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Influence of Stocking Density and Dietary Energy on Ostrich (*Struthio camelus*) Performance

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Abstract: The effects of stocking density on starter performance and of dietary energy on grower performance of ostriches were evaluated in two separate trials. Trial 1 was conducted to evaluate the influence of three different animal density treatments (33.5, 16.8 and 11.2 m^2/bird) on survivability and growth of ostrich chicks from 21 to 98 d of age. In Trial 1, chicks were randomly assigned by source and weight to the three density treatments with each density replicated three times and assigned to pens (9.2m x 29.3m) using a complete block design. Trial 2 was conducted to evaluate the effects of three levels of dietary energy (11.71, 12.90 and 14.09 MJ of ostrich TMEn/kg diet) on grower performance from 98 to 146 d of age. In Trial 2, ostriches were randomly assigned by weight to the three dietary treatments with each treatment replicated four times. In Trial 1, animal density had an effect ($P<0.05$) on body weight, weight gain and feed consumption. Body weight at 98 d of age was higher ($P<0.05$) for birds grown in the low density (41.5 kg) versus those in the moderate (38.5 kg) and high density (34.7 kg) treatments. Stocking density did not affect ($P>0.05$) feed to gain ratio. In Trial 2, dietary energy affected ($P<0.05$) body weight, weight gain and feed efficiency. Body weight at 146 d of age was higher ($P<0.05$) for birds consuming the high energy (69.1 kg) versus the low (66.0 kg) and moderate (65.5 kg) energy diets. Feed to gain ratio was similarly improved as diet energy level increased. These results provide quantitative information on the impact of available space and dietary energy on performance and have implications on the economics of production and on ostrich chick management.

Key words: Ostriches, stocking density, dietary energy; growth; feed to gain

Introduction

To gain competitiveness in the animal agriculture arena, the ostrich industry must focus on increasing chick survivability, maximizing growth and reducing costs associated with feeding. Factors affecting growth in ostriches are similar to those affecting other avian species and include diet, rearing environment, genetic potential, management and health status. The influence of rearing environment on growth has not been well documented in ostriches. Currently, ostriches are reared under a wide range of stocking densities, ranging from 16 to 40 m^2/bird (Verwoerd *et al*., 1999). In other poultry species, amount of available space has been shown to alter bird behavior (Lewis and Hurnik, 1990; Andrews *et al*., 1997; Carmichael *et al*., 1999) and influence health and performance of an individual (Proudfoot *et al*., 1979; Shanawany, 1988). Focusing research on adequate space requirements may lead to management changes that could help diminish stress and subsequently lead to improved survivability and growth of ostriches.

Additionally, limited information is available on maximizing growth through dietary manipulation. Despite recent studies that show that ostriches can be grown more efficiently (Cilliers *et al*., 1994; Blue-McLendon and Angel, 1995), there are concerns regarding the high costs associated with feeding, which may account for as much as 70% of total production costs (Brand *et al*., 2000). It is therefore important to determine the effects of diet nutrient levels on growth and efficiency of feed use so that more informed decisions can be made under commercial conditions based on specific ingredient and nutrient cost. Fats are useful for increasing the energy concentration of diets. Although apparent fat digestibility is extremely low in very young ostriches, apparent digestibility reaches levels above 85% by 10 weeks of age (Angel, 1993). Fat can be a useful tool to increase the energy concentration of grower diets and could be useful for maximizing weight gain and reducing feeding costs.

In two separate trails, this research examined the influence of stocking density on starter performance and level of dietary energy on grower performance.

Materials and Methods

Two experiments were conducted using unsexed mixed breed ostrich chicks that were obtained at four days (d) of age from three commercial farms and transported approximately 2253 km to the research facility over a two d period. All birds were kept in an enclosed house until 21 d of age to minimize any effects of shipping on the experiment. After 21 d birds were moved to outdoor pens (9.2m x 29.3m x 1.8m) that were equipped with a dustbath depression (1.8m x 1.8m) and a shelter (2.4m x 2.4m), in which the birds were kept nightly until 75 d of

Table 1: Composition and calculated nutrient content of the ostrich grower diets fed from 98 to 146 days of age (Trial 2)

Ingredients	Energy Level		
	Low g/kg	Moderate g/kg	High g/kg
Wheat middlings	373.90	300.00	260.00
Corn	295.00	275.65	224.50
Alfalfa	150.00	180.00	200.00
Soybean Meal (48%)	142.00	156.00	170.00
Fat (vegetable blend[1])	0.00	50.00	107.50
Iron sulfate	0.50	0.45	0.40
Ground limestone	6.50	4.50	3.25
Dicalcium phosphate	15.40	16.75	17.55
Copper sulfate	0.10	0.10	0.10
DL methionine	1.00	0.95	1.00
Other[2]	15.60	15.60	15.70
Calculated Nutrient Content			
Ostrich TMEn[3,4], MJ/kg	11.71	12.90	14.09
Poultry TMEn[5], MJ/kg	9.09	10.35	11.58
Dry Matter	904.5	911.3	918.5
Crude protein	182.4	180.8	180.6
Crude fat	28.6	76.7	131.9
Crude fiber	73.5	73.0	72.9
Ash	56.5	52.4	49.9
Lysine	9.0	9.1	9.4
Methionine	3.8	3.8	3.8
Total Sulfur Amino Acids	6.4	6.4	6.4
Calcium	10.0	10.0	10.0

[1] Vegetable blend consists of mixture of crude soybean & corn oil stabilized with ethoxyquin. [2] Other ingredients include choline chloride 70% liquid (1.5 g/kg), lignin binder (5.0g/kg), Mold-guard® (0.5g/kg), manganese sulfate (0.2g/kg), Primilac® (0.5g/kg) (commercial Lactobacilus based probiotic, Star-Labs, St. Joseph, MO, USA), salt (3.0g/kg for low & moderate; 3.1g/kg for high), santoquin 66 (0.5g/kg), 0.06% selenium premix (0.5g/kg), trace mineral premix[6] (0.5g/kg), vitamin premix[7] (1.9g/kg). [3] TMEn = Nitrogen-corrected true metabolizable energy. [4] TMEn values based on ostrich energy values for ingredients (Cilliers, 1994). [5] TMEn values based on poultry energy values for ingredients (NRC, 1994). [6] Contribution of trace mineral premix per kg of diet: 0.105g Zn (zinc oxide), 0.06g Mn (manganese oxide 50% & manganese sulfate 50%), 0.02g Fe (ferrous sulfate), 0.01g Cu (copper oxide), 0.0015g I (calcium iodate), 0.000025g Co (cobalt carbonate). [7] Contribution of vitamin premix per kg of diet: 0.0217g vitamin A, 0.0202g vitamin D3, 0.1147g vitamin E, 0.0036g vitamin B_{12}, 0.0154g riboflavin, 0.1234g niacin, 0.0343g panothenic acid, 0.0112g menadione, 0.0039g folic acid, 0.0154g biotin, 0.0057g thiamine, 0.0074g pyrioxidine.

age. Shelters contained sand floors, were cleaned daily and contained no additional source of heat. All birds were tagged with the Swiftack Identification System (Heartland Animal Health, Inc.) for individual identification.

Trial 1 was conducted to evaluate the influence of three stocking densities on growth of ostrich chicks during the starter phase, from 21 to 98 d of age. Twenty-one d old ostriches (144) were randomly assigned by body weight and farm of origin (source) to nine outdoor pens such that average body weight per pen was similar. Three stocking densities, 33.5 (8 birds/pen), 16.8 (16 birds/pen) and 11.2 (24 birds/pen) m^2/bird, were replicated three times in a complete block design. Pens were planted with an intermixture of clover (25%) and rye grass (75%). All birds were fed *ad libitum* two to three times per d a commercial ostrich starter diet that contained wheat middlings (250g/kg), corn (224g/kg), alfalfa (250g/kg), 48% soybean meal (215g/kg) and a vitamin and mineral premix. The diet was formulated to contain 210g/kg crude protein, 31g/kg crude fat, 84g/kg crude fiber, 11g/kg lysine, 4g/kg methionine and 8g/kg total sulfur amino acids. The nitrogen-corrected true metabolizable energy (TMEn) in the diet was calculated based on both chicken (NRC, 1994) and ostrich (Cilliers, 1994) energy ingredient values (8.53 and 11.39 MJ/kg TMEn, respectively). Turkey granite grit (1% of feed) was mixed with feed to encourage feed consumption until 52 days of age and water was provided *ad libitum*. Individual bird body weight was measured at 21, 28, 56 and 98 d of age and pen weight and weight gain were determined. Feed consumption by pen was determined

Table 2: Effect of stocking density on body weight, weight gain and feed efficiency of ostriches from 21 to 98 days of age (Trial 1)

Treatment (m^2/bird)	Body Weight (kg)		Body Weight Gain (kg)				Consumption (kg/bird)	Feed to Gain Ratio
	21 d	98 d	21 to 28 d	28 to 56 d	56 to 98 d	21 to 98 d		
33.5	2.61	41.52^a	1.42	12.06^a	29.46	38.92^a	34.08^a	2.11
16.8	2.55	38.51^a	1.50	11.01^{ab}	27.50	35.97^{ab}	28.86^b	2.01
11.2	2.45	34.73^b	1.63	10.26^b	24.48	32.28^b	25.82^c	2.09
SEM	0.09	1.27	0.15	0.34	1.16	1.25	0.42	0.10
ANOVA								
P Value	0.54	0.026	0.65	0.026	0.06	0.026	0.001	0.76
Regression								
P Value	0.25	0.005	0.33	0.005	0.014	0.005	0.00	10.87
R^2	NA[2]	0.70	0.33	0.69	0.60	0.69	0.95	NA[2]
Intercept	64.09	79.28	0.57	84.61	68.25	76.15	70.31	21.63
Slope	-19.0	-1.65	10.17	-6.17	-1.92	-1.68	-1.83	-2.72

[a,b] Means within columns with different superscript letters differ (P<0.05). [1] Each mean represents three replicates of each density. [2]Not applicable.

Table 3: Effect of dietary energy on body weight, weight gain, energy and feed efficiency and feed cost of gain for ostriches from 98 to 146 days of age (Trial 2)

Treatment (MJ/kg)[1]	Body Weight (kg)		Gain (kg)	MJ/kg of Gain	Feed to Gain Ratio
	98 d	146 d			
11.71	37.40	66.04^a	28.64^a	35.18	2.97^a
12.90	36.97	65.47^a	28.49^a	36.54	2.84^a
14.09	36.90	69.12^b	32.22^b	36.55	2.59^b
SEM	0.66	0.79	0.75	0.87	0.07
Analysis of Variance					
P Value	NS	0.037	0.019	NS	0.024
Regression					
P Value	NS	NS	0.032	NS	0.006
R^2	0.03	0.31	0.42	0.06	0.58
Intercept	18.20	-4.51	4.07	7.67	23.28
Slope	-0.15	0.26	0.30	0.14	-3.72

[a,b] Means within columns with different letters are statistically different (P<0.05). Each mean represents four replicates of each dietary treatment, each replicate containing12 birds. [1]Nitrogen-corrected true metabolizable energy values calculated based on ostrich energy values for ingredients (Cilliers, 1994).

daily. Feed to gain ratio was determined based on pen body weight and feed consumption. Twice daily animal checks were done and mortality was recorded as it occurred.

Trial 2 was conducted to evaluate the effects of three levels of dietary energy on grower performance, from 98 to 146 d of age. One hundred and forty four birds were rerandomized at the end of Trial 1. Twelve birds were assigned by body weight to each of 12 outdoor pens such that average body weight per pen was similar. Three different dietary energy treatments, 11.71 (low), 12.90 (moderate) and 14.09 (high) MJ of ostrich TMEn/kg diet, were assigned randomly to pens (4 pens/treatment). An effort was made to minimize diet ingredient changes (both level and ingredient use) while keeping ingredients and levels at commercial use levels. The same ingredients were used for all diets. Fat (vegetable blend of crude soybean and corn oil) was used as the primary source for energy changes in the diets. The composition and nutrient contents of the three diets are given in Table 1. Each pen of 12 ostriches was fed 22.7 kg diet and 1.5 kg alfalfa each day. To compensate for differences in feed consumption by pen, diet and alfalfa was not added when excess feed accumulated in the troughs. Pens used were the same as in Trial 1 but by 98 d of age the pens were dry lots with minimal or no vegetation cover. Water was provided *ad libitum*. Weight gain and feed conversion were determined from 98 to 146 days of age and pen weights were determined. Mortality was recorded as it occurred. A mixed model analysis of variance (SAS®, version 8.2, SAS Institute Inc.) was used to analyze the effects of stocking density (Trial 1) on body weight, weight gain and feed conversion (dependent variables). A similar model was used to analyze the effects of dietary energy (Trial 2) on body weight, weight gain and energy and feed conversion (dependent variables). A regression analysis (SAS®, version 8.2, SAS Institute Inc.) was used to test the linear effect of stocking density (Trial 1) and dietary energy (Trial 2) on dependent variables. Polynomial contrasts (Cody and Smith, 1991) were used to determine differences among treatments. Statistical significance was accepted as P<0.05.

Results and Discussion

In Trial 1, there were significant (P<0.05) effects of stocking density on body weight at 98 d of age (Table 2). Body weight at 98 d of age was similar (P>0.05) for birds housed at the low (41.52 kg) and moderate (38.51 kg) densities and was lowest for birds kept at the high (34.73 kg) density. The average body weight observed at 98 d of age for the birds in the high density treatment are similar to 30 kg reported previously for 90 d old ostriches (Degen *et al*., 1991; Angel, 1996). In Degen *et al*. (1991) study, ostriches were kept at a stocking density of 1 bird/m^2. No data on available space per bird is available for Angel's (1996) study. The body weights obtained in the low and moderate density treatments are, however, greater than what has previously been reported. Stocking density did not affect (P>0.05) feed to gain ratio (Table 2). The feed to gain ratio seen in this experiment in ostriches between 21 and 98 d of age (2.01 to 2.11) is similar to that (1.87) reported previously (Angel, 1996) for 8 to 90 d old ostriches fed a starter diet containing 220g/kg protein, 32g/kg fat and 69g/kg fiber. The lack of significant differences (P>0.05) in this trial, even though feed efficiency ranged from 2.01 in the moderate stocking density to 2.11 in the low stocking density may be due to the high variability (SEM = 0.10).

In Trial 2, increasing the level of dietary energy in the diet significantly increased (P<0.05) body weight of ostriches at 146 d of age (Table 3). Body weight was highest (69.12 kg) at 146 d for birds fed the high energy diet (14.09 MJ/kg). The body weights obtained at 146 d (65.47 to 69.10 kg) for all three treatments were, however, greater than what has been previously reported for birds of similar age. Degen *et al*. (1991) reported body weights of 51.54 kg for birds at 154 days of age fed a diet containing 12.55 MJ turkey ME/kg and Cilliers (1994) reported body weights of 40 kg for birds at 154 d of age fed diets containing 10.51 MJ ostrich AMEn/kg. The difference in body weights between experiments could be explained by differences in rearing environments, management, bird genetics and diet.

No significant differences were found (P>0.05) in the bird's ability to convert energy to body weight gain for the different diets (Table 3). This would explain why birds on the high-energy diet gained significantly more (P<0.05) body weight than birds maintained on the two lower energy diets (Table 3). Thus, feed conversion was affected (P<0.05) by energy level in the diet (Table 3). Birds fed the high-energy diet (14.09 MJ/kg) were more efficient (P<0.05) in converting feed to gain than birds fed the two lower energy diets. The ability of the bird to convert feed to gain is influenced by genetic potential, environment, management, and diet ingredient and nutrient levels. In this study genetic potential, environment and management were kept constant among treatments. Differences between ingredient levels were minimized within practical considerations. Diets differed primarily in their fat content, but they also contained small differences in the levels of wheat middlings, corn and alfalfa. These differences were allowed in order to achieve different diet energy levels, without altering levels of protein, crude fiber, lysine and methionine and to maintain use of commercial ingredients. These differences may have some impact on energy availability of the diets, but given work reported by Angel (1993) that ostriches at 10 weeks of age were able to obtain high (11.24 MJ/kg) levels of energy from a corn, wheat middling and alfalfa base diet and had high (857 g/kg) apparent fat digestibility, this concern was considered to be balanced by the need to use practical commercial diets.

The cost of feeding an animal is dictated largely by the cost of ingredients and nutrients. It is therefore important to select feed ingredients with cost in mind. Economic analysis of the different diets based on the amount the diet cost per kg of gain indicates that, at the time of the experiment, the cost of gain was reduced by feeding the high-energy diet. These cost relationships need to be established on a case by case basis using current local ingredient costs. The information provided in this paper can serve as a tool for least cost formulation when weight is being considered in the cost structure. In this study, feeding the 14.09 MJ/kg diet from 98 to 144 d of age resulted in a 5% savings in feed costs per bird. Although this reduction appears small on an individual basis, the reduction in feed costs could be substantial when applied to an entire production facility.

In conclusion, these results imply that space availability during rearing and diet energy level in the grower phase can influence ostrich performance. A stocking density of 16 m^2/bird was found to maximize performance in this study. Additionally, it appears that increasing the level of dietary energy in the diet by elevating the level of fat in the form of a crude soybean and corn oil blend contributes to increased performance during the grower phase. Since fats contribute more energy to metabolism per unit weight than protein and carbohydrate sources, using fats to increase diet energy levels may also potentially reduce feed costs.

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