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ABSTRACT The effect of ME and CP concentrations during the growth phase of Pearl Gray guinea fowl pullets on their egg production performance was evaluated. In a 3 × 3 factorial arrangement, five hundred forty 1-d-old Pearl Gray guinea keets were randomly assigned to experimental diets with 2,900, 3,000, and 3,100 kcal of ME/kg of diet; each contained 20, 22, and 24% CP, respectively, from 0 to 8 wk of age (WOA). From 9 to 16 WOA, experimental diets had 3,000, 3,100, and 3,200 kcal of ME/kg of diet, and each contained 17, 19, and 21% CP, respectively. At 17 to 22, 23 to 27, and 28 to 56 WOA, experimental diets were composed of 3,000, 2,900, and 2,800 kcal of ME/kg, and each had 18, 17, and 16% CP, respectively. Dietary treatments were replicated 4 times, and feed and water were provided ad libitum. Body weights were measured weekly from 0 to 22 WOA, and at 28 to 56 WOA the birds were observed for feed consumption, age at first egg, hen-day egg production (HDEP), egg weight, egg mass (EM), feed conversion ratio (FCR), internal egg quality (IEQ), shell thickness (ST), and BW at the end of each 28-d lay period for 7 consecutive periods. Mortality was recorded as it occurred. Overall, BW gains were higher ($P < 0.05$) in birds fed 3,000 and 3,100 Kcal of ME/kg and 24% CP from 0 to 8 WOA than other dietary treatments. Percentages HDEP, EM, and IEQ were higher ($P < 0.05$) and FCR was lower ($P < 0.05$) in pullets fed 3,000 and 3,100 kcal of ME/kg diet at 0 to 8 WOA than those fed 2,900 kcal of ME/kg. Birds on 22 and 24% CP diets at 0 to 8 WOA also exhibited higher HDEP, EM, and lower FCR than those on 20% CP diets. Thus, feeding 3,000 to 3,100 kcal of ME/kg of diet and 22 to 24% CP at 0 to 8 WOA and 3,100 to 3,200 kcal of ME/kg of diet and 19 to 21% CP at 9 to 16 WOA improved HDEP, EM, IEQ, and FCR of Pearl Gray guinea fowl laying pullets at 28 to 56 WOA.

Key words: Pearl Gray guinea fowl pullet, metabolizable energy, crude protein

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INTRODUCTION

The Pearl Gray guinea fowl is raised primarily for egg production. Guinea layers raised in cages lay on average 170 eggs per hen during a 36- to 40-wk lay period, whereas conventionally floor-reared breeders lay between 50 to 100 eggs per season (Hayes, 1987). This translates to high cost of production (Ayorinde and Oluyemi, 1989; Ayorinde, 1991) as a result of poor efficiency in converting feed to eggs. Poor egg production in guinea fowl is the primary cause of premium prices of 1-d-old keets that must be raised to meet the increasing demand for guinea meat. Although there is an increased demand for guinea fowl in the United States and around the world, it is evident that its production lags behind that of other poultry species such as chicken and turkey. There is therefore great need to improve production performance of the guinea fowl. Growing and developing a good pullet is one of the most important items in ensuring success in an egg production enterprise. The quality of the bird at the onset of her production cycle will greatly determine how profitable she will be during the period of lay. Special emphasis must therefore be placed on feeding the growing bird so that she may develop into a healthy productive individual who can fulfill her genetic potential (Bell and Weaver, 2002). There is a paucity of information pertaining to ME and CP requirements of the guinea fowl pullet, especially from hatch to 16 wk of age (**WOA**). The general consent stipulates that determination of nutrient requirements of different types of poultry is necessary to efficiently utilize their genetic potential for specific production goals (Pym, 1990).

Several studies have evaluated the ME and CP requirements of the Pearl Gray guinea fowl; however, they are quite inconclusive and most do not cover the period from 0 to 16 WOA. Most previous studies evaluating optimum ME and CP for the growing guinea fowl were conducted using mixed sexes. For instance, using guinea fowl of both sexes, Blum et al. (1975) evaluated energy and protein requirements of the growing guinea fowl. They reported

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Table 1. Composition of experimental diets fed from hatch to 8 wk of age

	ME (kcal/kg of diet) and CP level								
	2,900/ 20%	3,000/ 20%	3,100/ 20%	2,900/ 22%	3,000/ 22%	3,100/ 22%	2,900/ 24%	3,000/ 24%	3,100/ 24%
	(%)								
Ingredient									
Corn, yellow #2 (8% CP)	61.58	58.97	56.25	54.90	51.95	9.35	47.58	44.93	42.03
Soybean meal (48% CP)	30.69	31.00	31.60	36.25	36.80	37.30	42.20	42.70	43.30
Alfalfa meal (17% CP)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Meat and bone meal (50% CP)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Poultry blended fat	1.00	3.30	5.42	2.20	4.50	6.70	3.60	5.80	8.00
Dicalcium phosphate (18% P, 22% Ca)	1.10	1.10	1.10	1.00	1.10	1.00	0.95	0.90	1.20
Limestone flour (38.8% Ca)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.70
Salt	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
Vitamin-mineral premix[1]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DL-Met (98%)[2]	0.11	0.11	0.11	0.13	0.13	0.13	0.15	0.15	0.15
Calculated level									
ME, kcal/kg of diet	2,900	3,000	3,100	2,900	3,000	3,100	2,900	3,000	3,100
Crude fat	3.88	5.85	7.66	4.75	6.72	8.60	5.80	7.70	9.56
CP	20	20	20	22	22	22	24	24	24
Ca	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
P, total	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Available P	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Met	0.43	0.43	0.43	0.48	0.48	0.48	0.53	0.53	0.53
Met + Cys	0.78	0.78	0.78	0.85	0.85	0.85	0.92	0.92	0.92
Lys	1.14	1.14	1.14	1.31	1.31	1.31	1.46	1.46	1.46
Analyzed level									
Crude fat	3.79	5.80	7.57	4.72	6.68	8.52	5.74	7.64	9.49
CP	19.92	19.96	19.89	21.93	21.91	21.88	23.97	23.96	23.94

[1]Provided per kilogram of diet: retinyl acetate, 3,500 IU; cholecalciferol, 1,000 ICU; DL-α-tocopheryl acetate, 4.5 IU; menadione sodium bisulfite complex, 2.8 mg; vitamin B_{12}, 5.0 mg; riboflavin, 2.5 mg; pantothenic acid, 4.0 mg; niacin, 15.0 mg; choline, 172 mg; folic acid, 230 mg; ethoxyquin, 56.7 mg; manganese, 65 mg; iodine, 1 mg; iron, 54.8 mg; copper, 6 mg; zinc, 55 mg; selenium, 0.3 mg.

[2]Degussa Corporation, Kennesaw, GA.

that for the growing guinea fowl the diet should contain about 3,010 kcal of ME/kg of diet and 24 to 26% CP at 0 to 4 wk of age; 3,010 kcal of ME/kg of diet and 19 to 20% CP at 5 to 8 WOA; and 3,010 kcal of ME/kg of diet and CP concentrations of 16% or less at 8 to 12 WOA. According to Sales and Du Preez (1997), guinea fowl have their highest protein and energy requirement between 5 and 10 wk of age (about 10 g/d) and between 6 and 15 WOA (about 196 kcal/d), respectively. There is therefore a great need to evaluate optimum ME and CP for growth performance of the Pearl Gray guinea fowl pullet that will also provide for optimum egg production. The correlation of the level of ME and CP during the growing period of the Pearl Gray guinea fowl with their respective egg production performance has not been established. The objective of the present study was to evaluate the effect of varying dietary ME and CP at hatch to 16 WOA on egg production performance of the Pearl Gray guinea fowl pullet. Understanding the ME and CP requirements of the Pearl Gray guinea pullets will, in part, enhance their growth performance and ultimately improve their production efficiency. This will provide optimum ME and CP at hatch to 16 WOA that will also translate to optimum egg production.

In the present study the effect on egg production performance of various concentrations of dietary ME and CP fed to Pearl Gray guinea fowl pullets from hatch to 16 WOA was evaluated. The rationale behind evaluating the ME and CP requirements at hatch to 16 WOA that would provide optimum egg production performance to the Pearl Gray guinea fowl pullet is 3-fold: 1) the age at first egg (**AFE**) of the Pearl Gray guinea fowl was estimated at 28 to 32 wk of age (Oke et al., 2003), implying a significant delay in sexual maturity when compared with other avian species such as chickens; 2) the Pearl Gray guinea fowl exhibits a growth pattern characterized by accelerated growth phase from hatch to 11 wk of age (Sales and Du Preez, 1997; Nahashon et al., 2004); and 3) the Pearl Gray guinea fowl also exhibits a slower but significant growth phase from 12 to 16 WOA (Sales and Du Preez, 1997; Nahashon et al., 2004). Thus hatch to 16 WOA is a critical period in the development of the Pearl Gray guinea fowl pullet, and providing adequate ME and CP will, in part, have an important bearing on the birds' productivity during the laying period. Summers and Leeson (1993) and Keshavarz and Nakajima (1995) suggested that it might be necessary to begin dietary manipulation of nutrients, especially dietary ME and CP, at an earlier age during the growing period to be effective in increasing BW at the age of housing, thereby improving hen-day egg production (**HDEP**) and early egg size.

MATERIALS AND METHODS

Birds and Dietary Treatments

Five hundred forty female 1-d-old guinea keets of the Pearl Gray variety were obtained from Ideal Poultry

Table 2. Composition of experimental diets fed from 9 to 16 wk of age

	ME (kcal/kg of diet) and CP level								
	3,000/ 17%	3,100/ 17%	3,200/ 17%	3,000/ 19%	3,100/ 19%	3,200/ 19%	3,000/ 21	3,100/ 21%	3,200/ 21%
	(%)								
Ingredient									
Corn, yellow #2 (8% CP)	70.13	67.75	64.85	63.01	59.90	56.80	55.78	52.96	50.50
Soybean meal (48% CP)	22.30	22.60	23.20	28.00	29.47	29.93	34.00	34.50	34.96
Alfalfa meal (17% CP)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Meat and bone meal (50% CP)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Poultry blended fat	1.02	3.10	5.40	2.47	4.06	6.70	3.69	6.00	8.00
Dicalcium posphate (18% P, 22% Ca)	1.10	1.10	1.10	1.00	1.10	1.10	1.00	1.10	1.10
Limestone flour (38.8% Ca)	0.75	0.75	0.75	0.80	0.75	0.75	0.80	0.70	0.70
Salt	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
Vitamin-mineral premix[1]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DL-Met (98%)[2]	0.08	0.08	0.08	0.10	0.10	0.10	0.11	0.12	0.12
Calculated level									
ME, kcal/kg of diet	3,000	3,100	3,200	3,000	3,100	3,200	3,000	3,100	3,200
Crude fat	4.13	5.92	7.88	5.22	6.55	8.81	6.11	8.08	9.79
CP	17	17	17	19	19	19	21	21	21
Ca	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
P, total	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Available	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
Met	0.37	0.37	0.37	0.41	0.41	0.41	0.45	0.45	0.45
Met + Cys	0.68	0.68	0.68	0.75	0.75	0.75	0.81	0.81	0.81
Lys	0.92	0.92	0.92	1.07	1.07	1.07	1.23	1.23	1.23
Analyzed level									
Crude fat	4.06	5.80	7.79	5.14	6.51	8.67	5.90	7.91	9.68
CP	16.94	16.89	16.95	18.91	18.96	18.93	20.88	20.94	20.91

[1]Provided per kilogram of diet: retinyl acetate, 3,500 IU; cholecalciferol, 1,000 ICU; DL-α-tocopheryl acetate, 4.5 IU; menadione sodium bisulfite complex, 2.8 mg; vitamin B_{12}, 5.0 mg; riboflavin, 2.5 mg; pantothenic acid, 4.0 mg; niacin, 15.0 mg; choline, 172 mg; folic acid, 230 mg; ethoxyquin, 56.7 mg; manganese, 65 mg; iodine, 1 mg; iron, 54.8 mg; copper, 6 mg; zinc, 55 mg; selenium, 0.3 mg.

[2]Degussa Corporation, Kennesaw, GA.

Breeding Farms (Cameron, TX). These birds were randomly assigned to 9 dietary treatments in a 3 × 3 factorial arrangement. The dietary treatments fed from hatch to 8 WOA had 2,900, 3,000, and 3,100 kcal of ME/kg of diet, and each contained 20, 22, and 24% CP (Table 1). From 9 to 16 WOA these diets had 3,000, 3,100, and 3,200 kcal of ME/kg of diet, and each contained 17, 19, and 21% CP (Table 2). The birds receiving the lowest energy and lowest protein treatment at hatch to 8 WOA also received the lowest energy and lowest protein at 9 to 16 WOA, respectively. All experimental birds were fed a uniform diet (Table 3) from 17 to 56 WOA. The diets were fed in mash form, and feed and water were provided for ad libitum consumption.

Management of Experimental Birds

At 1 d old, experimental birds were weighed individually and randomly assigned to electrically heated, temperature-controlled Petersime battery brooders (Petersime Brood Units, Model 2SD12, Petersime Incubator Company, Gettysburg, OH) equipped with raised wire floors for the first 4 WOA. The battery cages measured 99 × 66 × 26 cm, and each housed 15 birds. At 1-d-old, the brooder temperature was maintained at 32.2°C for the first week and reduced gradually by 2.8°C every week until 23.9°C, and at this point on no artificial heating was provided to the birds. At 5 WOA the guinea keets were transferred into growing batteries that were not supplied with supplemental heating. However, constant room temperature was maintained at 21°C. The growing cages measured 163 × 69 × 33 cm, and each housed 7 to 8 birds from 5 to 9 WOA. Birds were then transferred to floor pens measuring 226 × 237 × 106 cm (15 birds/pen) where they were raised from 9 to 22 WOA. Ventilation within the growing cages was maintained by thermostatically controlled exhaust fans. At 23 WOA, the Pearl Gray guinea fowl pullets were weighed individually and randomly assigned to individual laying cages (30.5 × 45.7 × 45.7 cm) in a laying house. The birds were grouped according to their dietary treatments and replications during the growing period (hatch to 16 WOA). All birds received 23, 8, and 16 h constant lighting regimen from hatch to 11 WOA, 12 to 22 WOA, and 23 to 56 WOA, respectively. The Pearl Gray variety of guinea fowl experiences rapid growth rate at hatch to 11 WOA and a slower but significant growth rate at 12 to 16 WOA (Sales and Du Preez, 1997; Nahashon et al., 2004). This was the rationale behind the lighting program in this study. Body weights were measured weekly from hatch to 22 WOA, once prior to assigning the experimental birds to individual laying cages (28 WOA) and at the end of every 28-d lay period for 7 consecutive periods. Mortality was recorded as it occurred.

During the laying period, experimental birds were observed for feed consumption (**FC**), AFE, HDEP, egg weight (**EW**), egg mass (**EM**), feed conversion ratio (**FCR**), internal egg quality (**IEQ**), shell thickness (**ST**), and BW at

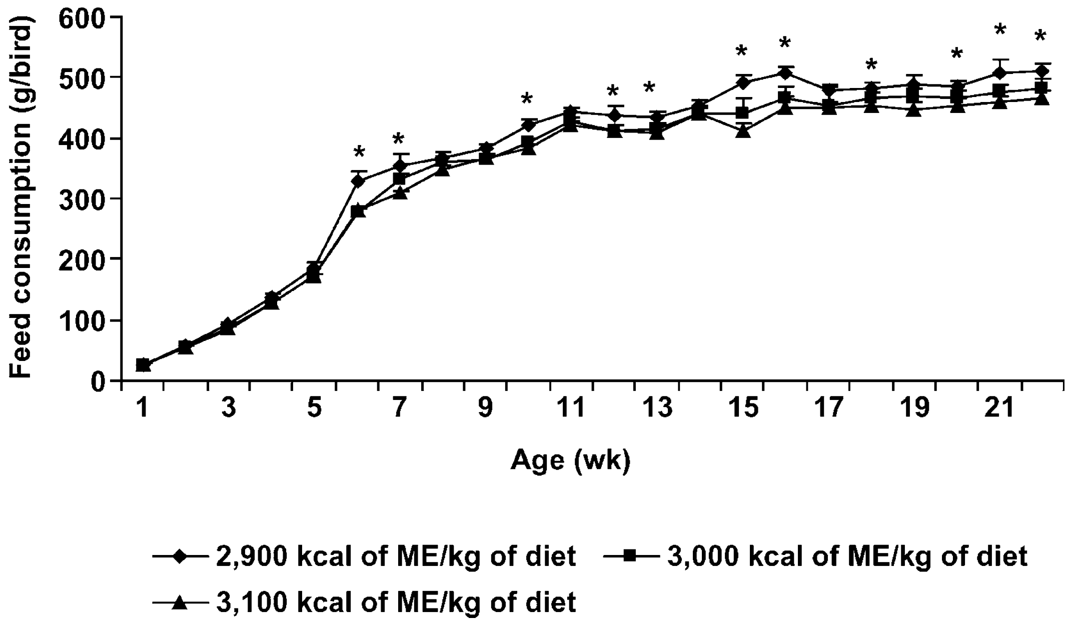

Figure 1. Mean feed consumption of Pearl Gray guinea fowl pullets fed diets with varying concentrations of ME from hatch to 16 wk of age (WOA) in preparation for egg production. At a time point, each bar represents the mean ± SE of 180 Pearl Gray guinea fowl pullets fed 2,900, 3,000, and 3,100 kcal of ME/kg of diet at 0 to 8 WOA. The diets were adjusted to contain 3,000, 3,100, and 3,200 kcal of ME/kg of diet at 9 to 16 WOA, respectively. *Indicates differences ($P < 0.05$) between pullets fed 2,900 and those fed diets containing 3,000 and 3,100 kcal of ME/kg of diet at 0 to 8 WOA, which were not different ($P > 0.05$).

the end of each 28-d lay period for 7 consecutive periods. Fifteen birds from each treatment were identified, and the same birds were weighed at the end of each 28-d period. Eggs were collected for 5 consecutive days to the end of each 28-d period and were used in determining EW, IEQ, and ST. The eggs were weighed individually and broken on a glass breakout stand with a reflective mirror to detect blood spots on the underside of the egg. Albumen heights were measured using a micrometer (B.C. Ames Co., Waltham, MA), the incidence of blood spots recorded, and Haugh units calculated using the formula described by Roush (1981). Eggshell thickness was determined using a caliper (B.C. Ames Co.). Two measurements from the midpoint of the opposite ends of

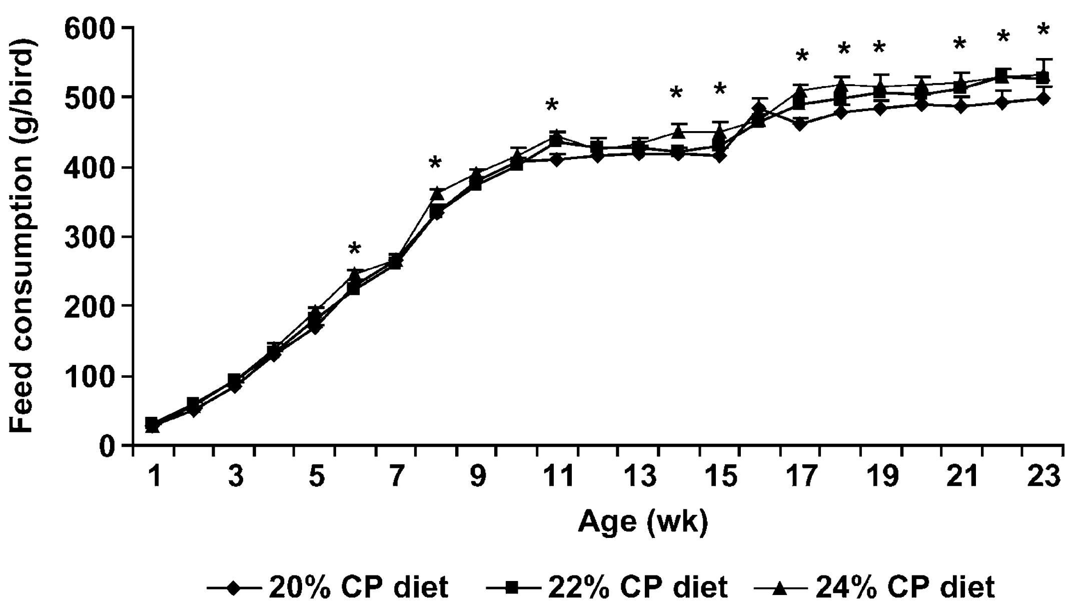

Figure 2. Mean feed consumption of Pearl Gray guinea fowl pullets fed diets with varying concentrations of CP from hatch to 16 wk of age in preparation for egg production. At a time point, each bar represents the mean ± SE of 180 Pearl Gray guinea fowl pullets fed diets containing 20, 22, and 24% CP diets at 0 to 8 wk of age (WOA). The diets were adjusted to contain 17, 19, and 21% CP at 9 to 16 WOA, respectively. *Indicates differences ($P < 0.05$) in feed consumption between pullets on 24% CP diets and those on 20 and 22% CP diets at 0 to 8 WOA, which were not different ($P > 0.05$).

Table 3. Composition of experimental diets fed to Pearl Gray guinea fowl from 17 to 56 wk of age

	ME (kcal/kg of diet) and CP level		
	3,000/ 18% (wk 17 to 22)	2,900/ 17% (wk 23 to 27)	2,800/ 16% (wk 28 to 56)
	(%)		
Ingredient and analysis			
Corn, yellow #2 (8% CP)	67.82	64.55	63.24
Soybean meal (48% CP)	22.60	24.50	22.50
Alfalfa meal (17% CP)	1.00	1.00	1.00
Meat and bone meal (50% CP)	3.00	0.00	0.00
Poultry blended fat	3.10	2.30	2.10
Dicalcium phosphate (18% P, 22% Ca)	1.10	2.00	2.20
Limestone flour (38.8% Ca)	0.75	5.00	8.30
Salt	0.30	0.30	0.30
Vitamin-mineral premix[1]	0.25	0.25	0.25
DL-Met (98%)[2]	0.08	0.10	0.11
Calculated level			
ME, kcal/kg of diet	3,000	2,900	2,800
Crude fat	5.92	4.79	4.54
CP	18	17	16
Ca	0.95	2.50	3.75
Total P	0.70	0.71	0.73
Available P	0.47	0.48	0.52
Met	0.39	0.37	0.35
Met + Cys	0.68	0.66	0.62
Lys	0.92	0.89	0.83
Analyzed level			
CP	17.91	16.85	15.89
Crude fat	5.63	4.51	4.26

[1]Provided per kilogram of diet: retinyl acetate, 3,500 IU; cholecalciferol, 1,000 ICU; DL-α-tocopheryl acetate, 4.5 IU; menadione sodium bisulfite complex, 2.8 mg; vitamin B_{12}, 5.0 mg; riboflavin, 2.5 mg; pantothenic acid, 4.0 mg; niacin, 15.0 mg; choline, 172 mg; folic acid, 230 mg; ethoxyquin, 56.7 mg; manganese, 65 mg; iodine, 1 mg; iron, 54.8 mg; copper, 6 mg; zinc, 55 mg; selenium, 0.3 mg.

[2]Degussa Corporation, Kennesaw, GA.

the longitudinal sections of the egg, and 1 measurement each from the large and small ends of the eggs was obtained. The average of the 4 measurements was considered ST for each individual egg.

Statistical Analysis

Percentage data (HDEP) were transformed into arc sine coefficients prior to analysis. Data were subjected to ANOVA using the GLM procedures of SAS (SAS Institute, Cary, NC) with ME and CP as treatment effects. All variables were analyzed as repeated measurements with the exception of mature BW, age at first egg, and mortality. Correlation analyses between treatment effects and performance variables were also computed using the GLM procedures. The statistical model used for mature BW and age and first egg was $Y_{ijkl} = \mu + M_i + P_j + (MP)_{ij} + R_{ijk} + \gamma_{ijkl}$, where Y_{ijkl} = response variables from each individual replication, μ = the overall mean; M_i = the effect of dietary ME; P_j = the effect of dietary CP; $(MP)_{ij}$ = the effect due to interactions between dietary ME and CP; R_{ijk} = the interexperimental unit (replications) error term; and γ_{ijkl} = the intraexperimental unit error term. The statistical model used for HDEP, FC, FCR, EW, EM, IEQ, ST, BW gain, and mortality was $Y_{ijklm} = \mu + M_i + P_j + T_k + (MP)_{ij} + (MT)_{ik} + (PT)_{jk} + (MPT)_{ijk} + R_{ijkl} + \gamma_{ijklm}$, where Y_{ijklm} = response variables from each individual replication, μ= the overall mean; M_i = the effect of dietary ME; P_j = the effect of dietary CP; T_k = the effect of time period; $(MP)_{ij}$ = the effect due to interactions between dietary ME and CP; $(MT)_{ik}$ = the effect due to interactions between ME and time periods; $(PT)_{jk}$ = the effect due to interactions between dietary CP and time periods; $(MPT)_{ijk}$ = the interactions between ME, CP and time periods; R_{ijkl} = the interexperimental unit (replications) error term; and γ_{ijklm} = the intraexperimental unit error term. Two-way interactions between CP and ME, CP and time periods, ME and time periods, and the 3-way interactions among ME, CP, and time periods were not significant ($P > 0.05$); thus, data were pooled across periods and analyzed for main effects. Least significant difference comparisons were made between treatment means for main effects when there was a significant F-value. Regression analyses were conducted using the GLM procedure to determine the rate of growth of birds in each dietary treatment during the accelerated growth phase (hatch to 16 WOA). Least significant difference comparisons were made between treatment means for main effects when there was a significant F-value. Differences in mortality among dietary treatments were analyzed using the χ^2 method. Significance implies ($P < 0.05$) unless stated otherwise.

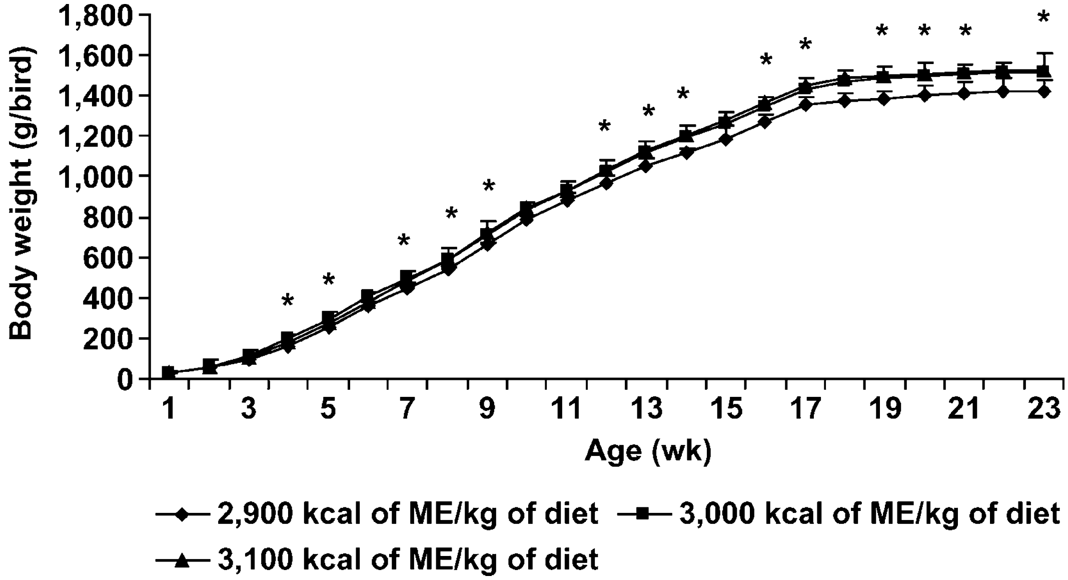

Figure 3. Mean BW of Pearl Gray guinea fowl pullets fed diets with varying concentrations of ME from hatch to 16 wk of age in preparation for egg production. At a time point, each bar represents the mean ± SE of 180 Pearl Gray guinea fowl pullets fed diets containing 2,900, 3,000, and 3,100 kcal of ME/kg of diet at 0 to 8 wk of age. *Indicates differences ($P < 0.05$) in BW between pullets on 2,900 kcal of ME/kg of diet and those on 3,000 and 3,100 kcal of ME/kg of diet at 0 to 8 wk of age, which were not different ($P > 0.05$).

RESULTS AND DISCUSSION

Phase 1 (Hatch Through 22 Wk of Age)

The inference on performance of the Pearl Gray guinea fowl pullets, which is reported in this section is based on dietary treatments that were applied to these pullets during part of their growth phase (hatch to 16 WOA; Tables 1 and 2). Feed consumption of Pearl Gray guinea fowl pullets at hatch to 22 WOA in response to dietary ME and CP concentrations are presented in Figures 1 and 2, respectively. Although differences in FC of birds fed diets containing 3,000 and 3,100 kcal of ME/kg of diet were not significant, they were significantly lower than those of birds fed 2,900 kcal of ME/kg of diet. Previous reports (Golian and Maurice, 1992) that support this premise have shown that birds consume feed to primarily meet their energy requirement. As such, birds on lower caloric diets will tend to consume more feed to meet their energy needs as opposed to those fed diets containing higher caloric diets. At hatch to 8 wk of age, the Pearl Gray guinea fowl pullets fed diets containing 24% CP diets consumed more feed than those fed 20 and 22% CP diets, which were not different ($P > 0.05$). An observation that was in agreement with this report (Leeson et al., 1993) suggested that low-CP diets significantly depressed appetite in poultry.

The growth curves of Pearl Gray guinea fowl pullets in response to dietary ME and CP concentrations from which the slopes of regression lines were derived are presented as Figures 3 and 4, respectively. The mean slopes of these regression lines representing BW of the Pearl Gray guinea fowl pullets at 0 to 16 WOA are presented in Table 4. Whereas slopes of regression lines for BW of birds fed diets containing 3,000 and 3,100 kcal of ME/kg of diet were not different ($P > 0.05$), the slope of regression line of birds fed diets containing 3,100 kcal of ME/kg of diet was 8% higher ($P < 0.05$) than that of birds on 2,900 kcal of ME/kg of diet at hatch to 8 WOA. Recent reports that complement this observation have shown that dietary ME composition has a major impact on body composition of chickens (Collin et al., 2003) as well as the guinea fowl (Nahashon et al., 2005). The slope of regression line of birds fed diets containing 24% CP were about 6% higher ($P < 0.05$) than those of birds fed diets containing 22 and 20% CP diets at 0 to 8 WOA. Sengar (1987) made similar observations where BW gain and feed efficiency of chicks were lowered when dietary CP was reduced. However, in this study, differences in slope of regression lines for BW of birds on 22% CP diets were not different from those of birds on 20% CP diets. Recent reports also showed that pullets fed diets containing 24% CP at 0 to 8 WOA and 17 or 19% CP at 9 to 16 WOA exhibited better FCR than those fed 20 or 22% CP at 0 to 8 WOA and 21% CP at 9 to 16 WOA, respectively (Nahashon et al., 2006).

Phase 2, Egg Production Period (28 Through 56 Wk of Age)

The responses reported in phase 2 of this study were based on treatments subjected to the Pearl Gray guinea fowl during part of their growth phase (hatch to 16 WOA). Blood spots were not observed in all dietary treatments during the seven 28-d data collection periods. Mature BW, AFE, and mortality of the replacement pullets are presented in Table 4. Mature BW of pullets that received diets composed of 3,000 and 3,100 kcal of ME/kg of diet were significantly ($P < 0.05$) higher by 7 and 4%, respectively, than those of birds on 2,900 kcal of ME/kg of diet.

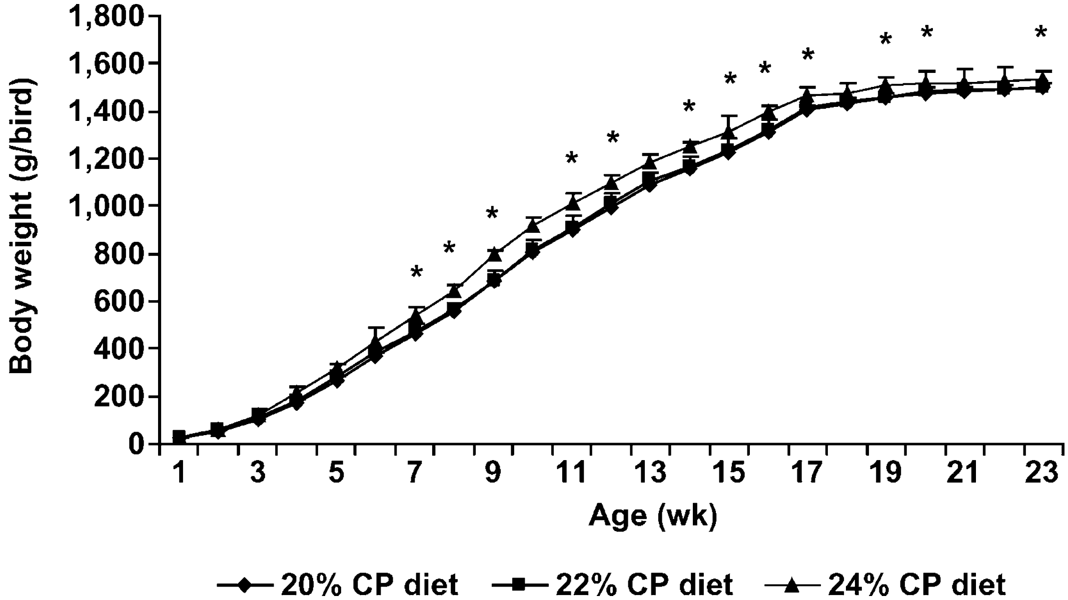

Figure 4. Mean BW of Pearl Gray guinea fowl pullets fed diets with varying concentrations of CP from hatch to 16 wk of age in preparation for egg production. At a time point, each bar represents the mean ± SE of 180 Pearl Gray guinea fowl pullets fed diets containing 2,900, 3,000, and 3,100 kcal of ME/kg of diet at 0 to 8 wk of age. *Indicates differences ($P < 0.05$) in BW between pullets on 2,900 kcal of ME/kg of diet and those on 3,000 and 3,100 kcal of ME/kg of diet at 0 to 8 wk of age, which were not different ($P > 0.05$).

Mature BW of birds on 3,000 kcal of ME/kg were also higher ($P < 0.05$) than those of birds on 3,100 kcal of ME/kg of diet. Mature BW were also 6 and 8% higher ($P < 0.05$) in pullets on 22 and 24% CP diets, respectively, than those on 20% CP diets. Birds fed diets containing 24% CP also exhibited BW that were 2% higher ($P < 0.05$) than those on the 22% CP diet. Other reports (Keshavarz, 1998) that were consistent with this observation indicated that BW of Single Comb White Leghorn pullets at 18 WOA was increased significantly due to the use of high energy and high CP diets (3,036 kcal ME/kg and 17.5%, respectively) as opposed to low energy and low protein diets (2,816 kcal ME/kg and 14.5%, respectively). Differences in AFE were not significant among dietary ME and CP concentrations. The average AFE among the dietary ME and CP concentrations was 257 and 260 d, respectively. On the contrary, Hocking (2004) reported that AFE of broiler breeders decreased with increasing BW, which was positively correlated with dietary energy level. A previous report (Joseph et al., 2000), which was in agreement with this study indicated that broiler breeder hens fed 18 or 16% CP diets did not differ in age at sexual

Table 4. Slope of regression lines for BW, age at first egg, and mortality of Pearl Gray guinea fowl hens fed diets with varying concentrations of ME and CP from hatch to 16 wk of age (WOA)

Item		Slope[1]	Mature BW[2] (g)	Age at first egg (d)	Mortality[3] (%)
ME, kcal/kg of diet					
0 to 8 WOA	9 to 16 WOA				
2,900	3,000	89.7[b]	1,600[c]	271	1.1
3,000	3,100	94.3[ab]	1,717[a]	263	0.8
3,100	3,200	96.0[a]	1,659[b]	266	0.9
Pooled SEM		1.33	8.6	2.9	0.03
CP (%)					
0 to 8 WOA	9 to 16 WOA				
20	17	92.8[b]	1,599[c]	269	0.8
22	19	92.9[b]	1,688[b]	263	1.0
24	21	97.9[a]	1,730[a]	261	0.8
Pooled SEM		1.65	9.3	3.1	0.05
		Probability			
ME		0.04	0.02	NS	NS
CP		0.05	0.01	NS	NS
ME × CP		NS	NS	NS	NS

[a–c]Means within columns with no common superscript differ significantly ($P < 0.05$).

[1]Slope of regression line for BW was determined for the accelerated growth phase (hatch to 16 WOA).

[2]Mature BW at 28 WOA.

[3]Cumulative mortality (28 to 56 WOA).

Table 5. Laying performance of Pearl Gray guinea fowl hens fed diets with varying concentrations of ME and CP from hatch to 16 wk of age (WOA)

		Feed consumption (g/hen/d)	Hen-day egg production (%)	Egg weight (g/egg)	Daily egg mass (g/hen/d)	Feed conversion ratio (g of feed/g of egg mass)	Internal egg quality (HU[2])	BW gain[1] (g/hen)	Shell thickness (mm) ($\times10^{-2}$)
ME,[2] kcal/kg of diet									
0 to 8 WOA	9 to 16 WOA								
2,900	3,000	122.5	43.9[b]	39.8	17.7[b]	6.8[a]	70.0[b]	126.3	1.8
3,000	3,100	120.3	47.7[a]	40.3	19.8[a]	6.1[b]	72.8[ab]	128.7	1.7
3,100	3,200	120.7	48.9[a]	39.4	19.7[a]	5.9[b]	74.7[a]	130.2	1.6
PSEM		1.14	1.23	1.11	0.62	0.04	1.12	3.68	0.28
CP, %									
0 to 8 WOA	9 to 16 WOA								
20	17	120.6	43.5[b]	39.9	17.1[b]	6.8[a]	72.1	122.6	1.7
22	19	122.8	47.1[a]	39.4	18.7[ab]	6.5[ab]	72.0	118.4	1.7
24	21	122.5	49.8[a]	40.12	0.3[a]	6.2[b]	73.2	121.8	1.6
PSEM		1.71	1.55	1.12	0.11	0.06	1.17	3.15	0.14
		Probability							
ME		NS	0.05	NS	0.05	0.05	0.05	NS	NS
CP		NS	0.05	NS	0.05	0.05	NS	NS	NS
ME × CP		NS	NS	NS	NS	NS	NS	NS	NS

[a,b]Mean feed conversion ratios within columns of ME or CP levels with no common superscript differ ($P < 0.05$).

[1]Average BW gain from 28 to 56 WOA.

[2]Haugh units.

maturity. Further, attainment of sexual maturity of Single Comb White Leghorn (**SCWL**) pullets based on evaluation of skeletal structures (shanks, keel etc.) and parts of the digestive tract did not differ among birds fed ad libitum as opposed to those subjected to feed restriction (Kwakkel et al., 1998).

The mean FC, HDEP, EW, EM, and FCR of Pearl Gray guinea fowl fed diets containing varying ME and CP concentrations from hatch to 16 WOA are presented in Table 5. Differences in mean FC of the guinea fowl layers fed diets containing 2,900, 3,000 and 3,100 kcal of ME/kg of diet at hatch-8 WOA were not significant ($P > 0.05$). Mean differences in FC of birds fed the 20, 22, and 24% CP diets were not significant as well. The lack of significant differences in FC of these birds was expected since, unlike the growth period, all experimental birds were fed isocaloric and isonitrogenous diets during the egg laying period (Table 3). It is therefore evident that differences in dietary ME and CP during the growth phase (hatch to 16 WOA) had no significant effect on FC of the Pearl Gray guinea fowl pullets during the egg production period.

Percent HDEP was significantly higher ($P < 0.05$) in birds that received diets containing 3,000 and 3,100 kcal of ME/kg of diet than those fed diets containing 2,900 kcal of ME/kg of diet at hatch to 8 WOA. As noted earlier, birds on the 3,100 and 3,000 kcal of ME/kg of diet exhibited higher mature BW than those on lower ME diets. Leeson et al. (1997) reported that regardless of strain, pullets with smaller body weight matured more slowly and produced less total EM to 70 WOA. Mean HDEP of the Pearl Gray guinea fowl layers fed diets containing 22 and 24% CP diets at hatch to 8 WOA was also higher ($P < 0.05$) than that of birds on the 20% CP diet.

Mean differences in EW (Table 5) among Pearl Gray guinea hens fed diets varying in ME and CP concentrations were not significant. Studies of Leeson et al. (1997) were in agreement with this report. They reported that EW of SCWL pullets grown on conventional or low protein diets fortified with additional amino acids were independent of rearing diet. On the contrary, feeding 18% as opposed to 16% CP diets to broiler breeders gave a positive response in initial EW and the number of double-yolked eggs (Joseph et al. 2002). Mean EW was not changed by increasing dietary energy of SCWL pullets. Related studies (Leeson et al., 1997; Keshavarz, 1998) that concur with this study revealed that dietary energy and protein levels did not have an effect on early egg size or overall performance of SCWL pullets up to 66 WOA. Daily EM was about 12% higher ($P < 0.05$) in birds fed diets containing 3,000 and 3,100 kcal of ME/kg of diet than those fed the 2,900 kcal of ME/kg of diet at hatch to 8 WOA. The higher EM in birds fed the 3,000 and 3,100 kcal of ME/kg of diet may be due to higher HDEP, which was associated with these diets. Positive and significant ($P < 0.05$) correlations between HDEP and EM and between EW and EM (0.96 and 0.39, respectively, Table 6) support this premise. Mean daily EM did not differ between birds on 3,000 kcal of ME/kg of diet and those on 3,100 kcal of ME/kg of diet. On the other hand the daily EM of birds on 24% CP diets was approximately 19% higher than that of Pearl Gray guinea fowl layers fed diets containing 20% CP diets. However, differences in daily EM between birds on 20 and 22% CP diet and also between birds on 22 and 24% CP diets were not significant. Previous studies (Leeson et al. 1997) have shown that pullets with smaller BW matured more slowly and produced less total EM to 70 WOA. These smaller birds ate less feed and produced smaller eggs. Keshavarz and Nakajima (1995) reported a slight effect ($P < 0.05$) on EW during 18 to 34 WOA when dietary energy level of

Table 6. Correlation coefficients among performance traits of Pearl Gray guinea fowl laying hens fed diets with varying concentrations of ME and CP from hatch to 16 wk of age[1]

Item	FC	FCR	HDEP	EW	EM	IEQ	ST	4-wk BW	10-wk BW	16-wk BW
CP	0.12	–0.21*	0.14	0.07	0.24*	0.25*	–0.12	0.60**	0.33*	0.30*
ME	–0.14	–0.33*	0.17	0.03	0.09	0.42*	0.16	–0.16	0.16	0.20
FC		0.25*	0.13	0.11	0.07	0.15	–0.06	0.18	0.09	0.13
FCR			–0.36*	0.09	–0.27*	0.12	–0.07	–0.28*	–0.25*	–0.26*
HDEP				0.12	0.96**	0.39*	–0.13	0.09	0.05	0.24*
EW					0.39*	0.53*	0.11	–0.08	–0.06	0.13
EM						0.51*	–0.09	0.09	0.07	0.09
IEQ[1]							–0.09	–0.06	0.08	0.07
ST								0.13	0.11	0.10
4-wk BW									0.69**	0.73**
10-wk BW										0.81**

[1]FC = feed consumption; FCR = feed conversion ratio; HDEP = hen-day egg production; EW = egg weight; EM = egg mass; IEQ = internal egg quality; and ST = shell thickness.

*$P < 0.05$; **$P < 0.01$.

SCWL pullets was increased. However, the presence of supplemental fat or increasing the protein level during the growing period did not have a beneficial effect on EW.

Mean FCR were about 15% lower in birds fed the 3,000 and 3,100 kcal of ME/kg of diet at hatch to 8 WOA than those fed diets containing 2,900 kcal of ME/kg of diet (Table 5). However, the mean FCR of birds fed diets containing 3,000 kcal of ME/kg of diet did not differ ($P > 0.05$) from that of birds fed diets containing 3,100 kcal of ME/kg of diet. A 10% improvement in FCR was observed in guinea layers on the 24% CP diet when compared with those on the 20% CP diet. Although mean FCR of birds on the 20% CP diet were also improved when compared with those of birds on the 22% CP diet, the mean differences in FCR were not significant ($P > 0.05$). A similar observation was made between birds on 22 and those on 24% CP diets.

The IEQ (Haugh units), BW gain, and ST of the Pearl Gray guinea fowl pullets are also presented in Table 5. Mean Haugh units of birds fed diets containing 3,100 kcal of ME/kg of diet at hatch to 8 WOA were about 7% higher ($P < 0.05$) than those of birds fed diets containing 2,900 kcal of ME/kg of diet at hatch to 8 WOA. Mean Haugh units were also 4% higher in birds on the 3,000 kcal of ME/kg of diet than those fed 2,900 kcal of ME/kg of diet at 0 to 8 WOA, although the mean differences were not significant. The Haugh units of birds on 3,000 kcal of ME/kg of diet did not differ from that of birds on 3,100 kcal of ME/kg of diet also. Varying dietary CP concentrations of Pearl Gray guinea fowl at hatch to 16 WOA did not seem to significantly influence IEQ because differences in Haugh units among the 20, 22, and 24% CP diets were not significant.

Differences in mean BW gain, ST, and cumulative mortality (Table 4) during the laying period were not different among birds fed diets composed of 2,900, 3,000, and 3,100 kcal of ME/kg of diet at 0 to 8 WOA. Mean differences in BW gain, ST, and cumulative mortality of the Pearl Gray guinea fowl layers fed diets containing 20, 22, and 24% CP diets at hatch to 8 WOA were also not significant.

Correlation coefficients among egg production variables of Pearl Gray guinea fowl are presented in Table 6. Correlations between FCR and ME and between FCR and CP were negative ($P < 0.05$), indicating that higher dietary ME and CP at hatch to 16 WOA may have contributed to lower FCR of the Pearl Gray guinea fowl pullets during the egg laying period. The variation in FCR and EM was most dependent on the number of eggs produced, hence the higher correlations among these variables. Positive and significant correlations were also observed between EM and both HDEP and EW and between IEQ and HDEP, EW, and EM. However, correlations between HDEP and EW were not significant. This observation was contrary to Emsley et al. (1977) who reported that strain-cross laying chickens exhibited negative correlations between HDEP and both EW and egg specific gravity.

Correlations between IEQ and dietary ME and CP concentrations was also positive and significant ($P < 0.05$). As expected, EM and HDEP were negatively correlated with FCR. For the most part, correlations between ST and other egg production variables were not significant. Significant ($P < 0.05$) correlations were also noted between 16-wk BW and egg production. Recent studies using broiler breeder birds have also shown that rapid growth increased egg output of broiler breeder pullets (Lewis and Gous, 2006).

Based on this study, feeding 3,000 to 3,100 kcal of ME/kg of diet and 22 to 24% CP at hatch to 8 WOA and 3,100 to 3,200 kcal of ME/kg of diet and 19 to 21% CP at 9 to 16 WOA improved HDEP, EM, IEQ, and FCR of Pearl Gray guinea fowl laying pullets at 28 to 56 WOA. These dietary concentrations seem to provide optimum growth and feed efficiency during the growth phase at hatch to 16 WOA. The positive correlations between 16-wk BW and egg production further support this conclusion.

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