Egg Production Efficiency in Dwarf Lines Selected for High and Low Body Weight as Influenced by Feed Restriction

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(Received for publication September 8, 1986)

ABSTRACT Hens from dwarf Single Comb White Leghorn lines selected for four generations for high (H) and low (L) body weight (BW) plus randombred controls (C), sixty birds per line, were placed in cages at 18 wk of age and randomly assigned to either a full-fed (FF) or restricted-fed (R) (10 percent less than FF group) treatment. Birds received a layer ration having 16% protein and 2,816 kcal/kg metabolizable energy. Water was provided ad libitum. Individual BW and egg weights (EW) were obtained, and daily feed intake (DFI), egg production (EP), performance efficiency (PE) [egg mass (EM) per BW], and feed efficiency (FE) [EM/DFI] were calculated for 28-day periods from 18 to 41 wk of age.

There were significant line, treatment, and age effects and line by age interactions for BW, EW, EM, DFI, and PE; FE was significantly influenced by age. There were significant treatment by age interactions for BW, DFI, and FE. Feed intake, BW, and EW were greatest for FFH hens and increased in all lines with age.

Maximum EM occurred during 30 to 33 wk for RH and RL hens, during 34 to 37 wk for FFH, and during 38 to 41 wk for FFL. Maximum PE occurred during peak EP. Maximum FE for FFH and FFL occurred during 26 to 29 wk and during 30 to 33 wk for RH and RL. Data for C hens were intermediate to the other lines. Feed efficiency was improved by restriction for L hens from 26 to 33 wk and for H hens from 26 to 33 wk and for H hens from 26 to 41 wk of age.

(Key words: egg production, efficiency, feed restriction, dwarf Leghorns)

INTRODUCTION

The conversion efficiency of feed to egg mass can be improved by selection for early sexual maturity, high egg number, large egg size, and extended viability; selection for feed efficiency usually results in reduced body weight (BW) and egg size (Fairfull and Chambers, 1984). Light weight hens generally convert feed to egg mass more efficiently than heavy weight hens with ad libitum feeding (Renden et al., 1984; Bish et al., 1985). Commercial breeders of layer-type hens may not want increased feed efficiency at the expense of BW because of their requirements for large egg size and the loss of the birds’ ability to produce large numbers of eggs under stressful conditions.

Selection for increased BW gain in meat-type birds has resulted in increased appetite and decreased maintenance requirements (Soller and Eitan, 1984). Genetic lines selected for increased BW are more efficient at converting feed to body mass than lines selected for decreased weight during the growing period under restricted feeding (Wisman and Siegel, 1963; Siegel and Wisman, 1966; Proudman et al., 1970). The objective of this study was to test the hypothesis that a heavy weight line of layer-type hens may be more efficient than lighter weight lines at converting feed to egg mass with restriction of feed.

MATERIALS AND METHODS

Chickens were produced by random breeding within lines (low, high and controls) of dwarf Single Comb White Leghorn (SCWL) stocks which had been selected four generations for BW at 20 wk of age (Benoff and Renden, 1983). At 18 wk of age, 60 hens per line were randomly placed into cages and given 15 h light per day. Water was provided ad libitum. Thirty hens per line were randomly assigned to a full feed treatment, and the remaining 30 hens of each line were fed 10% less than their respective full-fed group. Birds were individually given 150 g of feed (standard layer ration containing 16% protein and 2,816 kcal/kg metabolizable energy (ME)) in plastic cups (10 x 10 x 11.5 cm) the first day of the experiment (Roland et al.,
Feed remaining in the cups was weighed the following day to determine ad libitum feed consumption for each line. Ten percent feed restriction was initiated after the first determination of ad libitum feed consumption. Full-fed groups received 150 g of feed per day from 18 to 30 wk and 200 g of feed per day from 31 to 41 wk of age. Actual daily feed intake (DFI) was determined for each bird, and the daily mean intake for the full-fed group of each line was used to adjust feed provided to its restricted group.

Body and egg weights were determined at 20, 24, 28, 32, 36, and 40 wk of age. Egg weight was the average of three days collection prior to obtaining BW. Daily egg mass was calculated as estimated egg weight times the ratio of number of marketable eggs (including double yolks) per 28 days. Egg weights were not available at 20 wk for low weight hens. Mean individual DFI, performance efficiency (egg mass/BW), and feed efficiency (egg mass/DFI) were calculated for 28-day intervals from 18 to 41 wk of age (e.g., 18 to 21, 22 to 25, 26 to 29, 30 to 33, 34 to 37 and 38 to 41 wk of age).

Data were analyzed as a split-plot design with repeated measurements in time (Gill, 1978). Line (2 degrees of freedom), treatment (full-fed or restricted-fed; 1 degree of freedom), and age (5 degrees of freedom) were considered as fixed main effects.

RESULTS AND DISCUSSION

There were significant (P< .05) line and treatment effects for age at sexual maturity for low (L), control (C), and high (H) full-fed (158, 151 and 145 days, respectively) and restricted-fed groups (167, 156 and 148 days, respectively). Similar negative relationships between age at sexual maturity and BW have been observed by Dunnington and Siegel (1984) and Renden and Marple (1986). Mortality was not different among line and treatment combinations.

There were significant line, treatment, and age effects on body and egg weights, percent egg production, egg mass, feed intake and performance efficiency; age significantly affected feed efficiency. There were no significant line by treatment interactions. There were significant line by age interactions for body and egg weights, egg production, egg mass, feed intake, and performance efficiency. Treatment by age interactions were significant for BW, feed intake, and feed efficiency. There were significant line by treatment by age interactions for BW and feed efficiency. Data values for C hens were intermediate to those for L and H hens, and description of variable responses will be limited to these latter two groups.

Body Weight. Body weights were greater for H than L hens, greater for full-fed than restricted-fed birds, and increased with age in all groups (Figure 1). A significant line by age interaction for BW was due to H hens gaining weight at a greater rate than L or C hens. The significant treatment by age interaction was associated with increased difference between treatments with age, particularly in H hens. Feed restrictions of 5 to 20% have caused reductions in BW of layer-type hens in other studies (Polin and Wolford, 1972; Matsoukas et al., 1980).

Egg Weight. Egg weights were the average of three days collection prior to obtaining BW. Daily egg mass was calculated as estimated egg weight times the ratio of number of marketable eggs (including double yolks) per 28 days. Egg weights were not available at 20 wk for low weight hens. Mean individual DFI, performance efficiency (egg mass/BW), and feed efficiency (egg mass/DFI) were calculated for 28-day intervals from 18 to 41 wk of age (e.g., 18 to 21, 22 to 25, 26 to 29, 30 to 33, 34 to 37 and 38 to 41 wk of age).

Data were analyzed as a split-plot design with repeated measurements in time (Gill, 1978). Line (2 degrees of freedom), treatment (full-fed or restricted-fed; 1 degree of freedom), and age (5 degrees of freedom) were considered as fixed main effects.
**Egg Weight.** Egg weights of the two lines and treatments followed a similar pattern as described for BW (Figure 2). The significant line by age interaction for egg weight was due to greater rate of increase with age in weight of eggs from H hens compared to L or C hens. Egg and body weights are correlated in the chicken (Jaffe, 1966), and it would be expected that egg weight would follow changes associated with feed restriction or selection for body size.

**Egg Production.** The relationship among the lines and treatments for egg production was similar to that for BW (Figure 3). Egg production peaked at 28 wk for H full-fed hens and at 32 wk of age for the other line and treatment groups. The significant line by age interaction was due to a decreased difference in egg production between the lines after peak egg production.

Rate of egg production has been reported to be either unaffected by BW or significantly reduced in small birds (reviewed by Bish *et al.*, 1985). Initiation of 5 to 20% feed restriction before peak egg production has resulted in either no change (Polin and Woldorf, 1972) or decreased egg numbers (Gerry and Muir, 1976). Feed restriction of 10 to 15% after peak egg production can cause reduction in egg numbers (Gerry and Muir, 1976).

**Egg Mass.** The relationship among the line and treatment groups was similar to those for body and egg weights and egg production (Figure 4). Peak egg mass occurred at 32 wk in restricted-fed L and H hens, at 36 wk in full-fed H hens, and at 40 wk in full-fed L hens.

**Performance Efficiency.** Full-fed and restricted-fed L line hens were more efficient for total egg mass output on a body weight basis than H hens after 28 wk of age (Figure 5). Peak performance efficiency in the line and treatment combinations was associated with peaks in rate of egg production. The significant line by age interaction for performance efficiency was due to a greater rate of decrease in efficiency of H hens than L or C hens after peak egg production.

**Daily Feed Consumption.** The relationship among line and treatment combinations for DFI was similar to those for body and egg weights and egg production and mass (Figure 6). Feed consumption increased with age in all groups. The significant treatment by age interaction for feed consumption was due to greater rate of feed consumption with age in full-fed hens compared to restricted-fed hens, particularly in H hens.
Actual DFI of restricted-fed L and H birds ranged from 74.5 to 80.7% and from 82.2 to 87.3%, respectively, compared to their full-fed groups over the entire experimental period. The discrepancy between the actual feed restriction and proposed 10% restriction may be accounted for in part by the restricted hens not consuming the entire amount of feed provided to them and by full-fed hens wasting feed (i.e., throwing feed out of the cups). Unfortunately, feed wastage was not measured, and it is unknown why greater actual feed restriction occurred in the L line.

Combs et al. (1961) reported that restriction of energy to 81 and 87% of full-fed groups reduced BW and egg size in heavy layers, and Donaldson and Millar (1962) and Jackson (1970) suggested that minimum energy requirements of heavy breed layers was 75 to 81% of ad libitum intake. In this study, both protein and energy were restricted. Data from Shapiro and Fisher (1965) showed that 17 g of protein and 320 kcal ME per day are required for maximum nitrogen retention and optimum egg production in standard size SCWL layers (1.8 kg). Protein and energy intakes were above these recommended levels on a body weight basis in all treatment-line combinations after 28 wk of age.

Hocking et al. (1985) reported that light weight (2.08 to 2.99 kg) males consumed more feed and had higher maintenance requirements per body weight than medium (3.41 to 3.89 kg) or heavy (5.02 to 5.99 kg) males. Feed consumption per kilogram body weight (g/kg) for full-fed L and H hens was 49.7 to 78.0 g and 46.0 to 64.0 g, respectively, over the entire experimental period.

Feed Efficiency. Feed efficiencies for H and L treatment groups are shown in Figure 7. Feed efficiency peaked at 28 wk for H and L full-fed hens and at 32 wk of age for the restricted-fed hens. The treatment by age interaction was associated with a change in rank among treatments. Restricted-fed L hens were more efficient than their full-fed counterparts from 28 to 32 wk, and restricted-fed H hens were more efficient than their full-fed counterparts from 28 to 40 wk of age. It would seem that feed restriction after peak egg production was more beneficial to H line hens than to L line hens.

Feed restrictions from 5 to 20% of ad libitum controls before peak egg production have resulted in variable changes in feed efficiency with either no change or improvement (Sherwood and Milby, 1961; Polin and Wolford, 1972; Gerry and Muir, 1976; Muir and Gerry, 1978; Cunningham and Polte, 1984). Discrepancies among studies may be due to the difficulty of measuring actual feed consumption and the method of estimating feed efficiency (i.e., feed per dozen eggs or egg mass). Feed restrictions from 4 to 15% initiated after peak egg production have resulted in improvements in efficiency and economic returns (Sherwood and Milby, 1961; Gerry and Muir, 1976; Cunningham, 1984). Approximately 5% feed restriction after peak egg production would seem to provide a good balance between egg parameters (size and number) and feed efficiency. Morrison and Leeson (1978) reported that feed-efficient layers are less
active than inefficient hens. Hagger and Abplanalp (1978) and Garwood and Lowe (1981) stated that the primary consideration for improving production efficiency should be selection for increased egg production or egg mass rather than decreasing body weight.

REFERENCES


