tr>
<tr>
<td>MATERIALS AND METHODS</td>
<td>22</td>
</tr>
<tr>
<td>Experimental Design</td>
<td>22</td>
</tr>
<tr>
<td>Measurements</td>
<td>24</td>
</tr>
<tr>
<td>Statistical Analyses</td>
<td>24</td>
</tr>
<tr>
<td>RESULTS</td>
<td>28</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>30</td>
</tr>
<tr>
<td>Body Weight</td>
<td>30</td>
</tr>
<tr>
<td>Feed Traits</td>
<td>32</td>
</tr>
<tr>
<td>Flock Uniformity</td>
<td>35</td>
</tr>
<tr>
<td>Livability</td>
<td>36</td>
</tr>
<tr>
<td>LAYING PHASE</td>
<td>45</td>
</tr>
<tr>
<td>MATERIALS AND METHODS</td>
<td>45</td>
</tr>
<tr>
<td>Experimental Design</td>
<td>45</td>
</tr>
<tr>
<td>Ration</td>
<td>46</td>
</tr>
</tbody>
</table>
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Body weight means (g) by juvenile dietary treatment and age</td>
</tr>
<tr>
<td>2</td>
<td>Body weight gain means (g) by juvenile dietary treatment and age</td>
</tr>
<tr>
<td>3</td>
<td>Effect of beak trimming age (Week-1 vs Week-8) on growing period body weight gain means</td>
</tr>
<tr>
<td>4</td>
<td>Cumulative feed consumption means (g/bird) by juvenile dietary treatment and age</td>
</tr>
<tr>
<td>5</td>
<td>Cumulative protein consumption means (g/bird) by juvenile dietary treatment and age</td>
</tr>
<tr>
<td>6</td>
<td>Cumulative metabolizable energy consumption means (kcal/bird) by juvenile dietary treatment and age</td>
</tr>
<tr>
<td>7</td>
<td>Effect of beak trimming age (Week-1 vs Week-8) on growing period feed consumption means (g/bird)</td>
</tr>
<tr>
<td>8</td>
<td>Flock uniformity and livability at 20-weeks of age by juvenile dietary treatment</td>
</tr>
<tr>
<td>9</td>
<td>Body weight means (g) by juvenile dietary treatment at 24, 28, 32 and 44 weeks of age</td>
</tr>
<tr>
<td>10</td>
<td>Age at 50% egg production by juvenile dietary treatment</td>
</tr>
<tr>
<td>11</td>
<td>Age at 50% egg production by beak trimming treatment</td>
</tr>
<tr>
<td>12</td>
<td>Feed consumption means (g/bird) by juvenile dietary treatment for period (P) 1 through 6</td>
</tr>
<tr>
<td>13</td>
<td>Percent hen-day egg production means by juvenile dietary treatment for period (P) 1 to 6</td>
</tr>
<tr>
<td>14</td>
<td>Percent hen-housed egg production means by juvenile dietary treatment for period (P) 1 to 6</td>
</tr>
<tr>
<td>15</td>
<td>Percentage of eggs in each egg size category by juvenile dietary treatment (TRT) means for 24 weeks of production</td>
</tr>
<tr>
<td>16</td>
<td>Percent livability by juvenile dietary treatment for 24 weeks of lay</td>
</tr>
</tbody>
</table>
17 Percent livability by beak trimming treatment for 24 weeks of lay.................................................61
18 Percent livability by light intensity for 24 weeks of lay...............................................................61
19 Percent mortality due to prolapse by juvenile dietary treatment for 24 weeks of lay......................62
20 Percent mortality due to prolapse by beak trimming treatment for 24 weeks of lay......................63
21 Percent mortality due to prolapse by light intensity for 24 weeks of lay.....................................63
# LIST OF APPENDIX TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Composition (percent) and calculated analyses of grower diets (D)</td>
<td>75</td>
</tr>
<tr>
<td>2</td>
<td>Composition (percent) and calculated analyses of layer diets (D)</td>
<td>78</td>
</tr>
<tr>
<td>3</td>
<td>Analyses of variance for pullet body weight</td>
<td>79</td>
</tr>
<tr>
<td>4</td>
<td>Analyses of variance for pullet body weight gain</td>
<td>84</td>
</tr>
<tr>
<td>5</td>
<td>Analyses of variance for cumulative feed consumption</td>
<td>87</td>
</tr>
<tr>
<td>6</td>
<td>Analyses of variance for cumulative protein consumption</td>
<td>90</td>
</tr>
<tr>
<td>7</td>
<td>Analyses of variance for cumulative energy consumption</td>
<td>93</td>
</tr>
<tr>
<td>8</td>
<td>Analyses of variance for percent (arc sin) flock uniformity from 0 to 20 weeks of age</td>
<td>96</td>
</tr>
<tr>
<td>9</td>
<td>Analyses of variance for percent (arc sin) livability from 0 to 20 weeks of age</td>
<td>96</td>
</tr>
<tr>
<td>10</td>
<td>Analyses of variance for layer body weight</td>
<td>97</td>
</tr>
<tr>
<td>11</td>
<td>Analyses of variance for age at 50% production</td>
<td>99</td>
</tr>
<tr>
<td>12</td>
<td>Analyses of variance for feed per hen per hen-day by period</td>
<td>100</td>
</tr>
<tr>
<td>13</td>
<td>Analyses of variance for percent (arc sin) hen-day production by period for 24 weeks of lay</td>
<td>103</td>
</tr>
<tr>
<td>14</td>
<td>Analyses of variance for percent (arc sin) hen-housed production by period for 24 weeks of lay</td>
<td>106</td>
</tr>
<tr>
<td>15</td>
<td>Analyses of variance for percentage of six egg classification for 24 weeks of production</td>
<td>109</td>
</tr>
<tr>
<td>16</td>
<td>Analyses of variance for percent (arc sin) livability from 20 to 44 weeks of age</td>
<td>112</td>
</tr>
<tr>
<td>17</td>
<td>Analyses of variance for percent (arc sin) mortality due to prolapse from 20 to 44 weeks of age</td>
<td>112</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>27</td>
</tr>
</tbody>
</table>

1  Dietary regimes for 0 to 20 weeks of age
INTRODUCTION

Considerable research has been conducted to determine the proper feeding program for growing pullets that will develop into profitable egg producers. Results have been variable with varying recommendations coming forth; thus, different regimens are being followed in commercial production. A review of the literature indicates that pullets are reaching sexual maturity earlier. This earlier maturity may be a contributing factor in regard to the problem of prolapse which occurs in varying degrees from flock to flock. In recent years the use of high energy rations has become popular which may contribute to the problem of picking.

Since the incidence of prolapse and picking problems appears to be somewhat interrelated, management factors relevant to these events were considered. Thus, the primary objective of this study was to determine if the dietary levels of energy and protein provided during the growing phase, the age at which the beaks were trimmed, and the level of light intensity to which the birds were subjected during the egg laying period had any effect on the incidence of prolapse, body weight and egg production.
The efficiency with which hens utilize their diet has been shown to be influenced by managerial factors including: 1) the time in which birds have access to feed, 2) the amount of feed to which the birds have access, 3) dietary protein level, and 4) energy level of the diet fed.

Studies reported by Novikoff and Bieley (1945) and Tomhave (1958) on limiting the daily time birds have access to feed and reports by Kent (1951), Clark et al. (1962) and Yates and Schaible (1963) on skip-a-day feeding indicated inconsistent results. These feeding techniques were found to be unsatisfactory since chickens learn to increase rate of feed intake and thus ingest needed quantities of feed in shorter periods of time.

Quantitative feed restriction, in which predetermined portions of feed are fed daily during the restricted period, has been studied quite extensively. Mbugua and Cunningham (1983) reported a 5% decrease in body weight at 20 weeks of age when the feed allowance for pullets on an alternate day feeding program was limited to 95% of that consumed by the control group ("ad libitum" fed) the previous week. Strain et al. (1965) reported that restricted pullets were 310 g lighter than full-fed pullets at 147 days of age. This difference decreased to 40 g at 365 days of age. Similarly, Lee (1987) reported significantly lower body weight at 20 weeks...
of age with daily restrictive feeding (70% of the control). MacIntyre and Gardiner (1964) reported that sexual maturity was delayed by approximately 30 days by feed restriction with the duration of restriction having no effect, whereas Fuller and Dunahoo (1962) found a delay in sexual maturity from 0 to 4 weeks depending upon the duration of restriction. Similarly, Lee (1987) reported a significant delay in sexual maturity by daily restrictive feeding from 6 to 20 weeks of age as compared to the control. Mortality was greater during the rearing period, but lower during the laying period for restricted than for full-fed pullets (Bruckner and Hill, 1959). Egg production was shown to be slightly higher in restricted-fed pullets by Bullock et al. (1963), whereas Berg and Bearse (1961), Lillie and Denton (1966) and Mbugua and Cunningham (1983) reported no effect on egg production by the restricted feeding of birds during the growing phase. Nair and Ramakrishnan (1978) obtained a 6% decline in feed consumption in restricted pullets with a corresponding decrease in egg production. Feed restriction during the growing phase did not affect subsequent egg weight (Lee, 1987).

Even though quantitative feed restriction has advantages there are disadvantages which include: 1) the method is time consuming and thus labor cost is increased; and 2) it is difficult to make accurate adjustments to the amount of feed supplied to the pullets consequent to sudden changes in ambient temperature or during the times of stress (Gous, 1978).

The NRC (1984) recommends 18% (0 to 6 weeks), 15% (6 to 14 weeks) and 12% (14 to 20 weeks) crude protein for growing pullets. Protein
requirements have two components: 1) the essential amino acids needed by the bird because it cannot synthesize them or synthesize them rapidly enough to meet their needs, and 2) sufficient protein to supply either the non-essential amino acid themselves or supply amino nitrogen for their synthesis. Scott et al. (1982) reported that protein is required by pullets for tissue and feather growth and for maintenance. Summers and Leeson (1978) have shown that protein intake is positively associated with age of the growing pullets. Their calculations showed a consumed dietary equivalent of 11.5, 11.2, 17.1, 19.0 and 19.3% crude protein during the 4 to 8, 8 to 11, 11 to 14, 14 to 17, and 17 to 20-week growth period, respectively.

Low-Protein Diets

In several studies, a low-protein diet was fed after 8 weeks of age. A few studies have provided information on feeding low-protein diets during the 0 to 8 weeks of age period (Turk, 1961; Lillie and Denton, 1966; Leeson and Summers, 1979, 1980; Doran et al., 1983; Bish et al., 1984; Robinson et al., 1986; Summers et al., 1987).

Low-protein diets have been shown to be effective in reducing pullet body weight (Denton et al., 1959; Turk et al., 1961; Waldroup and Harms, 1962; Lillie and Denton, 1966; Petersen et al., 1966; Foster, 1971; Auckland and Fulton, 1973; Douglas et al., 1973; Spiller et al., 1976; Summers and Leeson, 1978; Bish et al., 1984; Douglas et al., 1985; Robinson et al., 1986; Summers et al., 1987). However, Blaylock (1956)
reported no differences in body weight at 20-weeks of age by feeding 12% protein after 5-weeks of age, and Chi (1985) found no difference in body weight after feeding 149 g protein/kg diet or 182 g protein/kg diet from 0 to 6-weeks of age. Lee (1987) showed no difference in 20-week body weight or body weight gain when low-protein diet (10.5%) was fed from 6 to 20 weeks of age. Carlson and Nelson (1981) concluded that a 12% protein diet was sufficient for growing layer-type pullets after 10 weeks of age. Turk et al. (1961) suggested that a protein level of 20 to 21% from 0 to 8 weeks of age gave best growth and feed efficiency; a protein level of 15 to 16% from 8 to 15 weeks was optimum or near optimum; and a protein level of 13 to 15% from 15 to 20 weeks gave the best performance with the fewest problems from feather picking and eating.

A prime reason to lower protein content is to economize the feed cost of the growing pullets. Pullets raised on low-protein diet had significantly reduced feed intake as compared to the controls (Bullock et al., 1963; Douglas et al., 1973; Kim et al., 1976; Leeson and Summers, 1979, 1980; Bullock et al., 1963; Doran et al., 1983). Leeson and Summers (1979) have reported a reduction of 100 g crude protein consumption for pullets raised on low-protein diet from 0 to 20 weeks of age, while Lee (1987) reported no significant difference in feed consumption when low-protein diets were fed between 6 and 20 weeks of age. Similarly, Summers et al. (1987) found no difference in total feed consumption up to 16 weeks of age for 15% and 21% protein diets. However, Turk et al. (1961) showed that pullets raised on a diet of 15% protein during the first 8-weeks followed by diets containing 13% and 11% protein during the
latter growing periods were less efficient in feed utilization than those fed 20% protein during the first 8-weeks of age and 15% during the latter growing period.

Delay in sexual maturity due to feeding low-protein diets to growing pullets has been shown in various experiments (Turk et al., 1961; Waldroup and Harms, 1962; Bullock et al., 1963; Foster, 1971; Douglas et al., 1973; Balnave, 1974, 1976). However, Wright et al. (1968) reported only a slight delay in sexual maturity by feeding pullets a diet containing 10% protein from 8 to 18 weeks. Berg and Bearse (1958) reported that decreasing dietary protein levels from 16% to 14% at 12 weeks and to 12% at 16 weeks did not affect the date of sexual maturity compared to the continual feeding of 16% protein. Similar results were shown by Lee (1987) when 10.5% protein diets were fed from 6 to 20 weeks. Chi (1985) showed that pullets fed a low-protein diet (149 g protein/kg) supplemented with methionine and lysine during 0 to 6 weeks of age matured 6 days earlier than pullets fed unsupplemented low-protein diets. Bish et al. (1984) reported no difference in sexual maturity when low and high protein diets were compared.

Leeson and Summers (1982) have shown that pullets are able to adapt to a wide range of dietary protein levels during the rearing period without great changes in their subsequent reproductive performance. Feeding a low-protein diet to growing pullets did not adversely affect subsequent egg production (Sunde and Bird, 1959; Bullock et al., 1963; Lillie and Denton, 1966; Wright et al., 1968; Blair et al., 1970; Foster, 1971; Douglas et al., 1973; Balnave, 1974, 1976; Stockland and Blaylock,
Lillie and Denton (1966) suggested that 12% protein diets fed from hatching to 20 weeks of age was adequate for subsequent egg production. However, Douglas et al. (1973) reported a reduction in subsequent egg production when 9.2% protein was fed to pullets from 8 to 18 weeks of age as compared with pullets fed a 14.0% protein diet. Similar results were shown by Kim and McGinnis (1976) when 12 and 15% protein diets were compared. Waldroup and Harms (1962) and Douglas et al. (1985) also found similar results when 10 and 16% protein levels were fed between 8 to 21 weeks of age. Whereas Christmas et al. (1974) found that fall-housed pullets could be fed a 9% protein diet from 8 to 18 weeks of age without greatly affecting laying performance. Leeson and Summers (1979, 1980) reported that low levels of protein fed to replacement pullets in early stages of growth and increasing protein with age did not significantly affect egg production. Chi (1985) reported that pullets fed the low-protein diet (149 g protein/kg) supplemented with methionine and lysine from 0 to 6 weeks of age had significantly better egg production than birds fed the unsupplemented low-protein diet. Dietary protein content fed from 7 to 20 weeks of age did not influence subsequent egg production.

Leeson and Summers (1979) showed no difference in mortality of growing pullets when step-up and step-down protein feeding programs were compared. Similar results were shown by Sunde and Bird (1959), Bish et al. (1984) and Robinson et al. (1986). However, Doran et al. (1983) reported that at 140 days of age birds subjected to juvenile step-up
protein feeding programs had higher mortality than the birds on step-down protein feeding programs. Auckland and Fulton (1973) also noted slightly higher mortality in groups receiving higher protein diets when 14.6, 11.3 and 9.1% crude protein diets were fed from 12 to 18 weeks of age.

Bullock et al. (1963) reported no adverse effect on mortality during the laying phase due to different levels of protein and energy during the rearing period. Similar results were shown by Sunde and Bird (1959), Auckland and Fulton (1973), Spiller et al. (1976), Leeson and Summers (1979) and Lee (1987). However, Doran et al. (1983) noted higher laying house mortality on the step-down protein feeding program.

No effect on egg weight by feeding low-protein diets (varying from 10.4 to 15%) at or after 6 weeks through 20-weeks of age was shown by Sunde and Bird (1959), Bullock et al. (1963), Foster (1971), Spiller et al. (1976) and Lee (1987). In these experiments, pullets were raised on a high protein diet (20-21%) during the 0 to 6-week age period. However, similar results were shown by Lillie and Denton (1966) by feeding a 12% protein diet from hatching to 20-weeks of age. Bish et al. (1984) and Robinson et al. (1986) found comparable average egg weights for step-up protein and conventionally fed pullets. However, Auckland and Fulton (1973) Blair et al. (1970), Leeson and Summers (1979, 1980), and Douglas et al. (1985) reported decreased egg weights when low levels of protein were fed.
Step-Up Protein

The concept of step-up protein feeding program was first initiated in 1978 by Summers and Leeson in a self-selection experiment in which commercial White Leghorn pullets were fed a 20% crude protein diet from 0 to 4 weeks and then given free choice selection of protein and energy supplements. Their calculations showed a consumed dietary equivalent of 11.5, 11.2, 17.1, 19.0 and 19.3% crude protein during 4 to 8, 8 to 11, 11 to 14, 14 to 17 and 17 to 20-week growth periods, respectively. They developed a step-up feeding program based on these observations. Pullets reared on the step-up protein feeding program were significantly lighter in body weight than the control at 20 weeks of age and throughout the laying cycle. Similar results were shown by Doran et al. (1983) except body weight differences were not significant at the end of the laying cycle. Bish et al. (1984) and Robinson et al. (1986) also noted significantly lighter body weights at 20 weeks of age, but the differences were no longer significant by 28 weeks of age. A possible explanation could be that in the studies by Leeson and Summers (1979) and Doran et al. (1983) the pullets were started on a low protein diet from day-old, whereas, in those of Bish et al. (1983) and Robinson et al. (1986), the pullets were provided a high protein diet during the first week. The amount of dietary protein required by the pullet to 20 weeks of age was less with the step-up than the conventional program (Leeson and Summers, 1979; Doran et al., 1983; Bish et al., 1984; Robinson et al., 1986).
Mortality during the growing phase was not affected by the step-up protein feeding program (Leeson and Summers, 1979; Bish et al., 1984; Robinson et al., 1986). However, Doran et al. (1983) subsequently found significantly greater mortality during the laying phase with a step-down program.

No significant differences in age at sexual maturity, egg production, feed consumption and feed conversion (feed consumed per dozen of eggs) between step-up protein program and conventionally reared pullets were reported by Leeson and Summers (1982), Maurice et al. (1982), Doran et al. (1983), Bish et al. (1984), and Robinson et al. (1986); whereas Leeson and Summers (1979) reported a significant delay in age at 50% egg production (8 days) and less feed intake per bird during the laying phase for those reared on step-up protein program. No difference in egg weight and shell quality due to feeding step-up protein vs. conventionally reared pullets were reported by Bish et al. (1984) and Robinson et al. (1986); however low egg weight and inferior shell quality were reported by Leeson and Summers (1979) and Doran et al. (1983).

In summary these studies indicate that step-up protein feeding regimens show promise for growing a more economic pullet without adversely affecting egg production.

Energy

The appetite of chickens fed nutritionally adequate diets is largely determined by their requirements for growth and maintenance. Feed
intake is inversely related to the energy content of the diet, and variation of energy levels by combinations of usual feed ingredients has little or no effect on growth when the diets are adequate in essential nutrients (Lee et al., 1971). Berg and Bearse (1958) and Berg (1959) reported little effect on live weight when different levels of energy in the diets were fed. Similar results were reported by Lillie and Denton (1966) and Doran et al. (1983). However, Lee (1987) found significantly lower 20-week body weights compared to controls when low energy diets were fed from 6 to 20 weeks of age. Similarly, Summers et al. (1987) reported a 6% increase in body weight at 16 weeks of age for birds fed the high density when compared to those on the low density diet. Leeson and Summers (1989) reported that at 140 days of age, birds fed diets providing 2,680 or 2,750 kcal ME/kg were smaller than birds fed diets providing 2,950 or more kcal ME/kg.

No effect of energy level on body weight gain was shown by MacIntyre and Aitken (1957), Berg (1959), Wolf et al. (1969), and Cunningham and Morrison (1977). Although, Lee (1987) found body weight gain of low energy fed pullets to be significantly lower than that of the control, he also noted that, when body weight gain was expressed as weight gain per total energy consumption, the low energy group was not significantly different from the control. However, when it was expressed as weight gain per total crude protein intake, there was a significant decrease which indicated protein utilization was hindered by low dietary energy. However, low energy diets have been shown to increase feed consumption

Berg and Bearse (1958), Quisenberry et al. (1959), Berg et al. (1963), Bolton et al. (1970), Cunningham and Morrison (1977) and Doran et al. (1983) reported no effect of dietary energy level on mortality to laying age. However, Fuller and Chaney (1974) reported that pullets delayed by restricting energy intake had greater mortality during the growing period. Increased feather picking and feather eating was observed when productive energy levels in the diet were above 2,200 kcal per kilogram by Turk et al. (1961).

Delayed sexual maturity in growing pullets fed low energy diets has been reported by Quisenberry et al. (1959), Bullock et al. (1963) and Fuller and Chaney (1974) but not by Berg and Bearse (1958), Berg (1959), Turk et al. (1961), Lillie and Denton (1966) and Cunningham and Morrison (1977).

Pepper et al. (1959), Quisenberry et al. (1959) and Lee (1987) reported no difference in subsequent egg production when low and high energy diets were compared. However, Wolf et al. (1969) reported a decrease in egg production by feeding low energy diets during the growing phase.

**Protein:Energy**

Bullock et al. (1963) investigated the effects of quantitative restriction of dietary protein and energy simultaneously and
individually. They concluded that restriction of either nutrient (protein or energy) would give a similar result and that the combined effect of protein and energy restriction could be considered as additive. Summers et al. (1987) fed a high density diet (21% crude protein and 3,091 kcal ME/kg) and a low density diet (15% crude protein and 2,600 kcal ME/kg) and found a 16% greater weight gain at 6 weeks of age with the high density diet which also resulted in approximately 11% more energy and 30% more crude protein intake than with the low density diet. The high density diet resulted in an 8% difference in weight gain at 16 weeks with an intake of 12% more energy and 33% more crude protein than the low density diet. They concluded that the pullet performance is more closely linked with energy intake than with protein, although Berg and Bearse (1958) reported that White Leghorn pullets can be fed diets containing a wide range of energy and protein ratio (kcal ME/kg to protein) from 166:1 to 224:1. Leeson and Summers (1989) reported that pullet growth to 140 days of age will be maximized with cumulative nutrient intake of 21 Mcal ME and 1,200 g CP, and such intake could be achieved with diet specification of 2,900 kcal ME/kg and 18% CP.

Prolapse

Prolapse, commonly referred in the poultry industry as "blow-out", is the prolonged eversion of the oviduct from the vent, which is often accompanied by blood-stained eggs and eventually death. The exact cause is unknown; however, the following factors may be involved: 1) sex hormone
imbalance, 2) hereditary predisposition, 3) laying at too early an age, 4) laying eggs of an unusual large size, and 5) starting production when overly fat (The Merck Veterinary Manual, 1961). Very little literature is available on the work pertaining to prolapse per se. Stafseth et al. (1932) did not find a specific cause of prolapse, but their opinion was that prolapse is a symptom of certain diseased conditions in the intestine and, more rarely, in the oviduct. Hens in their first year of production, especially White Leghorns, seem to have the most problem.

Burmester (1948) reported that chickens which received the male hormone (testosterone propionate pellets) had a significantly higher incidence of prolapse than sibs implanted with female hormone or cholesterol. The lowest incidence of prolapse occurred in the high dosage stilbesterol implanted group. He concluded that certain birds have a tendency to prolapse either because of insufficient estrogen or because of excessive amounts of androgens with the effect presumably being brought about by hormonal influence on ligaments of the oviduct, spread of the pubic bones, size of the cloaca and vent, and the pliability of the abdomen.

Waters et al. (1947) presented a report on prolapse from data gathered over a period of 8 years (1939 to 1946) for 13 different inbred lines of White Leghorn chickens. The percentage of incidence of prolapse varied, but evidence existed which showed that the tendency towards prolapse is an inherited trait.

Shemesh et al. (1984) found that prolapsed hens had significantly lower plasma 17 β-estradiol concentration than recovered or healthy hens.
He hence concluded that restoration of peripheral 17 β-estradiol concentration to normal levels was concomitant with recovery in prolapsed birds, and suggested that the estrogen exerts its effect by raising the level of prostaglandin synthetase activity in the uterus.

Sometimes vent picking is considered to be one of the causes of prolapse. The vent or cloacal area is particularly vulnerable for hens kept in cages without nest areas as the uterus is everted during egg laying and is an attractive target (Craig, 1981). Females which have been picked inside the vent may, because of the ensuing inflammation and irritation, continue to strain in an effort to dislodge the irritating material and eventually evert the cloaca with a resulting case of prolapse (Barger et al., 1958). Allen and Perry (1975) reported that the presence of a light near the cage seemed to accelerate the onset of pecking with vent pecking being most common during the laying cycle. Neal (1956) postulated that enteritis, if sufficiently severe to inflame the cloaca, could render a bird susceptible to cannibalistic attacks at the vents, and if infected tissues were consumed by cagemates, they too might become infected and later be more susceptible to cannibalism. Hughes (1973) reported that when esterogen, progesterone, testosterone, or esterogen + progesterone were given at 12 weeks of age, vent pecking was observed in the esterogen + progesterone group at and immediately after the onset of lay.
Beak Trimming

The common procedure used to minimize cannibalism among chickens is to trim the beaks which consists of removal of part of the upper beak and often also part of the lower beak. There are several methods of beak trimming and several ages when birds can be beak trimmed; however, the age at which the birds can best be beak trimmed is controversial. The most prevalent methods on a commercial basis are: 1) precision beak trimming at 6 to 8 days and 2) standard block cut at 8 to 10 weeks of age, where the lower beak is left slightly longer than the upper beak.

Beak trimming during the rearing period has been shown to result in a significantly lower body weight up to 20 weeks of age (Slinger and Pepper, 1962; Hargreaves and Champion, 1965; Beane et al., 1967; Andrade and Carson, 1975; Carson, 1975; Lee and Reid, 1977; Blokhuis et al., 1987; Deaton et al., 1987). However, Morgan (1957) showed no significant effect of beak trimming on growth rate. In some cases, the body weight difference did not persist during the laying period, as shown by Andrade and Carson (1975) at 35 weeks and Lee and Reid (1977) at 80 weeks. Carson (1975) reported that chicks beak trimmed after two days of delay in placement were only 3% lighter at 22 weeks and showed no difference at 51 weeks of age.

Significant reduction of feed consumption during the 20-week growing period by beak trimmed birds was reported by Hargreaves and Champion (1965), Andrade and Carson (1975), Lee and Reid (1977) and Lee (1980). Blokhuis et al. (1987) reported a 13.3% reduction in feed intake.
to 17 weeks of age when birds were beak trimmed at 45 days of age. Feed consumption was significantly reduced for pullets fed pellets and beak trimmed at hatching and again at 70 days of age (Deaton et al., 1987). The duration of reduction in feed intake has been shown to be quite variable. In some cases, feed intake did not return to normal (Slinger and Pepper, 1964; Hargreaves and Champion, 1965; Andrade and Carson, 1975; Lee and Reid, 1977); whereas, Lee (1980) reported that day-old beak trimming significantly reduced feed consumption during the growing period but not during the laying period. Lee and Reid (1977) reported that feed consumption in relation to body weight gain and feed efficiency were not significantly different.

A significant delay in sexual maturity for day-old beak trimmed pullets has been shown by Beane et al. (1967), Andrade and Carson (1975), Carson (1975) and Lee and Reid (1977). However, Morgan (1957) and Slinger and Pepper (1964) reported that beak trimmed birds matured earlier. Hargreaves and Champion (1965) found no difference in age at sexual maturity when one-half or three-fourths of the beak was trimmed at 18 weeks of age.

Bramhall and Little (1966) reported that pullets beak trimmed at 7 days of age had significantly higher egg production than those beak trimmed at 12 weeks of age. Andrade and Carson (1975) found no difference in egg production when pullets beak trimmed at 6 days of age were compared to non-beak trimmed birds. However, Morgan (1957) reported an increase in egg production for day-old beak trimmed birds. No significant difference in egg production for day-old beak trimming was reported by
Beane et al. (1967), Andrade and Carson (1975), and Lee and Reid (1977). Lee (1980) showed that egg production was not affected when beak trimming was performed at 4 or 8 weeks of age. However, Carson (1975) reported a decrease in egg production when chicks were beak trimmed at time of placement (day-old), but egg production was not affected when beaks were trimmed 2 days after placement. Hargreaves and Champion (1965) reported a significant decrease in egg production when pullets were beak trimmed at 18 weeks of age.

Day-old beak trimming did not effect egg weight (Beane et al., 1967; Andrade and Carson, 1975; Carson, 1975; Lee and Reid, 1977; Lee, 1980). Lee (1980) found that beak trimming at 4 or 8 weeks of age caused a significant reduction in egg weight compared to day-old beak trimming. Similar results were shown by Andrade and Carson (1975) when beak trimming was done at 12 or 16 weeks of age. However, Hargreaves and Champion (1965) reported no significant difference in egg weight when pullets were beak trimmed at 18 weeks of age.

Lee and Reid (1977) reported no influence of percentage of blood spots in the eggs of beak trimmed and non-beak trimmed birds.

Light Intensity During Laying Phase

Research workers have given considerable attention to vices, such as, cannibalism, vent pecking, pick-out and feather pecking. Numerous "causative factors" have been implicated, and may be classified as: 1) dietary composition, 2) environment, 3) hormonal influences, and 4)
psychic factors (Hughes and Duncan, 1972). In addition to beak trimming, which serves as an effective control measure, another method that warrants continued investigation is light intensity because of its influence on bird activity.

It is generally accepted that bright light increases the incidence of pecking damage (Kull, 1948). Boshouwers and Nicaise (1985) reported that the energy expenditure of the fowl is affected by its physical activity. Physical activity was found to be almost zero in the dark, and at the start of the photoperiod, the number of movements increased dramatically. The association between physical activity and light intensity was shown to be highly significant and positive (Boshouwers and Nicaise, 1987). Hughes and Black (1974) showed a similar relationship between physical activity and pecking damage, but did not find any consistent effect on pecking when bright and dim lights were compared. Hughes and Duncan (1972) reported that pecking was significantly increased from Week 3 to 21 when birds received high compared to low illumination.

King (1962) reported that pullets reared and kept in complete darkness would eventually mature sexually and produce eggs. Robert and Carver (1941) and Dobie et al. (1946) reported no differences in effect on egg production when the hens received 13 hours of light per day with varying light intensity from 10 to 313 lux. Similar results were shown by Nicholes et al. (1944) with varying intensities from 5 to 380 lux, and Ostrander et al. (1960) reported no advantage from supplying high intensity light in pens of laying hens. Morris and Owen (1966) concluded
that the minimum light intensity required for maximum egg production is in the range 2 to 10 lux. Dorminey et al. (1970) reported no significant differences in hen-day egg production over a 40- or 44-week period with light intensities varying from 1.1 to 32.3 lux. However, Abdelkarim and Biellier (1982) reported that increasing light intensity regardless of photoperiod resulted in significantly greater hen-day egg production, while Skaglund et al. (1975) reported that when hens were exposed to 5.38 lux, egg production was numerically better than when provided with 21.5, 53.8 or 107.6 lux. Grover et al. (1972) reported a significant interaction between energy level of diets and light intensity with the high energy feed (3,060 kcal metabolizable energy per kg) and high light intensity (15 to 30 lux) causing a depressed egg production and increased mortality. Boshouwers and Nicaise (1987) suggested that a minimal maintenance requirement at maximal egg production rate is achieved at about 15 lux in a 16 hour day and 8 hour night cycle because as light intensity was reduced from 120 to 15 lux, energy expenditure was reduced by about 9%.

Abdelkarim and Biellier (1982) reported that low intensity (between 5.38 and 10.76 lux), regardless of photoperiod, produced significantly greater egg specific gravity and body weight when compared to high intensity light (32.3 lux increased to 343.1 and 408.8 lux).

Skaglund et al. (1975) and Dorminey et al. (1970) found no influence of light intensity on laying house mortality, while Grover et al. (1972) showed a significantly higher mortality for birds subjected to higher light intensity (15 to 30 lux) than when subjected to lower light
intensity (5 to 12 lux). Dorminey et al. (1970) reported no significant light intensity influence on feed efficiency, egg weight, or percentage of floor and dirty eggs.
GROWING PHASE

MATERIALS AND METHODS

Experimental Design

For this experiment, 2,496 Dekalb XL pullet chicks, vaccinated for Marek's disease, were randomly assigned to treatment groups so as to obtain homogeneity among treatments. All chicks were wingbanded, weighed, and housed in groups of 39 birds/cage in the top deck of triple deck brood/grow commercial cage rearing units. Two cage units with eight cages on each level were located in each of four identical rooms equipped with temperature, ventilation, and light control. Each feeding regime and beak trimming treatment was represented in each cage unit. Each cage measured 61 x 61 x 40.6 cm high. Water was provided with two water cups per cage.

The cage floor was covered initially with a layer of newsprint to facilitate the early feeding of the chicks and to minimize the occurrence of legs slipping through the wire mesh floor. In order to reduce the population density at four weeks of age, one-half of the birds from each cage were transferred to the middle tier of cages and at 6 weeks of age one-third of the birds from the upper and middle tiers of cages were transferred to the lower cage tier while maintaining integrity of the treatments. This final housing arrangement resulted in 192 cages with
13 birds per cage for the remainder of the trial. At 20 weeks of age, the birds were transferred to laying cages.

For the initial 7 days, the birds were subjected to 22 hours of light. During the second week, the daylength was reduced to 18 hours followed by 16 hours the third week. With the beginning of the fourth week, a constant 10-hour day was used and continued through 18 weeks, whereupon, the daylength was increased by 30 minutes per week in preparation for the laying cycle. Light intensity was approximately 10 lux.

Four dietary treatments were utilized during the 20-week growing period. The feeding regimens varied in percent crude protein (CP), metabolizable energy per kilogram of diet (ME), and age (weeks) fed and identified as: conventional high energy regime (CHE), conventional medium energy regime (CME), conventional low energy regime (CLE), and step-up protein regime (SUP). The CP and ME levels plus the intervals fed are identified in Figure 1. All diets contained corn as the principal energy source and dehulled soybean meal as the principal protein source. All diets were fed in mash form "ad libitum". The ingredient profiles and calculated analyses of the grower diets are presented in Appendix Table 1.

Two beak trimmed treatments were superimposed on the dietary treatments. Beaks were trimmed by a precision-cut method at seven days of age (Week-1) on one-half of the birds in each dietary treatment. The other half of the birds had their beaks trimmed at eight weeks of age (Week-8) with the standard block cut method which left about 6 mm of the
upper beak between the cut and the nostril and permitted the lower beak to be slightly longer (about 3 mm) than the upper beak. Touch-up trimming was done at 18 weeks of age on those birds with beaks trimmed at seven days of age.

Measurements

Individual chick weights were determined at one day of age. Group weights by cage were obtained weekly for three weeks. Beginning with the fourth week, individual weights were taken every other week through 20 weeks of age. Due to the time constraints and numbers involved, it was necessary to obtain weight data from two rooms on one day and from the other two rooms the following day for each weigh period from four weeks of age. Individual weight gains were calculated at each appropriate weight interval. Daily mortality records were maintained throughout the 20-week growing period.

Feed consumption, on a per cage basis, was measured weekly to 4 weeks of age and then every other week for the remainder of the growing period. From these data, 0 to 20-week consumptions for feed, protein and metabolizable energy were calculated.

Statistical Analyses

Cage averages for body weight, weight gain and consumption of feed, protein and metabolizable energy, both periodic and cumulative, were subjected to tests of analyses of variance. Treatment differences were identified at the P≤0.05 level of significance using Duncans multiple
range test (Duncan, 1955). The statistical model used to test differences for Day 1, Weeks 1, 2, 3 and 4 was as follows:

\[ Y_{ijkl} = \mu + T_i + B_j + R_k + (TB)_{ij} + (TR)_{ik} + (BR)_{jk} + (TBR)_{ijk} + e_{ijkl} \]

where \( i = 1, 2, 3 \) and 4 diet treatments; \( j = \) Week-1 and Week-8 beak trimming treatments, \( k = 1, 2, 3, \) and 4 rooms, and \( l = 1, 2, \ldots, 64 \) cages.

The above model was used to test the differences for cumulative feed, protein and energy consumption through 20 weeks of age.

To test the differences at six weeks of age, the following model was used:

\[ Y_{ijklm} = \mu + T_i + B_j + R_k + D_l + (TB)_{ij} + (TR)_{ik} + (TD)_{il} + (BR)_{jk} + (BD)_{j1} + (RD)_{kl} + (TBR)_{ijk} + (TBD)_{ij1} + (BRD)_{jkl} + (TBRD)_{ijkl} + e_{ijklm} \]

where \( i = 1, 2, 3, \) and 4 diet treatments; \( j = \) Week-1 and Week-8 beak trimming treatments; \( k = 1, 2, 3 \) and 4 rooms; \( l = 1 \) and 2 decks and \( m = 1, 2, \ldots, 128 \) cages.

The above model was used to test differences at 8, 10, 12, 14, 16, 18 and 20 weeks of age, flock uniformity and livability at 20 weeks of age; however, this time \( l = 1, 2 \) and 3 decks and \( m = 1, 2, \ldots, 192 \) cages. Both flock uniformity and livability were transformed into arc
sine prior to analyses (Snedecor and Cochran, 1967). Flock uniformity for 20-week body weight was calculated on a treatment basis as the percentage of birds per treatment within ±10% of the respective treatment means. Livability was calculated as the number of initial birds started per treatment surviving to 20 weeks of age.

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**Figure 1.** Dietary regimes for 0 to 20 weeks of age.
Dietary crude protein (%)/metabolizable energy (kcal/kg)
levels for each diet (D)<sup>1</sup> utilized per treatment

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<sup>1</sup>Diet analyses are given in Appendix Table 1.

Note: All diets at 18 weeks contained 2.5% calcium.

Figure 1. Dietary regimes for 0 to 20 weeks of age
RESULTS

The growth response noted at various times during the juvenile growing phase was variable among the CHE, CME and CLE groups. However, the different protein and energy levels in the diets of these three regimes had the same influence on growth response to 20 weeks of age (Table 1). In the SUP groups, lowering the CP to 12% while maintaining a higher level of energy (2,904 kcal/kg) after the first week of age resulted in a significantly lower body weight than those on the other dietary treatments within one week (two weeks of age). This difference continued through the 20-week juvenile growing period (Table 1). The high energy and low protein diet fed during the period from one to four weeks of age may have resulted in the restriction of protein intake early in the growing cycle. Increasing the protein and lowering the energy after eight weeks of age resulted in significantly greater increases in weight gain through 16 weeks of age for the SUP fed birds than the other groups (Table 2). Even though compensatory growth occurred during this time, the body weights remained significantly less for SUP birds than for those on the other diets. Pullet body weight at 20 weeks of age did not differ between the Week-1 and Week-8 beak trimmed groups (Table 3).

No statistical difference in cumulative feed consumption for the 20-week growing phase was noted between the CHE and SUP treatments (Table 4). However, SUP birds consumed significantly less feed than CME and CLE birds. Consumption by CHE birds was significantly lower than CLE but no difference was observed between the CHE and CME groups and between the CME and CLE groups. The CME treatment birds consumed the least amount
of crude protein (g/bird) for the 20-week growing period with no
difference noted among the other treatments (Table 5). The SUP treatment
birds consumed significantly fewer kcal of ME per bird for the 20-week
growing period than those on the three other treatments (Table 6). The
CLE fed birds consumed significantly fewer kcal than either CHE or CME
fed birds which had similar energy intakes.

Week-1 beak trimmed birds consumed significantly less feed than
Week-8 beak trimmed birds from 2 to 18 weeks of age except for the 10 to
12-week period (Table 7). However, the cumulative feed consumption for
the 20-week growing period did not differ between beak treatment groups
(Table 7).

There was no statistical difference for either flock uniformity or
livability due to dietary treatments (Table 8) or age at beak trimming.
DISCUSSION

Body Weight

The average body weight at 20 weeks of age for the SUP fed birds (1,326 g) was significantly lower than the other treatments, with no difference between CHE, CME and CLE (1,413, 1,406 and 1,421 g, respectively, Table 1). These findings for the SUP regimen are in agreement with the previous studies by Leeson and Summers (1979, 1982), Doran et al. (1983), Bish et al. (1984), and Robinson et al. (1986). Chi (1985) reported no difference in body weight at 20 weeks of age whether pullets were fed diets containing 149 g protein/kg from 0 to 6 weeks of age and 120 g protein/kg from 7 to 20 weeks of age or 182 g protein/kg from 0 to 6 weeks of age and 151 g protein/kg from 7 to 20 weeks of age, which is similar to the CHE, CME and CLE treatments in this study. These data indicate that higher levels of protein were fed than was needed during the growing period and was not fully utilized since the 20-week body weights did not differ. Berg and Bearse (1958), Berg (1959), Lillie and Denton (1966) and Doran et al. (1985) reported no significant difference in body weights at 20 weeks of age from feeding different levels of energy in the diet at various times during the growing phase; whereas, Lee (1987) found significantly lower body weights at 20 weeks of age when low energy was fed from 6 to 20 weeks of age as compared to high energy diets. Leeson and Summers (1989) reported that, at 20 weeks of age, birds fed a diet providing either 2,650 or 2,750 kcal ME/kg were significantly lower in body weight than those fed 2,950 or more kcal ME/kg diet.
In a review of seven different experiments, Lee et al. (1971) reported that at ME levels above approximately 2,000 kcal/kg diet, pullet live-weight was 95% or more of the control weight, with the controls being the pullets fed the highest energy level in each experiment. This relationship was observed to be the case in this study for the CME (99.5%) and CLE (100.5%) fed birds in comparison to the CHE fed birds. However, the SUP fed birds were 93.8% of the CHE group even though the energy level was above 2,000 kcal/kg diet. This influence on body weight may have been due to the early restriction in nutrient intake due to the feeding of higher energy levels from 1 to 4 weeks of age and low protein levels from 1 to 8 weeks of age for the SUP fed birds.

The groups with beaks trimmed at Week-1 had significantly reduced body weights from 2 through 8 weeks of age compared to the untrimmed at that time. Those trimmed at Week-8 had significantly lower body weight from 10 through 12 weeks of age than those beak-trimmed at Week-1 with no difference between the two beak treatments observed at 20 weeks of age (Table 3). A similar response of a significant drop in body weight gain following a beak trimming procedure was reported by Andrade and Carson (1975). Lee (1980) found no difference in 20-week body weight for chickens with beaks trimmed at either 1 day, 4 weeks or 8 weeks of age. No significant interaction for body weight was noted between dietary treatments and age at beak trimming through 20 weeks of age.

A drop in body weight gain was noted in all treatments (Table 2) during the 12 to 14 week growing period. This decline became more pronounced during the 14 to 16 weeks period and improved during the 16
to 18 week period. The decline in weight gains during this time may have been a reflection of a diagnosed staphylocci infection in the flock.

Feed Traits

The cumulative feed consumption per bird from 0 to 20 weeks of age for the SUP fed birds was 6,680 g (Table 4). This amount was significantly less than the 6,871 g consumed by the CME fed birds and the 6,891 g for the CLE fed birds. The average consumption for those receiving the CHE diets was 6,777 g which did not differ from either the CME or SUP fed birds. However, the CHE fed birds had a significantly lower feed consumption than those on the CLE regime. A similar increase in feed consumption by feeding low energy diets was reported by Doran et al. (1983) and Lee (1987). Cunningham and Morrison (1976) reported a significant average increase of 8.1 g/pullet/day of feed intake in low energy diets from one day of age to 18 weeks of age compared to those on high energy diets. In a later experiment, Cunningham and Morrison (1977) found approximately 7% higher intake in pullets fed low energy diets; whereas, in this experiment, CLE fed pullets consumed 114 g more feed than those on the CHE diet which approximates 1.7%. Although there were differences in protein and energy levels in the diets at various time intervals in the CHE, CME and CLE regimens, the three had a similar effect on the cumulative feed intake through 16 weeks of age. Lowering the energy from 2,794 to 2,706 kcal/kg and the CP from 15 to 13% for the period from 14 to 18 weeks of age in the CLE regime resulted in a significantly higher cumulative feed intake for those birds by 20 weeks of age than for
the CHE and SUP groups. The CLE fed birds did not differ from those on CME in cumulative feed intake which would be expected since the total ME (kcal/kg of the diet) in the CME did not differ widely from that in the CLE group. Lowering the protein and maintaining a higher level of energy following one week of age in the SUP fed birds did not significantly affect the cumulative feed consumption through three weeks of age. However, the lower feed consumption of the SUP birds from 3 weeks of age to 12 weeks of age is apparently a reflection of their lower body weights, suggesting that the birds were consuming to meet their energy requirements. The low protein level of the diet from 1 to 8 weeks of age limited the protein intake resulting in slower body growth, thus lowering cumulative feed intake from 4 through 16 weeks of age. The lower energy fed to the SUP birds from eight weeks of age (2,794 kcal/kg from 8 to 14 weeks of age and 2,750 kcal/kg from 14 to 20 weeks of age) resulted in the birds eating more feed to meet their energy requirements which resulted in no statistical difference in feed consumption for the growing phase as compared to the CHE fed birds.

During the same period of time, feeding diets containing increasing levels of protein (15% CP diet from 8 to 14 weeks and 18% CP diet from 14 to 20 weeks) resulted in the SUP fed birds consuming similar amounts of cumulative protein (1,036 g) for the 0 to 20-week period as those fed the CHE (1,046 g) or CLE diets (1,038 g, Table 5). These results are in accord with those obtained by Bish et al. (1984) and Robinson et al. (1986), when similar increasing levels of protein were fed; however, the ME in their treatment was maintained at 2,900 kcal/kg through 0 to 20
weeks of age. Leeson and Summers (1979) reported a reduction of 100 g CP from 0 to 20 weeks of age, which may be due to the fact that their experiment consisted of feeding a lower level of CP and a higher level of ME from 1 day of age rather than from 7 days of age as was done in this experiment. Feeding a lower level of CP (13%) from 12 to 14 weeks of age in the CME treatment, while the other three were receiving 15% CP, resulted in the CME birds consuming significantly less protein (20 to 30 g) than the other dietary groups for the 0 to 20-week growing period.

The total ME consumption for SUP fed birds was significantly less than for the other three treatments (Table 6). This reduced ME consumption may be attributed not only to the smaller body size realized by the SUP fed birds, but also, in part, to the lower energy level of the diet fed during the latter portion of the growing period when feed consumption per se is expected to be higher. The lower energy level in the diet fed to the SUP birds resulted in a higher protein consumption than needed. It may be that the excess protein consumed was converted to energy as the resulting body weight and total ME consumed was significantly lower than for the other three treatments, indicating an inefficient use of protein. Birds fed CLE diets consumed significantly less total ME than those on the CHE and CME diets, which did not differ (Table 6). A similar trend was reported by Doran et al. (1983). Cunningham and Morrison (1976) reported a significant increase of caloric intake with low energy diets (2,843 kcal/kg in the starter diet and 2,865 kcal/kg in the grower diet) as compared to high energy diet (3,284 kcal/kg in the starter diet and 3,339 kcal/kg in the grower diet) during the
period from 0 to 12 weeks of age, but not during the period 12 to 18 weeks of age. The birds consumed approximately the same average number of calories per day (139 vs. 143 kcal).

Beak trimming at Week-1 resulted in a subsequent reduction in feed intake for the beak-trimmed birds relative to those with untrimmed beaks (Table 7). The lower feed intake associated with the trimmed beaks continued through 8 weeks of age. For the two-week period following the Week-8 beak trimming procedure, the birds consumed significantly less feed than those with beaks trimmed at Week-1. A similar drop in feed consumption following beak trimming was reported by Andrade and Carson (1975). Although the effect of beak trimming on feed consumption was noted as above, the cumulative feed consumption of 6,777 g per bird for Week-1 beak trimmed birds did not differ significantly from the 6,835 g per bird consumed by the Week-8 group (Table 7). This response was similar to that reported by Andrade and Carson (1975). No significant interactions were noted between dietary treatments and age at beak trimming for cumulative feed, protein and energy intake for the 0 to 20-week growing period.

Flock Uniformity

At 20 weeks of age, no statistical difference between dietary treatments was noted for flock uniformity, which was calculated on a within treatment basis (Table 8). The CHE (74.6%), CLE (72.8%) and SUP (70.7%) birds were within acceptable industry standards, i.e. 70% of birds were within ± 10% of the treatment means, whereas CME (68.8%) fed birds
were slightly below. No significant differences in flock uniformity by feeding step-up protein were reported by Leeson and Summers (1979), Bish et al. (1984) and Robinson et al. (1986). No significant difference in flock uniformity by beak trimming either at Week-1 (70.8%) or Week-8 (71.6%) were noted which is similar to the results reported by Andrade and Carson (1975).

Livability

Livability calculations excluded the mortality during the first eight days of the experiment since this mortality was due to mechanical causes, such as legs being trapped in the wire mesh floor, and not a reflection of the treatment per se. Dietary treatments did not adversely affect the percent livability during the 20-week growing phase of the experiment (Table 8). Similar results when feeding different levels of ME were reported by Berg and Bearse (1958), Bolton et al. (1970), Cunningham and Morrison (1977) and Doran et al. (1983). Similar findings for step-up protein fed birds were reported by Leeson and Summers (1979, 1982), Bish et al. (1984) and Robinson et al. (1986). However, lower livability was reported by Fuller and Chaney (1974) when pullets were delayed by restricted energy during the growing period, and by Doran et al. (1983) when feeding a step-up protein diet.

Livability did not differ by beak trimming either at Week-1 (99.1%) or at Week-8 (98.0%) for the 0 to 20-week period. This observation is in agreement with the findings reported by Andrade and Carson (1975).
Table 1. Body weight means\(^1\) (g) by juvenile dietary treatment and age

<table>
<thead>
<tr>
<th>Age (wk)</th>
<th>CHE</th>
<th>CLE</th>
<th>CME</th>
<th>SUP</th>
<th>PSE(^2)</th>
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</thead>
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</table>

\(^1\) Means within a row with different letters are significantly different (P\(\leq 0.05\)).

\(^2\) Pooled standard error.
Table 2. Body weight gain means\(^1\) (g) by juvenile dietary treatment and age

<table>
<thead>
<tr>
<th>Age (wk)</th>
<th>CHE</th>
<th>CME</th>
<th>CLE</th>
<th>SUP</th>
<th>PSE(^2)</th>
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</thead>
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</table>

\(^1\) Means within a row with different letters are significantly different (P<.05).

\(^2\) Pooled standard error.
Table 3. Effect of beak trimming age (Week-1 vs Week-8) on growing period body weight gain means

<table>
<thead>
<tr>
<th>Age (wk)</th>
<th>Periodic gain</th>
<th>Cumulative gain</th>
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<tbody>
<tr>
<td></td>
<td>Week-1</td>
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</table>

1 Means within a row with different letters are significantly different (p≤0.05).

2 Pooled standard error.
Table 4. Cumulative feed consumption means\(^1\) (g/bird) by juvenile dietary treatment and age

<table>
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<tr>
<th>Age (wk)</th>
<th>CHE</th>
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<th>CLE</th>
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<th>PSE(^2)</th>
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\(^1\) Means within a row with different letters are significantly different (P<0.05).

\(^2\) Pooled standard error.
Table 5. Cumulative protein consumption means\(^1\) (g/bird) by juvenile dietary treatment and age

<table>
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<th>Age (wk)</th>
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<th>SUP</th>
<th>PSE(^2)</th>
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</table>

\(^1\) Means within a row with different letters are significantly different (P<.05).

\(^2\) Pooled standard error.
<table>
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<th>Age (wk)</th>
<th>CHE</th>
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<th>CLE</th>
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1 Means within a row with different letters are significantly different (P ≤ .05).

2 Pooled standard error.
Table 7. Effect of age at beak trimming (Week-1 vs Week-8) on growing period feed consumption means (g/bird)

<table>
<thead>
<tr>
<th>Age (wk)</th>
<th>Periodic consumption</th>
<th>Cumulative consumption</th>
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</thead>
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<td>16</td>
<td>847.7a</td>
<td>850.3a</td>
</tr>
<tr>
<td>18</td>
<td>906.7a</td>
<td>906.6a</td>
</tr>
<tr>
<td>20</td>
<td>969.9a</td>
<td>938.4b</td>
</tr>
</tbody>
</table>

1 Means within a row with different letters are significantly different (P<.05).

2 Pooled standard error.
Table 8. Flock uniformity and livability at 20-weeks of age\(^1\) by juvenile dietary treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Uniformity</th>
<th>Livability</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE</td>
<td>74.6a</td>
<td>99.0a</td>
</tr>
<tr>
<td>CME</td>
<td>68.8a</td>
<td>98.9a</td>
</tr>
<tr>
<td>CLE</td>
<td>72.8a</td>
<td>97.4a</td>
</tr>
<tr>
<td>SUP</td>
<td>70.7a</td>
<td>98.9a</td>
</tr>
<tr>
<td>PSE(^2)</td>
<td>1.89</td>
<td>0.62</td>
</tr>
</tbody>
</table>

\(^1\) Means within a column with different letters are significantly different (P<.05).

\(^2\) Pooled standard error.
LAYING PHASE

MATERIALS AND METHODS

Experimental Design

The laying phase of the experiment was comprised of six 28-day periods for pullets between 20 to 44 weeks of age. At 20 weeks of age, 1,536 pullets from the growing phase were transferred to laying cage units. A three deck cage arrangement with 32 cages on each level was located in each of four identical rooms equipped with ventilation and light control. Birds were randomly distributed by beak treatment and juvenile dietary treatment group with all the birds in each cage being of the same treatment group. Each feeding regime and beak trimming treatment of the growing phase were represented in each cage unit. Four birds were placed in a cage providing a 348 square cm per bird floor space (30 x 46 cm). Water was provided by two water nipples per cage.

One-half of the birds (2 rooms) were subjected to high intensity light and the other half (2 rooms) to low intensity light. Light was supplied with incandescent bulbs. The high intensity light ranged from 500 to 2,600 lux without diffuser in place on a Luna Pro® light meter and 20 to 70 lux with a diffuser in place depending upon the distance from the light source. The low intensity light ranged from 80 to 650 lux without diffuser in place and 2.5 to 22 lux with diffuser in place. Day length was increased from 11 hours at 20 weeks of age to 11.5 hours at
Week 21 and 12 hours at Week 22. Beginning at 23 weeks of age, the day length was increased 15 minutes per week until 30 weeks of age at which time a 14-hour day length was maintained.

Ration

All birds were treated the same nutritionally during the laying period. The particular diet used was determined by commercial protocol which considers such factors as body weight, rate of production, ambiant temperature, egg size and age of the bird. The ingredient profiles and calculated analyses of the layer diets and periods fed are presented in Appendix Table 2. All diets were in mash form and fed "ad libitum" at approximately the same time each day.

Measurements

Body weight was measured on a cage basis at 24, 28, 32 and 44 weeks of age and feed consumption at 24, 28, 32, 36, 40 and 44 weeks of age from which hen-day calculations were made. Daily egg production on a cage basis was recorded through 44 weeks of age from which percentage hen-day and hen-housed production for six periods of 28-days each and their cumulative 44-week production figures were calculated. Days of age at 50% production was used as a measure of sexual maturity. Feed conversion was calculated in terms of feed per egg at the end of each 28-day production period.
Individual weights were recorded for all eggs collected for two consecutive days at the end of each 28-day production period. Eggs were sorted into egg size groups of pee-wee (35.5 g to 42.5 g), small (42.6 g to 49.5 g), medium (49.6 g to 56.6 g), large (56.7 g to 63.7 g), extra-large (63.8 g to 70.8 g), and jumbo (greater than 70.9 g). Specific gravity of these eggs was determined by a floatation method for evaluation of shell quality. Salt solutions were prepared in the range of 1.065 to 1.100 specific gravity units in increments of .005 units.

Livability records were maintained through 44 weeks of age, with the occurrence of prolapse noted. The criteria used in noting prolapse was: 1) redness or blood around the vent but no protrusions, 2) entrails or other protrusions from the vent, and 3) other physical damage in the vent area.

**Statistical Analysis**

Variations in body weight, feed consumption, feed conversion (feed per egg), egg weight, specific gravity and age at 50% egg production were tested by analysis of variance tests. Treatment differences were identified at the $P \leq 0.05$ level of significance using Duncans multiple range tests (Duncan, 1955). The statistical model used was:

$$Y_{ijklmn} = \mu + T_i + B_j + L_k + D_l + R_m + (TB)_{ij} + (TL)_{ik} + (TD)_{il} + (TR)_{im} + (BL)_{jk} + (BD)_{jl} + (BR)_{im} + (LD)_{kl} + (LR)_{km} + (DR)_{lm} + e_{ijklmn}$$
where \( i = 1, 2, 3, \) and 4 diet treatments; \( j = \) Week-1 and Week-8 beak trimming ages; \( k = \) high and low intensity lights, 1 = 1, 2 and 3 decks, 
\( m = \) replication of Rooms 1 and 2 for light treatment and \( n = 1, 2, \ldots, 384 \) cages. Hen-day and hen-housed egg production, percentage egg size, livability and mortality were transformed to arc sines prior to using the above model for analyses (Snedecor and Cochran, 1967).
RESULTS

The SUP reared birds had a significantly lower average body weight through 24 weeks of age than those reared on the other dietary regimes (Table 9). The SUP fed birds no longer differed from the CHE reared group at 28 weeks of age, and at 44 weeks of age, none of the juvenile dietary treatment groups exhibited any significant differences in body weights. The influence of juvenile dietary treatment on body weight was similar for the CHE, CME and CLE groups throughout the 24 weeks of lay (Table 9). Age at beak trimming and light intensity during the laying phase had no affect on body weight through 44 weeks of age.

Age at 50% production was similar for all juvenile dietary treatment groups (147.3, 148.6, 147.7 and 148.8 days of age for CHE, CME, CLE and SUP, respectively). The influence on age at 50% production did not differ between the two beak trimming treatments (148.0 days for Week-1 and 148.2 days for Week-8).

No significant differences due to juvenile dietary treatments, age at beak trimming or light intensity were noted for either egg production, feed consumption, feed conversion (feed consumed per egg), egg weights, shell quality, percentage livability (Tables 16, 17 and 18) and incidence of prolapse (Tables 19, 20 and 21) through the 24 weeks of lay.
DISCUSSION

The lack of any significant body weight differences at 44 weeks of age due to the juvenile dietary treatments (Table 9) is similar to the response reported by Berg (1959) and Doran et al. (1983), wherein, varying levels of energy during the juvenile period had no subsequent effect on body weights during the laying period. Pepper et al. (1959) and Lee (1987) reported that birds raised on high energy diets were slightly heavier at housing, but were not different in body weights from those grown on low energy diets at the end of laying period. The SUP raised birds were significantly lower in body weight through 24 weeks of age, with no difference at 28 weeks as compared to the CHE birds. However, the SUP birds were significantly lower than CME and CLE reared birds through 32 weeks of age. Bish et al. (1984) and Robinson et al. (1986) reported no significant difference in body weights of step-up protein raised birds after 28 weeks of age when compared to the conventionally reared birds. Leeson and Summers (1982) reported lighter body weights until 30 weeks of age for step-up protein reared birds, whereas in 1979, the same authors had reported lighter body weights throughout the laying period for SUP reared birds. However, all these studies involved different levels of protein and energy with different time periods for the step-up protein regimes. These results suggest that laying hens have the ability to compensate during the early laying period if the nutritional restriction during the growing phase is not extreme.
The lack of any difference in the effect of juvenile dietary treatments on age at 50% production (Table 10) is similar to the results reported by Berg and Bearse (1958), Lillie and Denton (1966) and Lee (1987), when feeding different levels of energy during the growing phase. Similar results from a step-up protein program during the juvenile period was reported by Leeson and Summers (1982), Maurice et al. (1982), Doran et al. (1983), Bish et al. (1984) and Robinson et al. (1986). Quisenberry et al. (1959) found that caloric restriction during the growing period was effective in delaying sexual maturity. Leeson and Summers (1979) reported a significant delay in age at 50% production when body weight was restricted by 13.2% of the conventionally reared pullets. Body weights of the SUP birds in this study were approximately 6% less than for the CHE birds. Week-1 and Week-8 beak trimmed birds did not differ in respect to age at which 50% production was attained (Table 11). Similar results were reported by Andrade and Carson (1975).

The influence of juvenile dietary treatments on laying house feed consumption (Table 12), egg production (hen-day and hen-housed, Table 13 and 14), egg weight, shell quality and feed conversion (feed consumed per egg) for six 28-day production periods did not differ among groups. Similar results of feeding different levels of energy during the growing period was reported by Doran et al. (1983) and Lee (1987). No significant differences between step-up protein reared pullets and conventionally reared pullets were reported by Leeson and Summers (1982), Maurice et al. (1982), Bish et al. (1984) and Robinson et al. (1986).
Eggs classified by weight into pee-wee, small, medium, large, extra-large and jumbo, and expressed as percentage of all eggs, are presented in Table 15. The SUP raised pullets laid a significantly higher percentage of pee-wee eggs (3.8 vs. 2.7, 2.7 and 2.5% in SUP vs. CHE, CME and CLE respectively) and a significantly lower percentage of extra-large eggs (4.8 vs. 5.6, 5.6 and 5.8% in SUP vs. CHE, CME and CLE, respectively). Differences in percentages of small, medium, large and jumbo were not statistically significant between groups. Fuller and Chaney (1974) reported that pullets delayed by restricting energy intake laid more large and extra-large eggs. Bish et al. (1984) and Robinson et al. (1986) showed no difference in cumulative percentage of any egg sizes to 52-weeks of production when pullets reared on the step-up protein program were compared with conventionally reared pullets; whereas, this experiment was conducted for a 24-week lay period. The small egg size appears to be associated with the reduced body weight at the onset of egg production in the SUP raised birds.

Livability for the 24-week lay period was unaffected by juvenile dietary treatment (Table 16). Similar effects of feeding different energy levels during the growing period were reported by Fuller and Chaney (1974), Doran et al. (1983), and Lee (1987). The same effect was shown by Leeson and Summers (1979), Maurice et al. (1982), Bish et al. (1984), and Robinson et al. (1986) who fed step-up protein regimens during the growing period. However, Doran et al. (1983) reported a significant decrease in laying house livability in birds raised on a step-down protein program as compared to a step-up feeding program.
Body weights, feed consumption, egg production, egg weight, percentage of egg sizes, shell quality and feed conversion (feed consumed per egg) did not differ between the two beak treatments which is in agreement with the findings reported by Andrade and Carson (1975). There were also no differences between the two light intensities used relative to the above production traits which is in agreement with the findings of Grover et al (1972).
Table 9. Body weight means\(^1\) (g) by juvenile dietary treatment at 24, 28, 32 and 44 weeks of age

<table>
<thead>
<tr>
<th>Age</th>
<th>CHE</th>
<th>CME</th>
<th>CLE</th>
<th>SUP</th>
<th>PSE(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>1552.0a</td>
<td>1564.0a</td>
<td>1559.2a</td>
<td>1516.7b</td>
<td>7.67</td>
</tr>
<tr>
<td>28</td>
<td>1597.9ab</td>
<td>1618.4a</td>
<td>1604.3a</td>
<td>1576.0b</td>
<td>8.24</td>
</tr>
<tr>
<td>32</td>
<td>1632.7ab</td>
<td>1649.8a</td>
<td>1641.2a</td>
<td>1612.0b</td>
<td>9.34</td>
</tr>
<tr>
<td>44</td>
<td>1726.7a</td>
<td>1739.8a</td>
<td>1726.4a</td>
<td>1713.1a</td>
<td>11.31</td>
</tr>
</tbody>
</table>

\(^1\) Means within a row with different letters are significantly different (P≤0.05).

\(^2\) Pooled standard error.
Table 10. Age at 50% egg production\(^1\) by juvenile dietary treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Age (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE</td>
<td>147.3a</td>
</tr>
<tr>
<td>CME</td>
<td>148.6a</td>
</tr>
<tr>
<td>CLE</td>
<td>147.7a</td>
</tr>
<tr>
<td>SUP</td>
<td>148.8a</td>
</tr>
<tr>
<td>PSE(^2)</td>
<td>0.52</td>
</tr>
</tbody>
</table>

\(^1\) Means within a column with different letters are significantly different (P ≤ 0.05).

\(^2\) Pooled standard error.

Table 11. Age at 50% egg production\(^1\) by beak trimming treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Age (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week-1</td>
<td>148.0a</td>
</tr>
<tr>
<td>Week-8</td>
<td>148.2a</td>
</tr>
<tr>
<td>PSE(^2)</td>
<td>0.37</td>
</tr>
</tbody>
</table>

\(^1\) Means within a column with different letters are significantly different (P ≤ 0.05).

\(^2\) Pooled standard error.
Table 12. Feed consumption means\(^1\) (g/bird) by juvenile dietary treatment for period (P) 1 through 6

<table>
<thead>
<tr>
<th>P</th>
<th>CHE</th>
<th>CME</th>
<th>CLE</th>
<th>SUP</th>
<th>PSE(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>85.3a</td>
<td>86.3a</td>
<td>86.2a</td>
<td>86.6a</td>
<td>0.46</td>
</tr>
<tr>
<td>2</td>
<td>108.0a</td>
<td>109.1a</td>
<td>108.9a</td>
<td>107.8a</td>
<td>0.82</td>
</tr>
<tr>
<td>3</td>
<td>114.0a</td>
<td>115.0a</td>
<td>114.0a</td>
<td>114.1a</td>
<td>0.89</td>
</tr>
<tr>
<td>4</td>
<td>123.1a</td>
<td>123.5a</td>
<td>122.8a</td>
<td>123.5a</td>
<td>0.85</td>
</tr>
<tr>
<td>5</td>
<td>117.6a</td>
<td>118.9a</td>
<td>117.7a</td>
<td>117.8a</td>
<td>0.86</td>
</tr>
<tr>
<td>6</td>
<td>120.8a</td>
<td>123.4a</td>
<td>120.6a</td>
<td>121.5a</td>
<td>0.95</td>
</tr>
</tbody>
</table>

\(^1\)Means within a row with different letters are significantly different (P ≤ 0.05).

\(^2\)Pooled standard error.
Table 13. Percent hen-day egg production means\(^1\) by juvenile dietary treatment for period (P) 1 to 6

<table>
<thead>
<tr>
<th>P</th>
<th>CHE</th>
<th>CME</th>
<th>CLE</th>
<th>SUP</th>
<th>PSE(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>55.0a</td>
<td>51.4a</td>
<td>53.9a</td>
<td>52.2a</td>
<td>1.40</td>
</tr>
<tr>
<td>2</td>
<td>83.2a</td>
<td>86.9a</td>
<td>85.0a</td>
<td>84.9a</td>
<td>1.48</td>
</tr>
<tr>
<td>3</td>
<td>88.0a</td>
<td>90.3a</td>
<td>88.1a</td>
<td>90.2a</td>
<td>1.12</td>
</tr>
<tr>
<td>4</td>
<td>89.4a</td>
<td>91.3a</td>
<td>90.0a</td>
<td>91.4a</td>
<td>0.96</td>
</tr>
<tr>
<td>5</td>
<td>87.2b</td>
<td>90.0ab</td>
<td>88.2ab</td>
<td>90.4a</td>
<td>1.02</td>
</tr>
<tr>
<td>6</td>
<td>85.1a</td>
<td>87.1a</td>
<td>85.2a</td>
<td>87.7a</td>
<td>1.08</td>
</tr>
</tbody>
</table>

\(^1\) Means within a row with different letters are significantly different (\(P \leq 0.05\)).

\(^2\) Pooled standard error.
Table 14. Percent hen-housed egg production means\(^1\) by juvenile dietary treatment for period (P) 1 to 6

<table>
<thead>
<tr>
<th>P</th>
<th>CHE</th>
<th>CME</th>
<th>CLE</th>
<th>SUP</th>
<th>PSE(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>54.6a</td>
<td>51.2a</td>
<td>53.7a</td>
<td>52.2a</td>
<td>1.41</td>
</tr>
<tr>
<td>2</td>
<td>82.2a</td>
<td>85.8a</td>
<td>83.8a</td>
<td>84.3a</td>
<td>1.51</td>
</tr>
<tr>
<td>3</td>
<td>86.6a</td>
<td>88.7a</td>
<td>86.6a</td>
<td>89.1a</td>
<td>1.21</td>
</tr>
<tr>
<td>4</td>
<td>87.6a</td>
<td>88.8a</td>
<td>87.5a</td>
<td>89.4a</td>
<td>1.13</td>
</tr>
<tr>
<td>5</td>
<td>85.9a</td>
<td>86.3a</td>
<td>85.8a</td>
<td>88.0a</td>
<td>1.22</td>
</tr>
<tr>
<td>6</td>
<td>83.0a</td>
<td>83.6a</td>
<td>82.2a</td>
<td>84.8a</td>
<td>1.29</td>
</tr>
</tbody>
</table>

\(^1\) Means within a row with different letters are significantly different (P≤.05).

\(^2\) Pooled standard error.
Table 15. Percentage of eggs in each egg size category by juvenile dietary treatment (TRT) means¹ for 24 weeks of production

<table>
<thead>
<tr>
<th>TRT</th>
<th>Pee-Wee</th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
<th>X-Large</th>
<th>Jumbo</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE</td>
<td>2.7b</td>
<td>15.1a</td>
<td>42.4a</td>
<td>33.3a</td>
<td>5.6a</td>
<td>0.8a</td>
</tr>
<tr>
<td>CME</td>
<td>2.7b</td>
<td>13.1a</td>
<td>43.0a</td>
<td>34.9a</td>
<td>5.6a</td>
<td>0.8a</td>
</tr>
<tr>
<td>CLE</td>
<td>2.5b</td>
<td>14.8a</td>
<td>44.3a</td>
<td>31.9a</td>
<td>5.8a</td>
<td>0.6a</td>
</tr>
<tr>
<td>SUP</td>
<td>3.8a</td>
<td>14.2a</td>
<td>44.4a</td>
<td>32.3a</td>
<td>4.8b</td>
<td>0.5a</td>
</tr>
<tr>
<td>PSE²</td>
<td>0.36</td>
<td>0.77</td>
<td>1.19</td>
<td>1.20</td>
<td>0.56</td>
<td>0.16</td>
</tr>
</tbody>
</table>

¹ Means within a column with different letters are significantly different (P<.05).

² Pooled standard error.
Table 16. Percent livability\(^1\) by juvenile dietary treatment for 24 weeks of lay

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Livability</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE</td>
<td>96.9a</td>
</tr>
<tr>
<td>CME</td>
<td>95.8a</td>
</tr>
<tr>
<td>CLE</td>
<td>95.6a</td>
</tr>
<tr>
<td>SUP</td>
<td>96.4a</td>
</tr>
<tr>
<td>PSE(^2)</td>
<td>0.99</td>
</tr>
</tbody>
</table>

Means within a column with different letters are significantly different (P≤.05).

\(^1\) Means within a column with different letters are significantly different (P≤.05).

\(^2\) Pooled standard error.

---

Table 17. Percent livability\(^1\) by light intensity for 24 weeks of lay

<table>
<thead>
<tr>
<th>Light Intensity</th>
<th>Livability</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>95.4a</td>
</tr>
<tr>
<td>Low</td>
<td>96.9a</td>
</tr>
<tr>
<td>PSE(^2)</td>
<td>0.78</td>
</tr>
</tbody>
</table>

Means within a column with different letters are significantly different (P≤.05).

\(^1\) Pooled standard error.
Table 17. Percent livability\(^1\) by beak trimming treatment for 24 weeks of lay

<table>
<thead>
<tr>
<th>Beak trimming</th>
<th>Livability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week-1</td>
<td>96.1a</td>
</tr>
<tr>
<td>Week-8</td>
<td>96.2a</td>
</tr>
<tr>
<td>PSE(^2)</td>
<td>0.70</td>
</tr>
</tbody>
</table>

\(^1\) Means within a column with different letters are significantly different (P ≤ 0.05).

\(^2\) Pooled standard error.

Table 18. Percent livability\(^1\) by light intensity for 24 weeks of lay

<table>
<thead>
<tr>
<th>Light intensity</th>
<th>Livability</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>95.4a</td>
</tr>
<tr>
<td>Low</td>
<td>96.9a</td>
</tr>
<tr>
<td>PSE(^2)</td>
<td>0.70</td>
</tr>
</tbody>
</table>

\(^1\) Means within a column with different letters are significantly different (P ≤ 0.05).

\(^2\) Pooled standard error.
Table 19. Percent mortality\(^1\) due to prolapse by juvenile dietary treatment for 24 weeks of lay

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Prolapse</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE</td>
<td>1.82a</td>
</tr>
<tr>
<td>CME</td>
<td>2.08a</td>
</tr>
<tr>
<td>CLE</td>
<td>2.34a</td>
</tr>
<tr>
<td>SUP</td>
<td>1.82a</td>
</tr>
<tr>
<td>PSE(^2)</td>
<td>0.71</td>
</tr>
</tbody>
</table>

\(^1\) Means within a column with different letters are significantly different (P ≤ 0.05).

\(^2\) Pooled standard error.
Table 20. Percent mortality due to prolapse by beak trimming treatment for 24 weeks of lay

<table>
<thead>
<tr>
<th>Beak trimming</th>
<th>Prolapse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week-1</td>
<td>2.47a</td>
</tr>
<tr>
<td>Week-2</td>
<td>2.56a</td>
</tr>
<tr>
<td>PSE²</td>
<td>0.50</td>
</tr>
</tbody>
</table>

1 Means within a Column with different letters are significantly different (P≤.05).

2 Pooled standard error.

Table 21. Percent mortality due to prolapse by light intensity for 24 weeks of lay

<table>
<thead>
<tr>
<th>Light intensity</th>
<th>Prolapse</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>2.47a</td>
</tr>
<tr>
<td>Low</td>
<td>1.56a</td>
</tr>
<tr>
<td>PSE²</td>
<td>0.50</td>
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</table>

1 Means within a column with different letters are significantly different (P≤.05).

2 Pooled standard error.
Summary and Conclusion

The different protein and energy levels in the juvenile dietary treatments had the same total influence on growth response at 20 weeks of age for CHE, CLE and CME fed birds, with SUP birds being significantly lower. The SUP raised birds resulted in significantly lower body weights from two weeks of age following the drop in CP (12%) while keeping a higher level of ME (2,904 kcal/kg) at one week of age. Increasing the CP to 15% and lowering the ME to 2,794 kcal/kg at 8 weeks of age resulted in the SUP birds gaining significantly more weight from 8 through 16 weeks of age; however, from 2 through 20 weeks of age, the body weights for SUP birds remained significantly less than for the other dietary treatments.

The 0 to 20-week total feed consumption for the birds raised on CHE was significantly lower than for those on CLE but not different from the CME or SUP fed birds, with the SUP birds being significantly lower than the CME and CLE fed birds. Difference in feed consumption between CME and CLE birds were not significant. The birds raised on the SUP diets consumed significantly lower kcal ME/bird followed by the CLE birds, with no difference between the CHE and CME birds for the 0 to 20-week growing period. The total protein intake (g/bird) for the 0 to 20-week growing phase was significantly lower in the CME fed birds with no difference among the CHE, CLE and SUP fed birds. Flock uniformity and livability was not influenced by juvenile dietary treatment through 20 weeks of age. Age at beak trimming (Week-1 and Week-8) had no influence on body weight, cumulative feed, energy or protein intake, flock uniformity and livability for the 20-week growing period.
Although the SUP raised birds were significantly lower in body weight when placed in laying cages, there was no significant difference between the SUP and CHE birds at 28 weeks of age, and at 44 weeks of age, there was no difference between any of the juvenile dietary treatments. When eggs were classified by weight into pee-wee, small, medium, large, extra-large and jumbo, the SUP fed birds laid significantly higher percentage of pee-wee eggs and significantly lower percentage of extra-large eggs.

The juvenile dietary treatments did not influence laying house feed consumption, age at 50% production, egg production (hen-day and hen-housed), egg weight, shell quality, feed conversion (feed consumed per egg), livability and mortality due to prolapse. Age at beak trimming and light intensity during the laying phase had no influence on the these parameters through the 24-week lay period.

These results suggest that within limits, a range in kcal ME and percent CP can be fed during various times of the growing period without any detrimental effect during the laying period. Furthermore, it seems that within the limits of this study, prolapse is not related to the energy or protein level fed during the juvenile growing period or age at beak trimming.


Cunningham, D. C., and W. D. Morrison, 1977. Dietary energy and fat content as factors in the nutrition of developing egg strain pullets and young hens. 2. Effects on subsequent productive performance and body chemical composition of present day egg strain layers at the termination of lay. Poultry Sci. 56:1405-1416.


rearing period on pullet growth, subsequent performance, and liver and abdominal fat at end of lay. Poultry Sci. 61:2421-2429.


APPENDIX
Appendix Table 1. Composition (percent) and calculated analyses of grower diets (D)

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>D 1</th>
<th>D 2</th>
<th>D 3</th>
<th>D 4</th>
<th>D 5</th>
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<tr>
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<td>63.34</td>
<td>76.50</td>
<td>61.88</td>
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<td>17.49</td>
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<td>3.50</td>
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<td>0.00</td>
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<td>3.25</td>
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<td>2.50</td>
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<td>7.25</td>
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<td>0.06</td>
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<td>0.50</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
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Calculated Analysis

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<td>2869</td>
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<tr>
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Appendix Table 1 (cont’d). Composition (percent) and calculated analyses of grower diets (D)

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<tr>
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<td>0.05</td>
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<tr>
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<td>0.05</td>
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<td>Soybean hull</td>
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Calculated Analysis

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<th>D 7</th>
<th>D 8</th>
<th>D 9</th>
<th>D 10</th>
</tr>
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<tbody>
<tr>
<td>Crude protein (%)</td>
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<td>15.19</td>
<td>15.29</td>
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<td>Fat (%)</td>
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<td>3.41</td>
<td>3.37</td>
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<td>3.22</td>
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Appendix Table 1 (cont’d). Composition (percent) and calculated analyses of grower diets (D)

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<tr>
<td>Alfalfa meal</td>
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</tr>
<tr>
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<td>1.25</td>
<td>1.20</td>
<td>1.20</td>
<td>1.30</td>
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<tr>
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<td>Salt</td>
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Calculated Analysis

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<tr>
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<td>3.31</td>
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<td>0.41</td>
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<td>0.18</td>
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### Appendix Table 2. Composition (percent) and calculated analysis of layer diets (D)

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<td>Wheat middlings</td>
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<td>5.00</td>
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<td>Corn meal</td>
<td>67.28</td>
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<td>70.05</td>
<td>69.85</td>
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<tr>
<td>48% Soybean meal</td>
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<td>12.80</td>
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<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
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##### Calculated Analyses

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<th>D 4</th>
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</thead>
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<td>14.2</td>
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<td>Met. energy (kcal/kg)</td>
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<td>3.60</td>
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<td>0.19</td>
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<tr>
<td>Methionine (%)</td>
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<td>0.35</td>
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Appendix Table 8. Analyses of variance for percent (arc sin) flock uniformity from 0 to 20 weeks of age

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Appendix Table 9. Analyses of variance for percent (arc sin) livability from 0 to 20 weeks of age

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Appendix Table 10. Analyses of variance for layer body weight

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### Appendix Table 10 (cont'd). Analyses of variance for layer body weight

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|         | LT                 | 1  | 21750.26       | 1.77    | 0.1842|
|         | DECK               | 1  | 11070.43       | 0.51    | 0.4475|
|         | R                  | 1  | 1204.17        | 0.78    | 0.6293|
|         | FDxBK              | 3  | 47854.55       | 1.29    | 0.2793|
|         | FDxLT              | 3  | 26286.30       | 0.71    | 0.5446|
|         | FDxDECK            | 6  | 61247.67       | 0.83    | 0.5465|
|         | FDxR               | 3  | 44250.38       | 1.20    | 0.3094|
|         | BKxLT              | 1  | 12053.29       | 0.43    | 0.5867|
|         | BKxDECK            | 2  | 18950.33       | 0.77    | 0.4650|
|         | BKxR               | 1  | 125187.76      | 2.05    | 0.1530|
|         | LTxDECK            | 2  | 101686.34      | 4.14    | 0.0167|
|         | LTxR               | 1  | 9919.28        | 0.81    | 0.3695|
|         | DECKxR             | 2  | 53993.12       | 2.20    | 0.1126|
|         | ERROR              | 351| 4311492.36     |         |       |
Appendix Table 11. Analyses of variance for age at 50% production

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|        | DECK                | 2  | 581.77         | 11.33   | 0.0017|
|        | R                   | 1  | 694.29         | 9.95    | 0.0017|
|        | FDxBK               | 3  | 168.55         | 0.81    | 0.4916|
|        | FDxLT               | 3  | 67.26          | 0.32    | 0.8100|
|        | FDxDECK             | 6  | 409.76         | 0.98    | 0.4394|
|        | FDxR                | 3  | 404.32         | 1.93    | 0.1241|
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|        | BKxDECK             | 2  | 102.93         | 0.74    | 0.4790|
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Appendix Table 12 (cont'd). Analyses of variance for feed per hen per hen-day by period

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|        | DECK                | 2  | 26.24          | 0.18    | 0.8391 |
|        | R                   | 1  | 6.72           | 0.09    | 0.7645 |
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Appendix Table 16. Analyses of variance for percent (arc sin) livability from 20 to 44 weeks of age

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Appendix Table 17. Analyses of variance for percent (arc sin) mortality due to prolapse from 20 to 44 weeks of age

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