EFFECTS OF GRADED LEVELS OF DIETARY PROTEIN AND ENERGY ON THE PERFORMANCE OF WHITE PEKIN DUCKLINGS

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Summary

Two experiments were undertaken to study the effects of graded levels of dietary protein and energy on the performance of growing meat-type ducklings. The results of Experiment 1 indicated that meat-type ducklings. gave satisfactory weight gain and feed utilisation on starter and finisher diets containing 18 percent protein with 3.00 Mcal ME/kg. There were no marked differences in performances characteristics obtained from eight week old ducklings by feeding them isocaloric diets with a wide range of protein concentrations (16 to 24 percent).

The results of Experiment 2 indicated that graded levels of dietary protein and energy in finisher diets did affect the performance of growing ducklings. The effects of graded levels of dietary protein on weight gain and the ether extract concent of the whole carcass were more distinct than for dietary energy. On the other hand the effects of graded levels of dietary energy on feed intake and feed efficiency were more distinct than dietary protein. The result of Experiment 2 confirmed the generally-accepted fact that ether extract content of whole body carcass of growing birds is related directly to the energy:protein ratio of the diet. It was concluded that the results of these studies indicated that the protein requirement of meat-type ducklings is less than for chickens or turkeys on starter and finisher diets, while the energy concentration lies between 3.00 to 3.25 Mcal ME/kg diet.

I. INTRODUCTION

There are limited published data on nutrient requirements of meat-type ducklings. The more important studies on their protein and energy requirements are listed in Table 1. The earliest experiment on protein requirements of growing meat-type ducklings (Horton, 1932) reported that ducklings given a 19 percent protein diet grew significantly faster than those given a 12 percent protein diet. This observation was confirmed by Hamlyn et al. (1934) who showed that the optimum level of protein for growing Pekin ducklings was 18 percent.

Scott and Heuser (1951, 1952), Heuser and Scott (1952) and Scott et al. (1957) showed that white Pekin ducklings are capable of maintaining an acceptable growth rate with a satisfactory efficiency of feed utilisation when offered simple and high energy diets. However, they noted that the carcass quality of the ducks produced on these high energy diets was unsatisfactory because of excessive fat in the evicerated carcasses. As a consequence Scott et al. (1959) conducted a series of experiments and found that by appropriate alteration in the energy:protein ratio of the diet, it was possible to produce marked changes in the carcass fat content without appreciably changing rate of growth or efficiency of feed utilisation. They concluded that carcass fat increased in direct proportion to the increase in the ratio of energy to -protein in

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the diet. While diets of equivalent energy protein ratios gave a carcass fat content that was approximately the same even though the diets varied considerably in energy content.

Dean (1972) summarised results of studies on the protein requirement of meat-type ducklings and the effect of energy:protein balance on carcass composition which were conducted at Cornell University Duck Research Laboratory. Those studies demonstrated that (I) the dietary protein requirement of duckling for maximum early growth is relatively high (22 percent protein) during the first two week post-hatching, but this decreases substantially to no more than 16 percent protein prior to market age; (2) the duckling has the ability, under favourable conditions, to overcome an early growth depression due to a protein deficiency and to achieve normal weight at market age; (3) increasing protein concentration relative to energy in the diet thereby reducing the calorie:protein ratio has been shown to reduce the amount of fat in the carcass, and to increase the amount of moisture, protein and lean meat in the carcass; (4) narrowing the calorie:protein ratio was found to have a greater effect on carcass composition during the first 4 weeks of growth than during the final 4 weeks.

In recent years, several investigators have reported that the protein requirement of meat-type ducklings was lower than that of the chicken or turkey. Summers et al. (1970) recommended protein requirement of meat-type ducklings for starter and finisher diets of 21.8 and 17.9 percent, respectively. Du Preez and Wessels (1970) found that the protein concentration of starter diets of meat-type ducklings was from 18.7 to 19.7 percent, which was lower than that recommended by Summers et al. However, Du Preez and Wessels (1970) did not present data to indicate the total performance of the ducklings to marketable age, hence it was rather difficult to draw definite conclusions of the effects of the low protein content of their starter diet. Luhmann and Vogt (cited by Wilson, 1975) stated that there were no significant difference in weight gain, feed efficiency and carcass composition between two groups of ducklings that received diets of 16.3 and 20.6 percent protein, respectively. But they noted that the fat content of the carcass was reduced when the high-protein diet was supplied throughout the eight-week growing period. Yule (1974) reported that 18 percent protein was required for maximum growth of an Australian strain of Pekin duck from 4 to 9 weeks of age fed a wheat-meat meal-based diet. He concluded that increasing protein content of the diet with constant metabolisable energy significantly increased weight gain but reduced income over feed as the cost of the extra protein was more than the value of the additional body weight gain. He reported also that increasing the energy density of the diet significantly improved feed efficiency to 9 weeks of-age. Bagot and Karunajeewa (1978) observed that ducklings fed a high-quality diet 24.7 percent protein and 2.90 Mcal ME/kg from 0 to 3 weeks, and 18.7 percent protein and 2.97 Mcal ME/kg during weeks 3 to 9 were heavier and converted feed more efficiently than those on a low-quality diet (20.6 percent protein and 2.65 Mcal ME/kg) from 0 to 3 weeks and 14.1 percent protein and 2.57 Mcal ME/kg during weeks 3 to 9. They reported also that male ducklings performed better than females. Under Cuban condition, Gutierrez (1974) found that protein levels of 16 to 18 percent of molasses-based diets were optimal for growing 3 to 9 week-old ducklings.

Auckland (1973) observed that weight gain, feed conversion efficiency and feed intake of 21 day-old, Aylesbury meat-type ducklings

TABLE 1 Protein and metabolisable energy (ME) requirements of growing meat-type ducklings as recommended or reported by different authors

No.	Age (weeks)	Protein (%)	Energy (Mcal ME/kg)	Authors	Country
1	0-12	19.0	-	Horton (1932)	U.S.A.
2	0-8	18.0	-	Hamlyn _et al_. (1934)	U.S.A
3	0-8	15.0-17.0	-	Scott and Heuser (1951)	U.S.A.
4	0-8	16.0	-	Scott _et al_. (1957)	U.S.A.
5	0-8	18.0-19.0	2.86	Scott _et al_. (1959)	U.S.A.
6	0-7	17.0	-	Rudolph (1961)	Germany
7	0-8	17.0	2.70	Helder (1968)	Holland
8	0-2	24.0	3.15	Dean (1968)	U.S.A.
9	0-2	24.0	3.08	Dean and Scott (1969)	U.S.A.
	3-4	20.0	3.08		
	5-7	16.0	3.08		
	3-7	18.0	3.08		
10	0-2	18.7-19.7	2.56	Du Preez and Wessels (1970)	South Africa
11	0-2	21.8	-	Summers _et al_. (1970)	Canada
	3-8	17.9	-		
12	0-8	17.0	-	NRC (1971)	U.S.A.
13	0-2	23.9-25.0	2.81-2.96	Bolton (1972)	England
	3-8	17.1-18.1	2.86-3.00		
14	3-8	18.7-19.0	3.01-3.09	Wilson (1972)	England
15	0-8	16.3	-	Luhmann and Vogt (1973)	Germany
16	0-3	24.7	-	Auckland (1973)	England
	4-8	19.5	-		
17	0-2	19-21	3.00	Hoj (1974)	Denmark
	3-8	14-15	3.00		
18	0-3	22	-	Yule (1974)	Australia
	4-9	18-20	2.75		
19	3-9	18.0	-	Gutierrez (1974)	Cuba
20	0-3	20.0	-	Leclercq and de Carville (1975)	France
21	0-2	22-24	3.00	Wilson (1975)	England
	3-8	18	3.00		
22	0-3	20.7	2.90	Hejgaard (1975)	Denmark
	4-8	15.8	3.00		
23	0-3	21.6	2.84	Brewster (1976)	Australia
	4-9	19.6	2.88		
24	1	20.0	2.90	Cherry Valley Farm (1976)	England
	2	18.0	2.90		
	3-5	16.0	2.90		
	6-7	14.0	2.90		
25	0-3	24.7	2.90	Bagot and Karunajeewa (1978)	Australia
	3-9	18.7	2.97		
26	0-8	24.0	3.10	Oluyemi and Fetuga (1978)	Nigeria

were significantly improved when given a diet containing 24.7 percent, instead of 19.5 percent protein. Wilson (1975) confirmed these results. He reported that Pekin-type ducklings given starter diets of 22 or 24 percent protein were significantly heavier at 14 days than those on diets with 18 to 20 percent protein. However, he found that there was no advantage in feeding diets with protein levels greaterthan 18 percent protein for more than the first 14 days of life.

Oluyemi and Fetuga (1978) found that the recommended nutrient concentrations for ducklings in a temperate environment were not suitable for ducklings under tropical conditions. They found that the ducklings under tropical condition should be fed 'diets containing 24 percent protein and 3.1 Mcal ME/kg up to 8 weeks of age for maximum growth and optimum feed efficiency. From these limited, and to some extent conflicting data (see Table 1), it is difficult to observe a clearly-defined response of the meat-type ducklings to the different dietaryregimens imposed during their growing period.

The experiments described here were conducted to determine the response of meat-type ducklings to different dietary regimens by lowering the protein content of isocaloric starter and finisher diets, or by altering the energy;protein ratio of the finisher diets.

II. MATERIALS AND METHODS

Two experiments were designed to determine the effects of graded levels of protein in diets of the same energy content, and the other on the influence of the graded levels of dietary protein in diets of different energy contents on the biological performance of growing meat-type ducklings.

White Pekin meat-type ducklings of a commercial strain were used for both experiments; the ducklings were housed in cages with wire floors. Electric heating was provided during the first three weeks, and continuous white light was provided throughout the experimental period. The ducklings were debeaked at 5 days of age, The experimental diets were pelleted. Feed and water were available for the ducklings at all times. The significance of differences between the treatment means was established by analysis of variance and least significant difference values.

(a) Experiment 1

There were 96 males and 96 female ducklings. At one-day old ducklings were weighed individually, wing banded, and then allocated at random to 16 cages so that each cage held 12 males or 12 female ducklings.

Four different starter diets were given during the first two weeks. Each diet was allocated to two cages of males and to two cages for females. After two weeks of age, one cage from each sex continued to receive the same starter diet as their finisher diet, while the second cage of each sex received a finisher diet of 16 percent protein. This gave eight combinations of dietary treatments for each sex. The dietary treatments were continued until the ducklings reached eight weeks of age. The composition of the experimental diets are shown in Table 2.

TABLE 2 Composition (%) of the experimental diets

Ingredients	Dietary proteins (%)				
	24	22	20	18	16
Yellow corn	50.0	50.0	50.0	50.0	50.0
Wheat	13.3	19.0	25.0	30.8	36.3
Soybean oil meal	26.5	20.8	14.8	9.0	3.5
Fish meal	5.0	5.0	5.0	5.0	5.0
Meat meal	5.0	5.0	5.0	5.0	5.0
Duck premix[1]	0.2	0.2	0.2	0.2	0.2
TOTAL					
Calculated analysis					
Crude protein (%)	24.0	22.1	20.0	18.0	16.2
ME (kcal/kg)	2991	3018	3078	3086	3039
Energy:protein ratio	124.6	136.6	153.9	171.5	190.9

[1]Duck premix (per kg of diet)

Vitamin A	14000 IU
Vitamin D3	1500 IU
Vitamin E	15 IU
Menadione Sodium Bisulphite	3 mg
Vitamin B2	6 mg
Pyridoxine Hydrochloride	0.2 mg
Vitamin B12	12 mg
Calcium Panthothenate	112 mg
Nicacin	40 mg
Folacin	2 mg
Manganese	60 mg
Iodine	1.2 mg

The five experimental diets were made isocaloric by the adjustment of the amounts of wheat and soybean meal in the diets. The amino acids composition of the experimental diets are shown in Table 3.

TABLE 3 Amino acids composition of the experimental diets (g/100 g diet)

Amino acids	**Dietary protein levels (%)**					**Recommended[1]**	
	24	22	20	18	16	S[2]	F[3]
Lysine	1.43	1.08	1.11	0.89	0.83	0.94	0.75
Methionine	0.53	0.41	0.40	0.40	0.39	0.44	0.35
Arginine	1.69	1.21	1.33	1.11	1.24	1.25	1.00
Thereonine	0.79	0.68	0.61	0.64	0.64	0.75	0.60
Histidine	0.62	0.47	0.58	0.48	0.40	0.44	0.35
Glycine	1.52	1.16	1.19	1.05	1.29	1.12	0.90
Valine	1.30	1.08	1.09	0.99	0.93	1.00	0.80
Isoleucine	1.04	0.78	0.78	0.78	0.78	0.88	0.70
Leucine	2.24	1.83	1.83	1.63	1.60	1.63	1.30
Tyrosine	0.89	0.62	0.61	0.58	0.59	0.75	0.60
Phenylalanine	1.27	0.94	0.93	0.87	0.77	0.88	0.70

[1]Amino acids levels suggested by Dean and Scott (1969)

[2]S = Starter diet
[3]F = Finisher diet

The ducklings were individually weighed at the start of the experiment and weekly intervals thereafter. Feed intake was recorded, daily, to the nearest g. At two-weekly intervals (2, 4, 6 and 8 weeks of age) two ducklings from each cage were fasted for 12 hours and killed by cervical dislocation. The frozen carcasses were cut into small pieces and passed five times through a 3 horsepower mincing machine to give an apparently homogenous mince. Samples of about 500 g were taken from each batch and stored in a deep freeze. Two core samples from each batch of minced were put into Soxhlet extraction thimbles and dried to constant weight in a forced-draft oven at 70°C to determine moisture content of the entire body carcass. Ether extract content of the mince was determined by extracting the oven-dried material for 8 hours with petroleum spirit (b.p. 40–60°C). Nitrogen content of the ether extracted mince was determined using a micro-Kjeldahl procedure. Total minerals were estimated by loss of weight following heating a sample of the mince at 600°C for 6 hours.

(b) Experiment 2

One-day old male and female ducklings were raised separately and given a 24 percent protein and 3.00 Mcal ME/kg pelleted starter diet for three weeks. The ducklings were then individually'weighed, wing-banded, and divided, at random, into 20 groups so that each group had a similar initial mean weight, and weight distribution. There were four males and four females in each group, which was raised in a metabolism cage with a wire-mesh floor located in a poultry house. The dietary treatments consisted of four protein levels (12, 16, 20 and 24 percent), each at five energy levels (2.50, 2.75, 3.00, 3.25 and 3.50 Mcal ME/kg diet). Thus there were 20 experimental diets that differed in protein and energy combination. The composition of the experimental diets are given in Table 4, and their amino acids content in Table 5. The experimental diets were prepared from conventional ingredients; vegetable oil was used to increase the energy level of the diets. The calculated metabolisable energy of the experimental diets was based on the values given by Scott et al (1969). One diet was allocated to each cage of ducklings from 3 to 8 weeks of age. Individual ducklings were weighed weekly; feed and water intake were recorded, daily, for each cage. Two males and two females from each cage were randomly selected at the end of the experiment for ether extract and moisture content of the carcass as described previously.

III. RESULTS

(a) Experiment 1 Influence of protein levels

(i) Performance from d 1 to 14. The effects of dietary treatment on weight gain, food intake, FCR (feed conversion ratio), PER (protein efficiency ratio), amount of weight gain is g per g of protein intake), CER (caloric efficiency ratio, amount of energy consumed in Mcal, per gram of weight gain) are summarised in Table 6.

(ii) Weightgain. At two weeks of age ducklings that had received the high-protein (24 percent) diet were slightly, but not significantly ($P > 0.05$), heavier than those fed the medium-protein diets (22, 20 and 18 percent). No significant difference was observed in the rate of growth between males and females.

TABLE 4 Composition (%) of the experimental diets used in Experiment 2

Ingredients	Diet									
	1	2	3	4	5	6	7	8	9	10
Yellow corn	30.00	27.50	24.25	21.25	36.00	33.00	30.00	27.00	42.00	39.00
Wheat	30.00	27.50	24.25	21.25	36.00	33.00	30.00	27.00	42.00	39.00
Wheat bran	31.00	26.00	21.00	19.00	18.00	16.00	12.30	8.20	5.50	2.50
Soybean meal	1.50	10.50	23.00	28.00	2.60	7.50	16.50	25.00	2.00	10.00
Fishmeal	2.00	3.50	3.00	7.00	2.00	6.00	7.50	9.40	3.00	5.00
Limestone	1.00	1.00	1.00	0.90	1.00	1.20	0.90	0.80	1.00	0.95
Bone meal	1.30	1.20	0.85		1.30	0.50	0.20	–	1.35	0.80
Mineral mix[1]	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Vitamin mix[2]	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Cr_2O_3	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
DL-methionine	0.20	0.15	0.05		0.15	0.10			0.15	0.10
Lysine-HCl	0.40	0.05			0.35	0.10			0.40	0.05
Vegetable oil										
TOTAL	100	100	100	100	100	100	100	100	100	100
Calculated analysis										
ME (Mcal/kg)	2500	2514	2497	2501	2756	2758	2749	2749	3011	3010
Crude protein (%)	12.1	16.0	20.1	24.1	12.1	16.1	20.1	24.0	12.1	16.0
Energy:protein ratio	206.6	157.1	124.2	103.8	227.8	171.3	136.8	114.6	248.8	188.1

[1]The mineral mixture (in 1 kg final diet) supplied the following: 5.0 $KHCO_3$; 6.0 NaCl; 0.33 Mn SO_4; H_2O; 0.33 $FeSO4.7H_2O$; 3.0 MgSO4 (anhydrous); 0.00267KI; 0.0167$CuSO4.5H_2O$; 0.0623ZnO; 0.0017$CoCl_2.6H_2O$; 0.0063$NaMoO4.2H_2O$; and 0.0001 Na_2SeO4.

TABLE 4 (continued) Composition (%) of the experimental diets used in Experiment 2

Ingredients	Diet									
	11	12	13	14	15	16	17	18	19	20
Yellow corn	35.50	32.50	44.50	38.00	34.00	29.00	40.00	39.00	33.50	27.00
Wheat	35.50	32.50	44.50	38.00	34.00	29.00	40.00	39.00	33.50	27.00
Wheat bran	3.40	-	-				-			
Soybean meal	11.50	18.40	-	11.30	16.00	21.10	3.70		9.10	19.00
Fishmeal	11.00	14.00	4.60	5.00	9.00	13.20	3.50	12.50	14.00	15.15
Limestone	0.50		0.70	0.70	0.50		1.25	0.40		
Bone meal	-	-	1.05	0.80	-	-	1.00	0.60	-	-
Mineral mix[1]	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Vitamin mix[2]	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Cr_2O_3	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
DL-methionine	-	-	0.15	0.10	-		0.40	-	-	-
Lysine-HCl	-	-	0.30	-	-	-	0.30		-	-
Vegetable oil	-		1.60	3.50	3.90	5.10	7.25	5.90	7.30	9.25
TOTAL	100	100	100	100	100	100	100	100	100	100
Calculated analysis										
ME Mcal/kg	2999	2999	3251	3251	3245	3255	3504	3501	3507	3502
Crude protein (%)	20.0	24.1	11.9	16.1	20.0	24.1	12.0	16.0	20.1	24.0
Energy:protein ratio	150.0	124.4	273.2	202.0	162.3	135.1	292.0	218.9	174.5	145.9

[2]The vitamin mixture (in mg/kg final diet) supplied the following: thiamine-HCl, 15.0; riboflavin, 15.0; nicotinamide, 50.0; D-calcium panthothenate, 20.0; pyridoxine-HCl, 6.0; folic acid, 6.0; biotin, 0.6; menadione sodiumbisulfite, 1.52; cholinechloride, 1400; inositol, 250.0; and butylated hydroxytoluene, 100; (in IU) vitamin D3, 4500; vitamin A, 5000; and vitamin E, 110; and (in micrograms) vitamin B12, 20.

TABLE 5 Amino acids[1] composition of the experimental diets (g/100 g diet)

Exp.Diet	Lysine	Methionine	Arginine	Threonine	Histidine	Glycine	Valine	Isoleucine	Leucine	Tyrosine	Phenylalnine
1	0.82	0.41	0.76	0.29	0.36	0.74	0.57	0.47	1.07	0.35	0.65
2	0.82	0.40	1.00	0.37	0.39	0.96	0.65	0.65	1.35	0.49	0.75
3	1.17	0.37	1.33	0.51	0.34	1.12	0.78	0.89	1.74	0.59	0.94
4	1.26	0.38	1.48	0.50	0.49	1.15	0.85	0.94	1.75	0.67	1.01
5	0.83	0.42	0.86	0.30	0.30	0.77	0.61	0.51	1.17	0.51	0.68
6	0.86	0.45	0.99	0.36	0.26	0.98	0.68	0.63	1.43	0.59	0.91
7	1.14	0.41	1.33	0.51	0.29	1.11	0.81	0.83	1.78	0.78	1.14
8	1.46	0.59	1.57	0.66	0.41	1.27	1.00	1.04	1.98	0.90	1.42
9	0.78	0.35	0.69	0.22	0.22	0.62	0.52	0.43	1.10	0.44	0.64
10	0.77	0.47	0.88	0.38	0.25	0.77	0.67	0.53	1.30	0.48	0.78
11	1.21	0.56	1.25	0.54	0.42	1.10	0.83	0.80	1.67	0.71	1.07
12	1.38	0.56	1.57	0.50	0.50	1.25	0.98	0.95	2.06	0.87	1.28
13	0.76	0.42	0.71	0.29	0.21	0.78	0.60	0.47	1.29	0.48	0.66
14	0.87	0.39	0.93	0.35	0.27	0.90	0.72	0.64	1.39	0.68	0.83
15	0.99	0.42	1.27	0.40	0.35	1.06	0.79	0.73	1.66	0.71	1.03
16	1.42	0.52	1.48	0.56	0.38	1.26	0.91	0.98	2.11	1.00	1.34
17	0.78	0.57	0.72	0.25	0.19	0.69	0.52	0.42	1.05	0.37	0.52
18	0.84	0.43	0.84	0.37	0.30	1.06	0.67	0.59	1.40	0.54	0.69
19	1.12	0.42	1.12	0.49	0.28	1.04	0.80	0.77	1.69	0.77	1.24
20	1.37	0.49	1.49	0.56	0.34	1.42	0.97	0.94	1.98	0.94	1.23
S[2]	0.94	0.44	1.25	0.75	0.44	1.12	1.00	0.88	1.63	0.75	0.88
F[3]	0.75	0.35	1.00	0.60	0.35	0.90	0.80	0.70	1.30	0.60	0.70

[1]Using amino acid levels suggested by Dean and Scott (1969)

[2]S = starter diet; [3]F = finisher diet

TABLE 6 Effect of graded levels of dietary protein on the performance growing ducklings from d 1 to 14.

	Dietary protein (%)				Sex	
	24	22	20	18	Male	Female
Weight gain (g)	320.00	310.8	310.2	308.9	310.8	314.2
	SE[1]6.0 NS[2]				SE 4.5NS	
Total feed consumption (g)	542.0	553.0	551.3	554.8	543.4	557.1
	SE 13.6 NS				SE 9.6NS	
Feed conversion ration (FCR)	1.74	1.74	1.78	1.79	1.73	1.80
	SE 0.05 NS				SE 0.04 NS	
Protein efficiency ratio (PER)	2.48[a3]	2.57[a]	3.06[b]	3.05[b]	2.89[b]	2.69[a]
	SE 0.05**				SE 0.03*	
Caloric efficiency ratio (CER)	4.93[a]	5.20[ab]	5.08[a]	5.39[b]	4.97[a]	5.33[b]
	SE 0.05**				SE 0.03**	

[1]SE = Standard error of the means

[2]NS = Not significant, **P< 0.01 *P< 0.05

[3]a,b values with different superscripts are significantly different (P< 0.05)

(iii) Feed intake. Ducklings given medium-protein diets ate slightly more feed than those given high protein diet while females tended to consume more feed than males.

(iv) Feed conversion ratio. Ducklings given medium-protein diets (18 and 20 percent) had a significantly poorer feed conversion ratio than those given higher protein diets (22 and 24 percent).

(v) Protein and caloric efficiency ratios. The PER of ducklings given starter diets containing medium-protein (18 and 20 percent) was significantly (P< 0.05) better than those ducklings given starter diets containing higher amounts (22 and 24 percent). Male ducklings had higher (P< 0. 05) PER value than female ducklings. The CER of ducklings given the starter diet containing 24% protein was better (P< 0.05) than one containing 18 percent protein, but not different from those given 20 and 22 percent protein diets. CER of male ducklings was better (P< 0.01) than of females.

(vi) Carcass composition. The effects of dietary treatment on moisture, ether extract, protein and ash in the carcass of two-weeks old ducklings are shown in Table 7.

TABLE 7 Effects of graded levels of dietary protein on the mean chemical composition of the carcass of ducklings killed at 2 weeks of age.

	Dietary protein (%)				Sex	
	24	22	20	18	Male	Female
Moisture (%)	67.6	67.2	65.4	62.6	66.2	65.2
	SE 0.67 NS [1,2]				SE 0.47 NS	
Ether extract (%)	12.50 a [3]	12.94 a	14.81 ab	17.75 b	13.91	15.09
	SE 0.75*				SE 0.53 NS	
Ether extract (% dry matter)	38.58 a	39.46 a	42.73 ab	47.33 b	41.00	43.05
	SE 1.51*				SE 1.06 NS	
Protein (%)	15.55	14.84	15.26	15.21	14.99	15.44
	SE 0.25 NS				SE 0.18 NS	
Ash (%)	2.47	2.59	2.46	2.65	2.43 a	2.65 b
	SE 0.08 NS				SE 0.06 +	

[1] SE = Standard error of the means

[2] NS = Not significant, *P< 0.05, +0.10 > P > 0.05

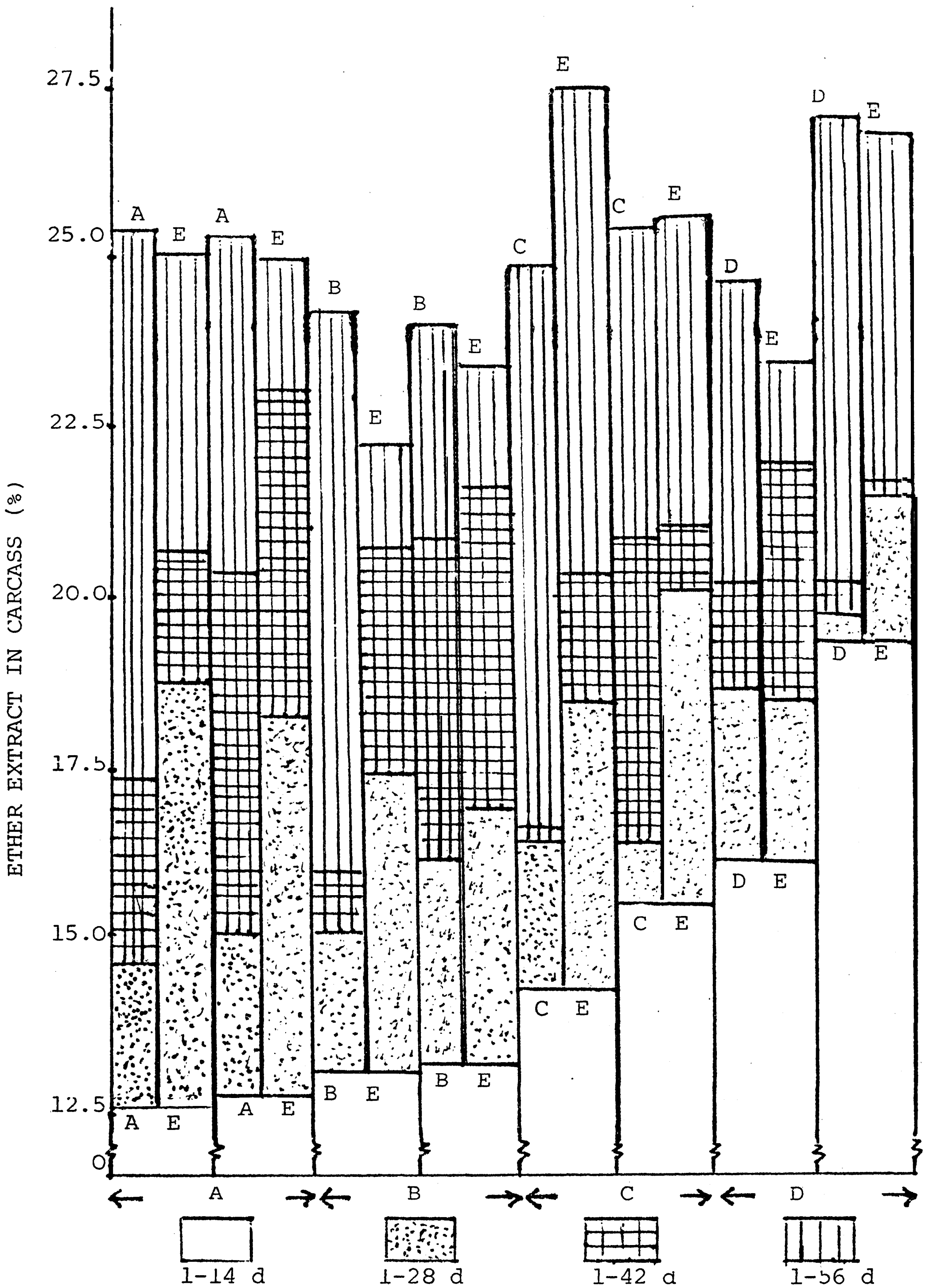
[3] a,b values with different superscripts are significantly different (P< 0.05)

Except for ether extract, none of these components was significantly affected by the graded levels of protein in the diets. The percentage of ether extract in whole'carcass of ducklings given the low protein diet (18 percent) was higher (P< 0.05) than those given the high protein (22 and 24 percent). Percentage of ether extract in the carcass of males was non-significantly lower than those of female ducklings.

(vii) Performance from d 1 to 56. The results of dietary treatment on the performance of growing ducklings between 1 and 56 d of age are summarised in Tables 8, 9 and 10 and Fig. 1.

(viii) Weight gain. Weight gain by ducklings given low-protein starter and finisher diets of 18/18 percent protein, respectively, was similar at 56 d to those given high-protein starter and finisher diets. Ducklings given an 18 percent protein diet throughout the 56 d experimental period were heavier (P< 0.01) than the other groups of ducklings,

Fig. I. The percentage of ether extract of wet carcass of male and female ducklings at 2, 4, 6 and 8 weeks of age. (exp. diet. A = 24% protein; B = 22% protein; C = 20% protein; D = 18% protein; E = 16% protein)



Males were heavier ($P< 0.05$) than females at 56 d.

TABLE 8 Effects of graded levels of dietary protein on the performance of growing ducklings from d 1 to 56.

Treatments	Weight gain (g)	Feed consumption (g)	FCR	PER	CER
Sex					
Male	2908.6^{b}[1]	7520.3^{a}	2.58^{a}	2.27^{b}	7.94^{a}
Female	2837.8^{a}	7366.3^{b}	2.77^{b}	2.17^{a}	8.58^{b}
[2]SE	14.6*[3]	87.3*	0.05**	0.02**	0.11**
Dietary Protein[4] (%)					
24/24	2829.0^{ab}	7798.0	2.76	2.22	8.51
22/22	2826.1^{ab}	7707.00	2.73	2.16	8.33
20/20	2833.6^{ab}	7465.5	2.64	2.18	8.13
18/18	2959.5^{c}	7885.5	2.67	2.28	8.25
24/16	2954.8^{bc}	7812.0	2.64	2.25	8.11
22/16	2794.3^{a}	7392.0	2.65	2.26	8.15
20/16	2907.0^{bc}	7724.5	2.66	2.19	8.26
18/16	2881.5^{ab}	7761.5	2.70	2.25	8.34
SE	29.3**	174.6^{NS}	0.07^{NS}	0.04^{NS}	0.22^{NS}

[1]a,b,c, = values with different superscripts are different ($P< 0.05$)

[2]SE = standard error of the means

[3]NS = not significant **$P< 0.01$ *$P< 0.05$

[4]starter diet (1-14b) finisher diet (15-56 d)

(ix) Feed intake and feed conversion ratio. Except for differences ($P< 0.05$) between males and females there were no effects of dietary treatments on feed intake nor on FCR. However, there was a sex effect in that males were superior ($P< 0.01$) to females in converting feed to gain reflecting the increased feed intake of the females.

(x) Protein and calorie efficiency ratios. There were no significant effects of graded levels of dietary protein of starter and finisher diets on PER and CER values during the 56 d experimental period. The PER and CER values of male ducklings were both significantly better ($P< 0.01$) than those of females at the end of the experiment.

(xi) Carcass composition. The results of the effects of dietary treatments on carcass moisture and ether extract, protein and ash in the dry matter of carcass mince of ducklings at 56 d are shown in Table 9.

TABLE 9 Effects of graded levels of dietary protein on the composition (%) of the dry matter of the carcass of ducklings at 56 d.

	Ether extract		Moisture	protein	Ash
	Wet carcass	Dry matter			
Sex					
Male	24.6	55.4	55.5	15.7	2.8
Female	25.3	56.9	55.5	14.9	2.8
SE[1]	0.4 NS[2]	0.5 NS	0.5 NS	0.3 NS	0.07
Dietary[3] protein (%)					
24/24	25.4	56.6	55.1	15.4	2.9
22/22	24.1	55.2	56.2	15.7	2.8
20/20	25.0	55.3	54.8	15.6	2.8
18/18	25.8	57.0	54.8	15.4	2.8
24/16	25.0	56.1	55.4	15.3	2.4
22/16	22.8	54.5	57.8	15.0	2.9
20/16	26.5	58.4	59.2	15.4	2.8
18/16	25.0	56.1	55.5	15.0	2.7
SE	0.8 NS	1.09 NS	0.9 NS	0.51 NS	0.1 NS

[1]SE = Standard error of the means

[2]NS = Not significant

[3]Starter diet (1-14d), finisher diet (15-56 d)

The dietary treatments did not affect the body composition of the ducklings at 56 d. Data presented in Table PO and Figure 1 indicated that the significant effect of dietary treatments on ether extract content of the wet carcass is only in ducklings at 2 and 4 weeks of age.

(b) Experiment 2. Influence of dietary protein and energy levels

The main results of the second experiment are shown in Tables 11, 12 and Figure 2.

(i) Weight gain. The protein levels and the energy levels of the experimental diets affected weight gains of the ducklings. Ducklings given the diet containing 24 percent protein were lighter ($P< 0.01$) than those given the 20 and 12 percent protein diets. Weight gains were no different among diets containing 12, 16 and 20 percent. The weight gain of ducklings given the low (2.50 Mcal/kg/g) and the high (3.50 Mcal ME/ kg) energy diets were significantly ($P< 0.05$) lighter than those ducklings given a diet containing 3.25 Mcal ME/kg. The weight gain of those ducklings given diets of medium energy level

Fig. 2. Relationship between percentage of ether extract in wet carcass and dietary energy : protein ratio in male (O---O) and female (●——●) ducklings at 8 weeks of age

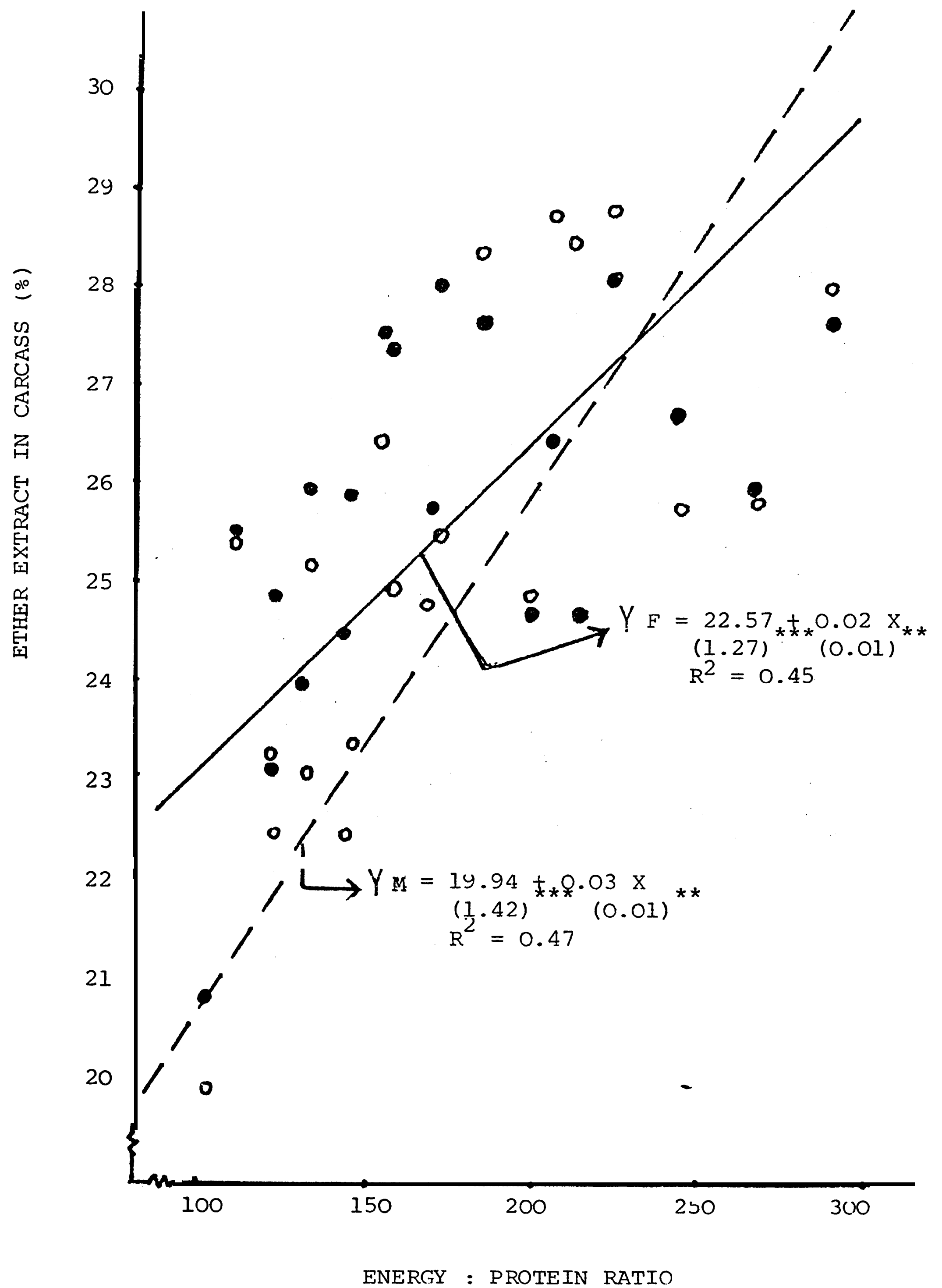


TABLE 10 Effect of graded levels of dietary protein on the percentage of ether extract in the wet carcass of 2, 4, 6 and 8 weeks old growing ducklings.

Treatments :	Age (weeks)			
	2	4	6	8
Sex				
Male	13.9	17.1	19.2[a]	24.6
Female	15.1	18.1	21.0[b]	25.3
SE[1]	0.53[NS 2]	0.33[NS]	0.5*	0.4[NS]
Dietary protein[3] (%)				
24/24	12.5[a4]	14.7[a]	18.8	25.4
22/22	12.9[a]	15.5[ab]	18.4	24.1
20/20	14.8[ab]	16.3[ab]	18.6	25.0
18/18	17.8[b]	19.1[c]	20.2	25.8
24/16		18.5[bc]	21.8	25.0
22/16		17.0[ab]	21.1	22.8
20/16		19.6[c]	20.2	26.5
18/16		19.8[c]	21.7	25.0
SE	0.7*	0.6*	1.00[NS]	0.8[NS]

[1]SE = standard error of the mean

[2]*P< 0.05 NS = not significant

[3]Starter diet (1-14d)/finisher diet (15-56d)

[4]a,b values with different superscripts are different (P< 0.05)

(2.75, 3.00 and 3.25 Mcal ME/kg) were not different. Weight gain was least for ducklings on the lowest energy level (2.50 Mcal ME/kg) followed by the highest energy level (3.50 Mcal ME/kg). Males were heavier (P< 0.01) than females.

(ii) Feed intake and feed conversion ratio. The amount of feed consumed was only slightly influenced by protein level. Ducklings given the highest protein level (24 percent), consumed less (0.1< P< 0.05) feed than those ducklings given the lowest protein level (12 percent), and slightly less feed than those ducklings given 16 and 20 percent protein diets. Feed conversion ratio was not influenced by the protein levels of the diets. The effect of energy levels on feed intake and feed conversion ratio were significant (P< 0.01). Ducklings given low-energy diets consumed more (P< 0.01) feed than those on higher energy levels. It was apparent that the amount of feed consumed declined as the energy content of the diet increased. The best FCR based on the effect of energy level was obtained from ducklings which received a 3.25 Mcal ME/kg diet.

(iii) Protein and caloric efficiency ratio. The PER values of ducklings given high-protein diets (20 and 24 percent) were poorer (P< 0.01) than those PER of ducklings given low-protein diets (12 and 16 percent). The graded levels of dietary protein did not affect the CER of the growing ducklings to 8 weeks. The energy levels did influence the PER values of the ducklings. The best PER was observed for ducklings given the lowest energy diet (2.50 Mcal ME/kg). The values were better ($P < 0.01$) than those PER obtained from ducklings given higher energy

TABLE 11 Effect of graded levels of dietary protein and energy on the weight gain of growing ducklings from d 21 to 56, and on the ether extract (%) and moisture of wet carcass (%) at 56 d.

Treatments	Weight gain (g)	Ether extract: Wet Carcass (%)	Ether extract: Dry carcass (%)	Moisture (%)
Sex				
Male	2035.9^{b1}	25.4	53.6	52.6
Female	1794.5^{a}	25.9	54.0	52.1
SE[2]	35.8**[3]	0.2^{NS}	0.5^{NS}	0.2^{NS}
Protein levels (%)				
12	1975.7^{b}	27.3^{c}	55.8^{c}	51.0^{a}
16	1889.8^{ab}	26.4^{b}	55.1^{bc}	52.0^{ab}
20	1988.8^{b}	25.3^{b}	53.1^{ab}	52.3^{b}
24	1806.6^{a}	23.5^{a}	51.0^{a}	53.9^{c}
SE	35.8**	0.3**	0.6*	0.3*
Energy levels (Mcal/kg)				
2.50	1811.7^{a}	24.7^{a}	53.2	53.6^{b}
2.75	1932.7^{bc}	26.3^{b}	55.0	52.3^{b}
3.00	1935.1^{bc}	25.8^{ab}	54.3	52.5^{b}
3.25	2013.9^{c}	25.2^{ab}	52.8	52.4^{b}
3.50	1882.6^{ab}	26.3^{b}	53.6	50.9^{a}
SE	40.0*	0.4*	0.7^{NS}	0.4*

[1]a–c, values with different superscripts are significantly different ($P < 0.05$)

[3]** $P < 0.01$ *$P < 0.05$ NS = Not significant

[2]SE = standard error of the means

diets (3.00, 3.25 and 3.50 Mcal ME/kg). On the other hand the poorest CER was obtained from the ducklings given the lowest energy diet and the best CER from those given the diet with 3.25 Mcal ME/kg.

(iv) Carcass composition. The effects of dietary treatments on the moisture and ether extract in the whole carcass of 8 week-old ducklings are shown in Table 11. Ducklings given'a 24 percent protein diet had a lower ($P < 0.01$) ether extract than those given lower protein diets. The most ether extract in the wet carcass was obtained from ducklings given the 12 percent protein diet. The energy levels of the experimental diets influenced ($P < 0.05$) the ether extract of wet carcass but not on a dry matter sample. Moisture content was influenced by both dietary protein and energy levels. Ether extract and carcass moisture of the wet carcass of female ducklings were similar to those of males.

TABLE 12 Effect of graded levels of dietary protein and energy on the performance of growing ducklings from d 21 to 56.

Treatments	Daily feed intake (g/duck)	Daily water intake (ml/duck)	Feed conversion ratio (FCR)	Protein efficiency ratio (PER)	Caloric efficiency ratio (CER)
Protein concentration (%)					
12	192.9[b1]	828[ab]	3.42	2.42[c]	10.85
16	182.5[ab]	786[a]	3.38	1.88[b]	11.16
20	185.6[ab]	870[b]	3.38	1.39[a]	10.83
24	175.0[a]	920[b]	3.42	1.22[a]	11.30
SE[2]	4.2+[3]	31+	0.06[NS3]	0.06**	0.19[NS]
Energy concentration (Mcal.kg)					
2.50	206.0[c]	928	3.98[c]	1.43[a]	11.82[c]
2.75	198.1[c]	863	3.59[b]	1.62[ab]	10.92[ab]
3.00	182.8[b]	818	3.39[b]	1.82[bc]	11.08[b]
3.25	170.3[ab]	833	2.97[a]	1.98[c]	10.32[a]
3.50	162.8[a]	803	3.03[a]	1.78[bc]	11.03[b]
SE	4.7**	34[NS]	0.06**	0.07**	0.21**

[1]a–c values with different superscripts are significantly different (P< 0.05)

[2]SE = Standard error of the means

[3]NS = Not significant

**P< 0.01 *P< 0.05 +0.10> P > 0.05

IV. DISCUSSION

It was shown in Table 6 that the best protein level was from 18 to 20 percent for the starter diet for optimum performance to two weeks of age for meat-type ducklings, with 3.00 Mcal ME/kg diet. These values are lower than those reported by Dean (1968, 1972), Dean and Scott (1969), Summers et al. (1970), Bolton et al. (1972) Auckland (1973) and Wilson (1975), but are in general agreement with those reported by Horton (1932), Hamlyn et al. (1934), Scott et al. (1934), Scott et al. (1959), Du Preez and Wessels (1970) ,Hoj (1974) and Leclercq and de Carville (1976) (see Table 1). Excess protein in isocaloric diets of male and female ducklings from d 1 to 56 tended to reduce growth. This observation is in agreement with those reported by Dean (1967) and Luhmann and Vogt (1973), as cited by Leclercq and de Carville (1976). Dean (1967) stated that the weight gain of meat-type ducklings at 56 d was reduced as the protein level was increased above 22 percent for starter and finisher diets. Luhmann and Vogt (1973) showed that excess protein (24.5 percent in the diet of Pekin ducklings tended to reduce growth rate as compared with a 20 percent protein diet.

Data in Table 11 showed that weight gain of ducklings given a finisher diet with a low-protein level (12 percent) was as satisfactory as that for ducklings given a 20 percent protein finisher diet, and better ($P< 0.01$) than for those given a 24 percent protein diet. This result suggests that growing ducklings after 3 weeks of age do not need a high-protein finisher diet. Similar results were reported by Scott et al. (1959), Rudolph (1961), Helder (1968) and Hoj (1974). Scott et al. (1959) who concluded from the results of a series of experiments that 16 percent protein in the ration of meat type ducklings was sufficient from hatching to market age to achieve maximum weight gain. They stated that the high-protein level in the diet influenced weight gain of meat-type ducklings only during the early stage of growth. A similar result has been reported by Rudolph (1961) who showed that up to the age of 7 weeks, a 17 percent protein diet gave the same results as a 20 percent protein diet. Helder (1968) found that ducklings given a 12.5 percent protein finisher diet up to eight weeks had little effect on slaughter weight. However, the results presented in this paper were not in agreement with those reported by Yule (1974), Gutierrez (1974), Bagot and Karunajeewa (1978) and Oluyemi and Fetuga (1978). The weight gain of the duckling from 3 to 8 weeks was significantly affected by the dietary energy content of the finisher diets. The highest weight gain was achieved by ducklings given a diet containing 3.25 Mcal ME per kg, and the lowest was by ducklings given a diet containing 2.50 and 3.50 Mcal ME per kg. It was noted that the response of growth to energy increment diminish at 3.50 Mcal ME per kg of diet. An energy level of 2.50 Mcal ME per kg of diet was too low to support maximum growth; on the other hand an energy level of 3.50 Mcal ME per kg of diet was too high. This result confirmed that of Wilson (1975), in that an energy level of 2.6 Mcal ME per kg diet was too low to support an acceptable rate of growth of meat-type ducklings. The result of this experiment indicates that diets with a metabolisable energy level within the range of 2.75 to 3.25 Mcal per kg was required to support maximum weight gain of meat-type ducklings. The difference between weight gain at eight weeks of age of male and female ducklings in experiment I was 70.8g, and in experiment 2 was 241.4 g. This difference between experiments is probably due to difference in management. Males and females in experiment 1 were raised separately, and in experiment 2 both sexes were raised together. This observation might indicate that males and females should be raised separately to obtain maximum performance of each sex.

The PER value of ducklings given low-protein or high-energy diets. was better ($P< 0.01$) than those given higher-protein, or lower-energy diets (Table 12). On the other hand the graded levels of protein in isocaloric diets did not affect the protein efficiency ratios. These results indicate that ducklings appeared to be particularly undemanding for protein during the early growth period compared to chickens and turkeys. Ducklings given a low-energy diet ate more ($P< 0.01$) feed than those given a high-energy diet (Table 12), while feed intake among ducklings given isocaloric diets (Table 8) was not significantly different. These results are in agreement with other growth studies that have demonstrated that animals eat to meet an energy requirement, and that the energy concentration of the diet is the most important single factor in regulating intake. Feed conversion ratio was therefore dependent on the energy content of the diet and was not affected by the dietary protein level as shown in Tables 8 and 12. The lower the energy content of the diet the poorer the FCR. Increasing the energy level of the diet above 3.25 Mcal ME per kg did not appear to give further improvement in efficiency of feed utilisation. Under the condition of this study, the best FCR at eight weeks of age was 2.97. This result is comparable with that reported by Scott et al. (1959) and Brewster (1976), but different from that reported by Bagot and Karunajeewa (1978). Scott et al. reported a maximum efficiency of feed utilisation by White Pekin ducklings at seven and one half weeks of age 2.9 to 3.0 kg of feed per kg of gain. Brewster (1976) found that FCR of seven and nine week-old Pekin ducklings was 2.78 and 3.44 respectively, while Bagot and Karunajeewa (1978) reported a poor FCR at nine weeks of 4.52.

Increasing dietary protein levels of isocaloric starter diets from 18 to 24 percent did affect significantly the percentage of ether extract in wet carcass during the early stage of life of both males and females (Table 7). When the ducklings were changed from the high to the low protein diets at two weeks of age, the effect of the high-protein diet on ether extract of the whole carcass at the older age was much less apparent, and values at 6 and 8 weeks of age were not different among the different dietary treatments (Table 10 and Figure 1). These results are in agreement with those reported by Scott et al. (1959) and Dean (1969). However, the results of this study are not in agreement with the suggestion of Auckland (1973). He suggested that the feeding of excess protein in the diet appears to offer more scope than quantitative feed restriction in reducing body fat in growing meat-type ducklings. The results of experiment 2 as shown in Table 11 indicated that the carcass ether extract was influenced by the dietary, protein and energy levels. It appears that ether extract content of growing ducklings is related directly to the energy:protein ratio of the diets. The data shown in Figure 2 suggest that a high ratio of energy to protein produced a greater ether extract deposition in ducklings than was obtained with a low ratio of energy to protein. This observation is in agreement with those reported by Scott et al. (1959) and Du Preez and de Carville (1970).

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