EFFECT OF PREVIOUS EXPERIENCE, AND ENVIRONMENTAL VARIATIONS ON THE PERFORMANCE AND PATTERN OF FEED INTAKE OF CHOICE FED AND COMPLETE FED BROILERS

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SUMMARY

A series of five experiments was carried out to compare the effect of previous experience and temperature variation on the performance and pattern of feed intake of the choice-fed and complete-fed broilers.

In the first experiment, 3 week old broiler cockerels, either previously experienced (group 3) or inexperienced (group 2) in choice feeding, were offered free choice of whole sorghum (10% CP, 13.16 MJ ME/kg) and protein concentrate (41.6% CP, 9.74 MJ ME/kg) for 3 weeks. Group 1 (control birds) were fed a complete finisher diet (19.1% CP, 12.32 MJ ME/kg) throughout. Although body weight and total feed consumption were not affected by the feeding treatments, the inexperienced (group 2) broilers consumed less sorghum and twice as much protein concentrate as the experienced (group 3) birds when choice fed. Thus, group 2 birds were significantly less efficient in utilizing protein, amino acids and other nutrients than groups 1 and 3. Group 3 (experienced choice feeding) were the most efficient in feed utilization.

Experiments 2 and 3 investigated the possibility of alleviating heat stress on broilers performance by offering the chickens complete diets or free choice of diets, as in Experiment 1 with extra illumination.

Three week old broiler cockerels, experienced in choice feeding, were housed either at a constant 20°C or in a cyclical temperature room, maintained at 20±1°C during the cool period (4pm-9am) and at 33±1°C during the hot period (9am-4pm). When light was provided for 24 hours (as in Expt. 2) the cockerels in the hot cyclical temperature regimen were able to fully compensate for their reduced feed intake of the complete diet and thus body weight and feed efficiency were not adversely affected, but when only 16 hrs light was provided (as in Expt. 3) a 3% depression in body weight was recorded. In both experiments 2 and 3, the choice fed birds housed in the cyclical temperature regimen consumed significantly ($p<0.05$) less energy but maintained their protein intake, when compared to the chickens fed either the complete diet or free choice at the constant 20°C. Body weight of the choice- fed birds in Expt. 3 was not depressed by heat stress although light was provided for only 16 h/day. Feed efficiency of the choice-fed chickens was consistently better than those fed the complete diet when the chickens were exposed to heat stress.

Expt. 4 compared the performance and pattern of feed intake of choice-fed and complete-fed broilers when housed either in a room where the temperatures fluctuated or were maintained at a constant daily 20°C. Materials and methods were similar to Expt. 3 but after 10 days on the feeding treatments the temperature of the cyclical temperature room was maintained daily at either 20+1°C or 33+1°C during the hot period (9am-4pm). Body weights of the birds fed the-complete diet and housed in the cyclical temperature regimen were significantly lower than those choice-fed and similarly housed or those fed either complete or free choice housed at a constant 20°C. Regardless of the temperature regimen, the choice-fed birds grew as well as the complete fed birds housed at a constant 20°C. The daily

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feed intake of the broilers fed either the complete or free-choice diets fluctuated inversely following the daily temperature fluctuations, but the composition of the grain and protein concentrate consumed was altered by the choice-fed chickens who nearly maintained their protein intake at the same level as the choice-fed birds housed at $20 \pm 1^{o}C$.

Experiment 5 investigated if the mechanisms of feed intake regulation of the choice-fed birds as shown in hot environments would be exhibited by broilers housed in a cyclical cold ($10^{o}C$) room. Three week old broiler breeder cockerels experienced in choice feeding were housed either at a constant $20 \pm {}^{o}C$ temperature or in a cyclical cold temperature room (held at 20 or at $10^{o}C$) and offered either complete or free-choice diets as in Expt. 3. Body weights of the choice-fed birds housed in the cyclical cold room were significantly ($p<0.05$) heavier than those fed the complete diet irrespective of temperature regime. The choice-fed broilers housed in the cyclical cold room consumed more sorghum only but as much protein concentrate as the choice fed birds kept at a constant $20^{o}C$. Overall, the choice fed birds were more efficient in converting feed than those fed the complete diet and significantly more efficient when the birds were exposed either to heat or cold stress.

In all experiments, carcass yield was not affected by feeding treatment or temperature regime. Except for Expt. 5, all the choice-fed broilers laid down as much pad or abdominal fat as those fed the complete diet irrespective of the temperature regime. The choice-fed birds in all experiments had significantly heavier gizzards than those fed the complete diet. Further, there was no proventriculus hypertrophy found in the choice-fed birds, but 30-50% of the complete diet fed birds sampled were found to have hypertrophy of the proventriculus.

INTRODUCTION

The recent interest to re-examine the choice feeding of chickens with whole grain and protein concentrate was highlighted by the energy crisis in the 1970s. Further it has been observed that the coefficient of variation among individual birds within a flock was estimated to be about 10% when measured in both egg production and in feed intake of the flock (Emmans, 1978). Thus Emmans (1978) considered that the advantages of choice feeding could be expected from the reduction of the grinding and handling costs of the grain and the efficiency of the nutrient utilization by individual birds, with the assumption that the individual birds in a flock will consume a diet based on their particular physiological needs. Since then the work on free choice feeding in both growing and laying chickens has been based on Emman's concept that the feed intake regulation in free choice feeding systems is based on the inter-relationship between physiological state and nutrient requirement of the chickens) with little consideration for other factors such as behavioural or genetic factors. However, over the last decade, reports on choice feeding of poultry are controversial with some reports of excellent results (Leeson and Summers 1983; Karunajeewa and Tham 1984; Cumming 1984 in laying hens and Mastika and Cumming 1981a,b; Cumming 1983; Rose 1985 in broilers) while others suggest that fowls can not self select their nutrient requirements (Blake et al 1984; Robinson 1985 in laying hens and Maurice et al 1979; El-Husseiny and Ghazalah 1980; Scholtyssek 1982 in broilers). Overall reports dealing with laying birds suggest they are more frequently successful than broilers, with their limited life span of only a few weeks. These discrepancies are probably due to different approaches in solving the problems of choice feeding.

It is well accepted that the deleterious effects of high environmental temperature on broilers performance is due largely to the depression in feed consumption (El-Husseiny 1979, Deaton et al 1983; Austic 1985). Many attempts have been made to overcome this problem using either nutritional, management or combined approaches. From the nutritional aspect, a lot of work has concentrated on reducing heat increment of the diet with fat supplementation (Dale and Fuller 1979); improving the amino acid balance (Waldroup et al 1976); improving amino acid : ME ratios (Sinurat and Balnave 1985); increasing the protein content of the diet (Cowan and Michie 1978) or using high density diets (Summers 1974). Ideally, the birds should be housed in controlled temperature sheds to provide the optimum temperature for both broilers and layers. However, this approach may be very expensive especially in warm countries like Australia. Other published work, using a management approach, in hot environments was reported by Dale and Fuller (1980); Deaton et al (1984) by cycling the temperature; and Savory (1978) by changing the light intensity. All the above reports deal with conventional, complete diets and the results have not always produced the anticipated results.

Recently, Mastika and Cumming (1981a,b) reported that broiler chickens, housed in experimental cages, could adequately balance their diets when they were offered a choice of whole sorghum and protein concentrate and grew as well as broilers fed a complete pelleted diet. However, the results of the limited published work on free choice feeding of poultry housed in different environments is conflicting (Blake et al 1984; Scott and Balnave 1985; Picard 1985 in laying hens; and Cowan and Michie 1977; Mastika and Cumming 1981b in broilers), and most of the above reports deal with constant high or low temperatures. Under natural conditions, ambient temperature is not constant but fluctuates considerably over 24 hours and even from day to day, particularly in Australia. Consequently, the energy requirement of the chickens fluctuates throughout the day and again may vary markedly from day to day in Australia. Theoretically, by offering the chickens a choice of grain as a source of energy, along with protein concentrate, which is rich in vitamins and minerals, chickens should have the opportunity to adjust their energy intake in varying environmental conditions and maintain their protein, vitamin and mineral intakes.

A series of experiments was designed to study the effect of previous experience of choice feeding on the performance and feed intake pattern of choice-fed broilers. Further, to investigate the possibility of alleviating the growth-depressing effect of heat stress by offering chickens a choice of whole grain and protein concentrate in different warm environments. Finally to study the performance and pattern of feed intake of choice-fed broilers when housed in a room with marked daily temperature fluctuation and also when housed in a cold environment.

MATERIALS AND METHODS

Chickens and Management

Commercial male broiler chicks (Hyline) were used in Expts. 1,2,3 and 4 and male broiler breeder (sire line) chicks (Hyline) used in Expt. 5. The chickens were housed in electrically-heated brooders for the first 3 weeks and received feed and water ad lib. All birds were vaccinated by eye drop method at one-day-old with A3 infectious bronchitis vaccine and by the same method with Vic-s infectious bronchitis vaccine at 14 days of age (Cumming 1983).

Experiment 1 Two hundred and forty day-old broiler chickens were divided into 3 groups. Group 1 and Group 2 were fed a complete commercial broiler starter diet until the birds were three weeks old. Group 3 was fed the same complete diet for 10 days and then 'trained' to choice feeding on whole sorghum and protein concentrate (Table 1) until 3 weeks of age.

TABLE 1 Diet composition.

Ingredient	Complete crumble diet	Protein conc.
Wheat	12.0	-
Sorghum	59.8	-
Rice pollard	1.0	11.4
Millrun	-	-
Meat meal	8.97	27.6
Blood meal	0.73	7.2
Sunflower meal	8.50	21.0
Cottonseed meal	3.0	8.6
Soybean meal	3.0	20.0
Tallow	1.85	1.6
Lysine	0.23	-
Methionine	0.17	-
Choline chloride (75%)	0.05	0.1
Salt	0.08	-
Vit. Minerals mix	0.62	2.4
Calculated chemical analysis		
Crude protein	19.1	41.57
(determined)	20.3	41.50
Metabolizable energy (MJ)/kg	12.32	9.74
(determined)	12.38	10.17
Ca (%)	1.03	3.12
Phosphorus, available (%)	0.59	1.60
Fat (%)	3.25	5.29
Crude fibre (%)	3.51	6.22
Methionine (%)	0.48	0.77
Lysine (%)	1.05	2.62
Aspartic acid (%)	1.35	3.70
Glutamic acid (%)	3.17	5.34

At 3 weeks of age the birds were individually weighed and 36 birds were selected from each group, wingbanded, then divided into 6 groups of 6 birds each and placed in wire cages (75 x 75 x 38 cm). Group 1 was fed a complete finisher diet (Table 1) while groups 2 and 3 were offered a choice of whole sorghum and protein concentrate (Table 1), group 2 being the 'untrained' choice feeding group, while group'3 was the experienced choice feeding group.

Experiment 2 Two hundred day old broiler cockerels were fed, initially, a complete commercial broiler starter diet to 10 days and then 'trained' to choice feed, as in Expt. 1. One hundred three week old birds were selected from the 200, wingbanded and divided into 20 groups of 5 birds which were then placed in wire cages as Expt. 1. Ten such groups were assigned to each controlled-temperature room.

Experiment 3 One hundred and twenty, 3-week old birds were similarly selected from 200 'trained' choice-fed chickens, wingbanded and divided into 20 groups of 6 birds which were then placed in wire cages as Expt. 1. Ten such groups were assigned to each controlled-temperature room.

Experiment 4 One hundred and sixty, 3-week old birds were selected from 300 'trained' choice-fed chickens, wingbanded and divided into 32 groups of 5 birds, which were then placed in wire cages as for Expt. 1. Sixteen such groups were assigned to each controlled-temperature room.

Experiment 5 One hundred and ninety two 3-week old broilers were selected from 350 *trained' choice-fed birds, wingbanded and divided into 32 groups of 6 birds, which were placed in wire cages as Expt. 1. Sixteen such groups were assigned to each controlled temperature room.

In each room, 10 groups (in Expts. 2 and 3) and 16 groups (in Expts. 4 and 5) of chickens were randomly distributed to each of the two treatments - a complete crumble finisher diet (treatment 1) and a choice of whole sorghum and crumbled protein concentrate (treatment 2). Feed and water were provided ad lib throughout.

Experimental Rooms

Experiment 1 was run in an uncontrolled temperature room with normal day-light. Experiments 2 and 3 were carried out in two controlled temperature rooms measuring 5 x 6 m wide each. A cyclical temperature regimen was employed in one room, ranging from 20±1°C during the 'cool period' (4pm-9am) and 33±1°C during the 'hot period' (9am-4pm), while the cool room was held at a constant 20±1°C throughout the experiment. Both rooms received 24 h light in Expt. 2 and 16 h light per day from 4am-8pm in Expt.3 and were dark for the remainder. Experiment 4 was run in a similar way as Expt. 3 but, after 10 days on these treatments, the temperature of the cyclical temperature room was maintained daily at either 20±1°C or 33±1°C during the 'hot period' (9am-4pm). Experiment 5 was carried out in the same manner as Expt. 3 but the temperature of the cyclical temperature room was arranged as follows: 1. at the beginning of the experiment, when the birds were 21 days old, both rooms were set at a constant 20±1°C; 2. after 10 days on the experimental diets, the temperature of the cyclical temperature regimen was changed to 10±1°C from 8am-4pm and 20+1°C from 4pm-8am for 11 days. The temperature in the cyclical temperature regimen was reversed to 20+1°C from 8am-4pm and 10±1°C from 4pm-8am for a final 7 days. The temperature of the control room remained constant at 20±1°C throughout the experiment.

Diets

Composition and calculated chemical composition of the diets used in these experiments are presented in Table 1. The protein concentrate and the complete finisher diets were in crumble form and sorghum was offered whole.

Observations

Feed intake was measured and recorded daily between 8.30 and 9.00 am in Expt. 1. In Expts 2,3 and 4 feed intake was measured twice daily, between 8.30 and 9.00 in the morning and 3.30 and 4.00 in the afternoon. Feed intake of the chickens in Expt. 5 was also recorded twice daily, between 8.00 and 8.30 am and 4.00 and 4.30 pm. In all experiments, chickens were individually weighed at weekly intervals, Experiments 1 ,3 and 4 continued for 3 weeks while experiments 2 and 5 for 4 weeks. At the end of each experiment, 3 representative birds (nearest to the mean weight from each replicate group) in Expt. 1 and 2 birds in Expts. 2,3,4 and 5 were killed and dressed for carcass and organ weight evaluation.

Statistical analysis

A completely randomised design was used in Expt. 1 while in Expts 2,3,4 and 5 a similar design with factorial arrangement was employed. All data were subjected to analysis of variance (Snedecor and Cochran 1967) and when significant treatment effects were found, a Studentized range test was used for comparison (Steel and Torrie 1960).

RESULTS

Experiment 1

TABLE 2 Effect of experience on the performance, carcass and organ weights of broilers fed free choice or complete diets (Experiment 1).

	Body wt. (6 weeks) (g)	Weight gain (g)	FCR	Carcass (%)**	Fat pad (%)	Abd. fat (%)	Gizzard + provent. (%)	Proventriculus hypertrophy
Complete diet	1781a*	1332a	1.95a	71a	3.05a	3.72a	1.69a	7/18
Choice + Inexperience	1769a	1320a	1.98a	71a	2.45b	3.06b	2.24b	0/18
Choice + Experience	1777a	1328a	1.89b	71a	3.19a	3.94a	2.24b	0/18
SEM	17.5	17.57	0.018	0.38	0.22	0.22	0.05	

* Values in the same column with different letters are significantly different ($P<0.05$)

** Expressed as % of live body weight

Results are presented in Tables 2 and 3 and Figs 1 and 2. Body weight and total feed intake of the broilers at 6 weeks of age were not affected by the three feeding treatments. Group 3 (experienced choice-fed birds) converted feed more ($p<0.05$) efficiently than Group 2 or Group 1 birds. When offered free choice, the inexperienced birds (Group 2) consumed less sorghum but almost twice as much protein concentrate as the experienced birds (Group 3). In selecting their own nutrients, Group 2 birds consumed the same amount of energy, but more ($p<0.05$) protein, lysine, methionine, aspartic and glutamic acids than the experienced Group 3 birds. Carcass yield (%) was

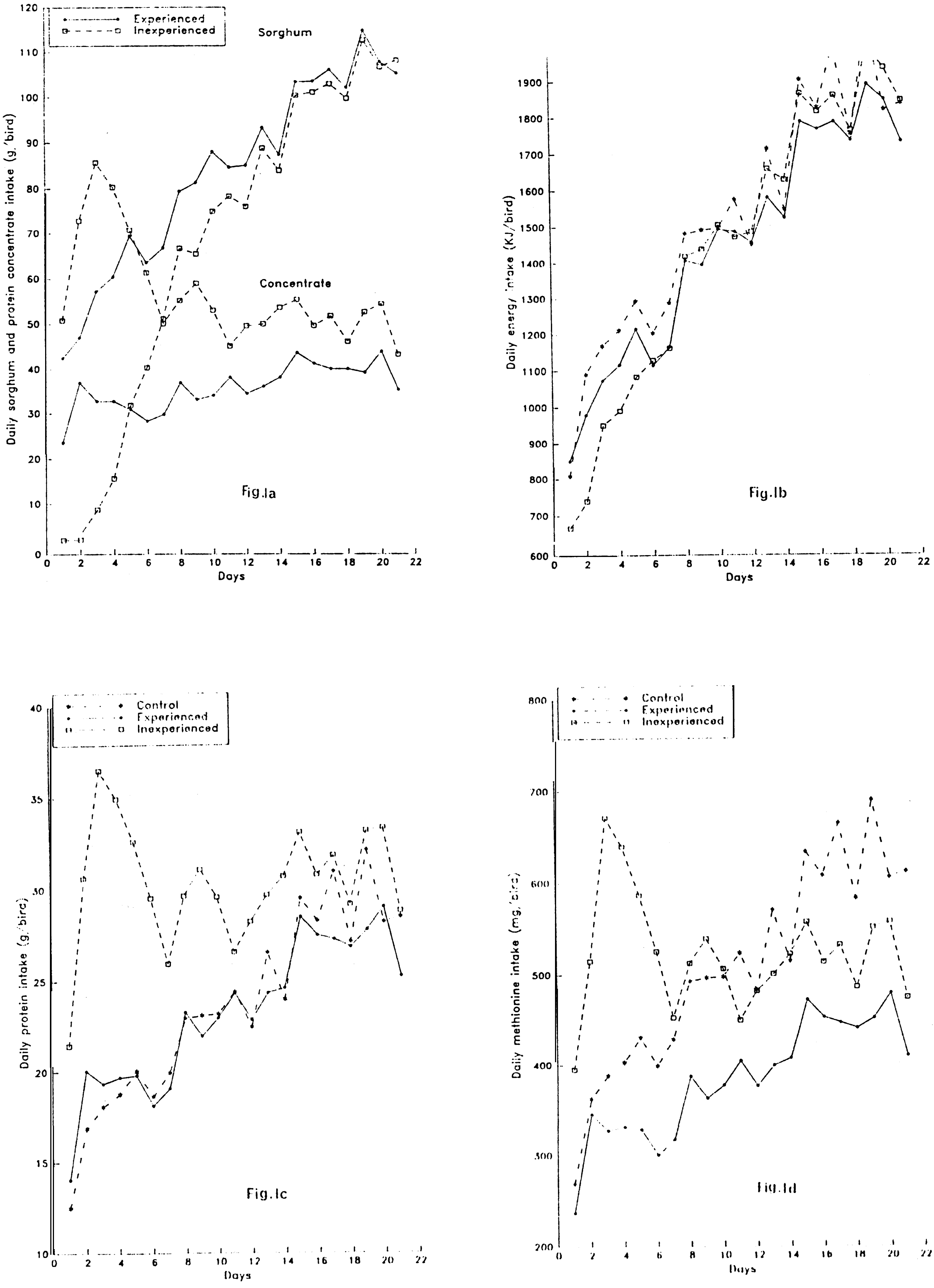

Fig. 1 Sorghum and protein concentrate (la), energy (lb), protein (lc) and methionine (Id) intakes of inexperienced and experienced birds fed free-choice and of the control birds fed a complete diet (Experiment 1).

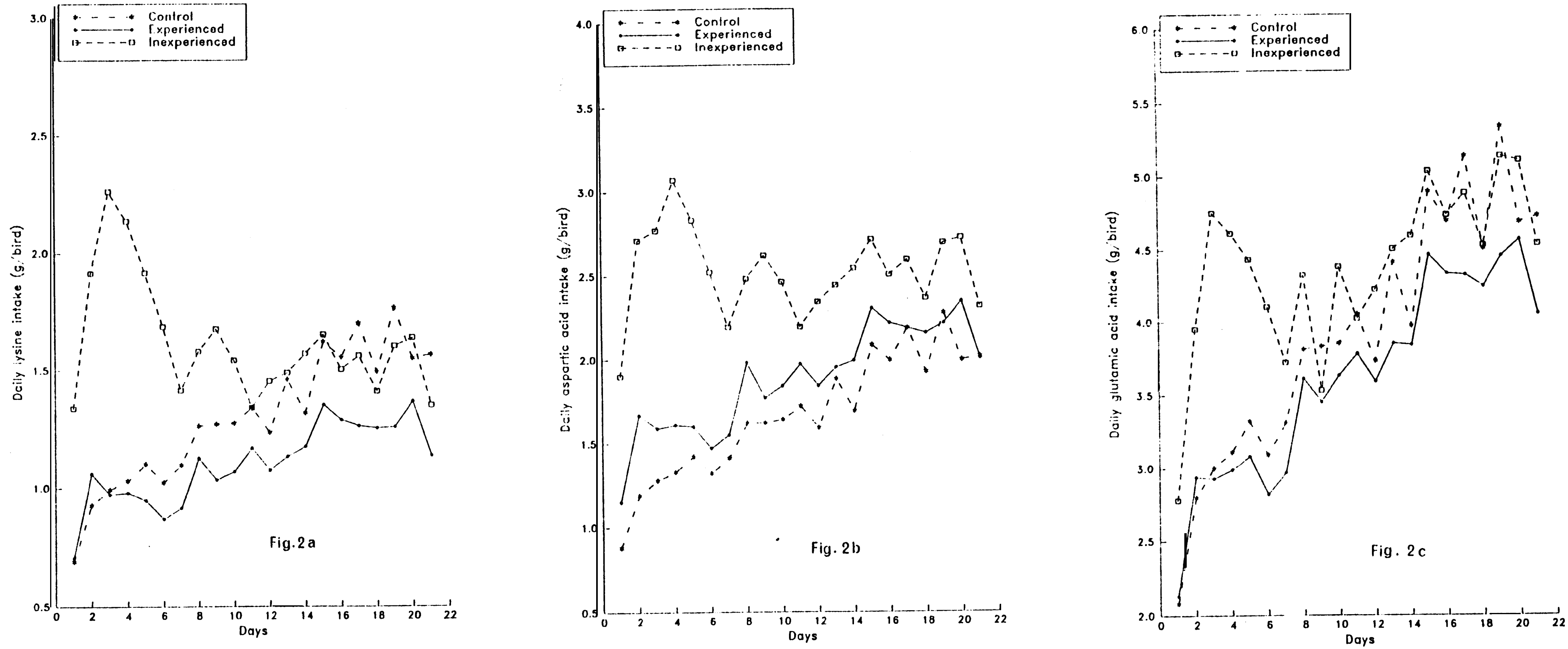

Fig. 2 Calculated lysine (2a), aspartic acid (2b), glutamic acid (2c) of inexperienced and experienced birds fed free-choice and of the control birds fed a complete diet (Experiment 1).

not affected by feeding regimen. Fat pad and abdominal fat of the inexperienced Group 2 birds were significantly ($p<0.05$) lower than Group 1 or Group 3 birds. Both Group 2 and Group 3 birds had bigger ($p<0.05$) gizzards than the complete fed broilers. There was no proventriculus hypertrophy found in the choice fed birds, but 7 out of 18 birds sampled (39%) of the complete fed birds were found to have hypertrophy of the proventriculus.

TABLE 3 Effects of experience on feed preference and nutrient intake of broilers fed free choice or on complete diets (Experiment 1).

	Feed intake (g)			Protein (g)	Metabolizable Energy intake (MJ)	Lysine (g)	Methionine (g)
	Whole sorghum	Prot. conc.	Total				
Complete diet	-	-	2597a*	496a	31.09a	27.27a	10.65a
Choice + Inexperience	1420	1194	2614a	638b	30.31a	34.12b	11.24a
Choice + Experience	1740	763	2503a	491a	30.33a	23.36a	8.14b
SEM			37.5	19.3	0.47	1.40	0.31

* Values in the same column with different letters are significantly different ($P<0.05$)

Experiment 2

Results are presented in Tables 4 and 5 and Fig. 3. Neither feeding system, nor room temperature had any effect on body weight, feed consumption and feed conversion ratio (FCR) of the broilers with 24 h light. Broilers fed the complete diet and housed at 20^oC consumed 20% more feed than those housed in the cyclical temperature regimen during the 'hot period' (9am-4pm) (Fig. 3a). However) this reduction in feed intake was compensated for by the chickens during the 'cool period' (4pm-9am) (Fig. 3a) when they consumed more feed, Choice-fed broilers at 20^oC consumed 30% more grain than those in the cyclical temperature regimen during the 'hot period' (9am-4pm) (Fig. 3b), but during the 'cool period' (4pm-9am) the sorghum intake was relatively constant (Fig. 3c). The choice-fed broilers at constant 20^oC consumed significantly ($P<0.05$) more energy than those kept in the cyclical temperature regimen. Overall, the choice-fed broilers at either a constant 20^oC or in the cyclical temperature regimen consumed as much protein as their complete diet counterparts. Carcass, fat pad or abdominal fat weight were not affected by either feeding system or room temperature. The gizzard weights of the choice-fed birds were heavier ($p<0.05$) than those fed the complete diet, irrespective of room temperature. Four out of 10 birds sampled housed at a constant 20^o C and 5 out of 10 birds sampled housed at cyclical temperature had proventriculus hypertrophy when fed the complete diet. There was no proventriculus hypertrophy found in the choice-fed birds for both temperature regimens.

TABLE 4 Performance, carcass and organ weights of choice- or complete-fed broilers kept in different environments with 24 hours illumination (Experiment 2)

Treatments		Body wt. (7 weeks) (g)	Body weight gain (g)	FCR	Carcass (%)**	Fat pad (%)	Abd. fat (%)	Gizzard + provent. (%)	Proventriculus hypertrophy
20±1°C	Complete	2125a*	1678a	2.19a	69a	3.2a	3.65a	1.69a	4/10
	Choice	2157a	1709a	2.21a	70a	2.7a	3.18a	2.10b	0/10
33±1°C	Complete	2115a	1668a	2.19a	70a	3.1a	3.46a	1.62a	5/10
	Choice	2138a	1693a	2.14a	70a	3.3a	3.98a	2.09b	0/10
SEM		13.9	14.2	0.01	0.39	0.19	0.24	0.05	
Effect of feeding		NS	NS	NS	NS	NS	NS	***	
Effect of temperature		NS	NS	NS	NS	NS	NS	NS	
Feeding vs temperature		NS	NS	NS	NS	NS	NS	NS	

* Values in the same column with different letters are significantly different ($p<0.05$)

** Expressed as % of live body weight

TABLE 5 Feed, protein and energy intakes of choice- or complete-fed broilers kept in different environments with 24 h illumination (Experiment 2)

Treatments		Feed intake (g/bird) Sorghum	Concent.	Total	Protein intake (g/bird)	ME intake (MJ/bird)
20±1°C	Complete	-	-	3665a	700a	45.15ab
	Choice	2772	1000	3772a	693a	46.77b
33±1°C	Complete	-	-	3648a	697a	44.95ab
	Choice	2591	1033	3624a	688a	44.16a
SEM				28.5	10.4	0.60
Effect of feeding				NS	NS	NS
Effect of temperature				NS	NS	*
Feeding vs temperature				NS	NS	NS

* Values in the same column with different letters are significantly different ($p<0.05$).

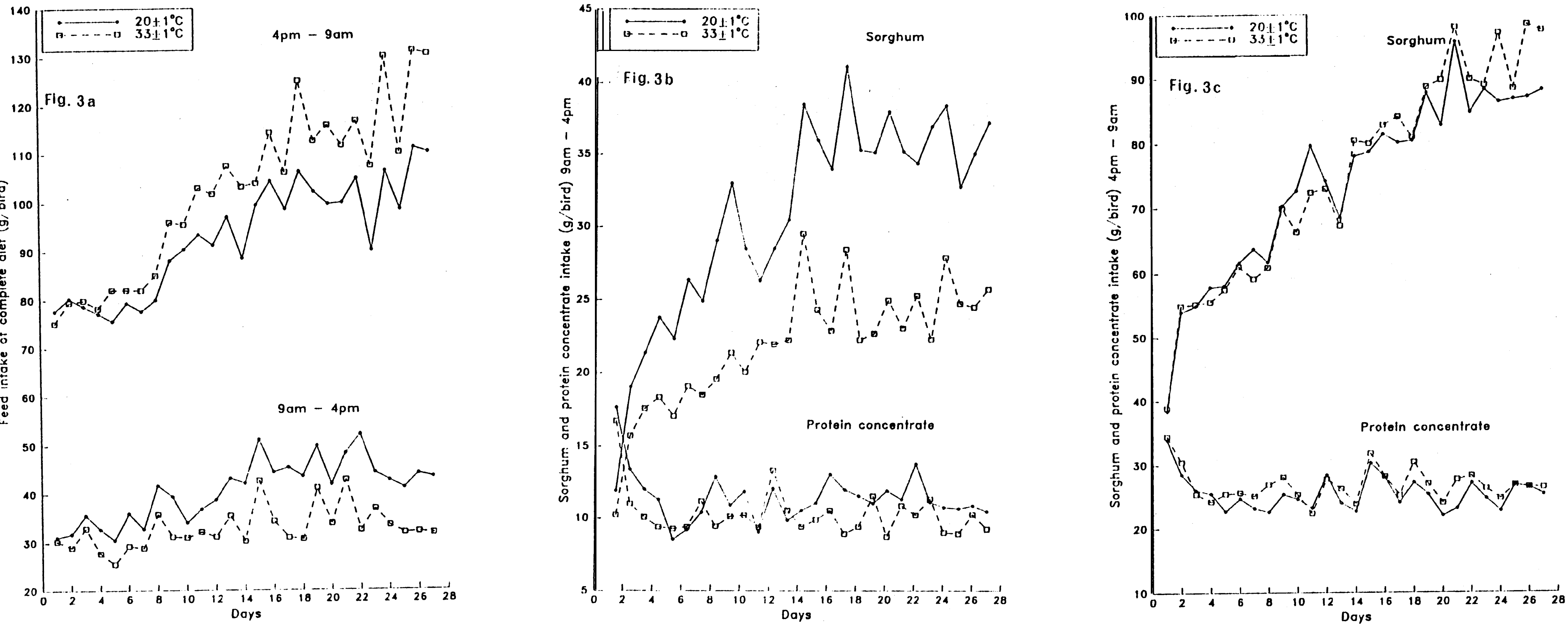

Fig. 3 Feed intake of a complete diet of birds at 20°C during a hot (9am-4pm) and cool (4pm-9am) period (3a); sorghum and protein concentrate intake of choice fed birds at 20°C, or in a cyclical regime when measured during the hot (9am-4pm) period (3b) or the cool (4pm-9am) period in Experiment 2 with 24h lighting.

Experiment 3

Results are presented in Tables 6 and 7 and Fig. 4. When light was provided for only 16 h/day, total feed intake of the birds fed either the complete diet or free choice and kept in the cyclical temperature regimen was reduced by 7.5% compared to those held at a constant 20°C. Body weights of the broilers fed the complete diets housed in the cyclical temperature regimen were reduced by 3% compared with those similarly fed in the constant 20°C, although this reduction was not statistically significant ($p>0.05$). During the 'hot period' (9am-4pm), broilers on the cyclical temperature regimen and fed the complete diet consumed 29% less feed than those kept at constant 20°C (Fig. 4a). Similarly, the choice fed birds, during the 'hot period' consumed 34% and 8% less sorghum and protein concentrate respectively than those kept at a constant 20°C (Fig. 4b). During the 'cool period' (4pm-9am) the choice-fed birds consumed as much sorghum as and 7% more protein concentrate than those kept at a constant 20°C temperature (Fig. 4c). The birds kept at a constant 20°C and fed either a complete diet or free choice, consumed more ($p<0.05$) energy than those housed in the cyclical temperature regimen. Protein consumption in all treatments was similar ($p>0.05$) except for those kept in cyclical temperature regimen and fed a complete diet when it was lower ($p<0.05$). Overall, the choice-fed birds housed in the cyclical temperature regimen converted feed more ($p<0.05$) efficiently than those housed at a constant 20°C and fed either complete diet or free choice. Carcass, fat pad and abdominal fat weights were not affected by either feeding system or room temperatures. Gizzards of the choice fed birds were heavier ($p<0.05$) than those fed the complete diet in both temperature regimens. There was no proventriculus hypertrophy found in the choice-fed birds in both temperature regimens, but 3 out of 10 birds sampled and housed at constant 20°C and 4 out of 10 birds sampled and housed in the cyclical temperature room and fed the complete diet were found to have hypertrophy of the proventriculus.

TABLE 6 Performance, carcass and organ weights of broilers fed either a complete-diet or choice-fed and housed in different environments with 16 h illumination (Experiment 3)

		Body wt. (6 weeks) (g)	Body weight gain (g)	FCR	Carcass (%)**	Fat pad (%)	Abd. fat (%)	Gizzard + provent. (%)	Proventriculus hypertrophy
20±1°C	Complete	1740a*	1259a	2.09a	69a	2.6a	3.3a	1.87a	3/10
	Choice	1761a	1281a	2.08a	70a	2.7a	3.4a	2.47b	0/10
33±1°C	Complete	1689a	1209a	2.01ab	70a	2.7a	3.2a	1.86a	4/10
	Choice	1735a	1254a	1.96b	70a	2.5a	3.2a	2.40b	0/10
SEM		21.6	21.4	0.02	0.53	0.21	0.23	0.06	
Effect of feeding		NS	NS	NS	NS	NS	NS	***	
Effect of temperature		NS	NS	***	NS	NS	NS	NS	
Feeding vs temperature		NS	NS	NS	NS	NS	NS	NS	

* Values with different letters are significantly different ($p<0.05$)
** Expressed as % of liveweight

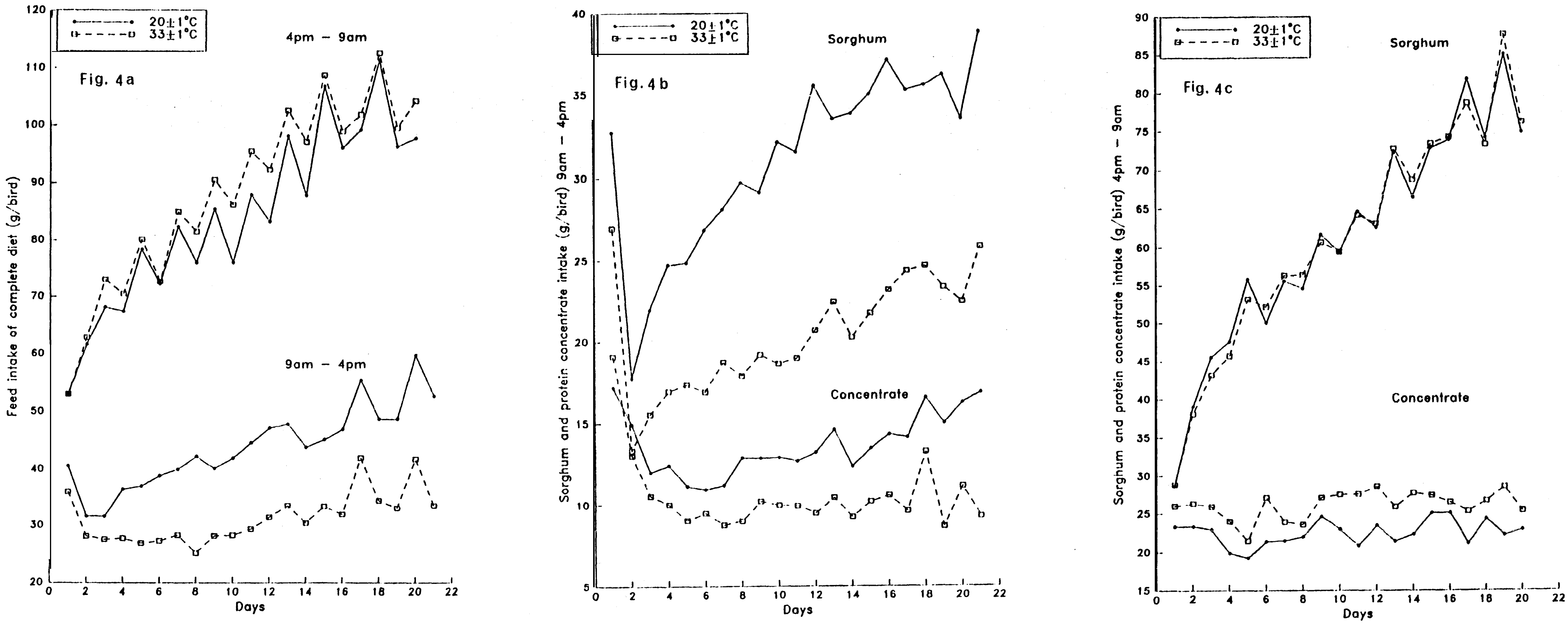

Fig. 4 Feed intake of a complete diet of birds at 20°C and in a cyclical temperature regime during the hot (9am-4pm) and cool (4pm-9am) period (4a), intake of sorghum and protein concentrate of birds at 20°C or in a cyclical regime during the hot (9am-4pm) period (4b) and cool (4pm-9am) period (4c) in Experiment 3 with 16h lighting.

TABLE 7 Feed, protein and energy intake of broilers fed either a complete diet or choice-fed and housed in different environments with 16 h illumination (Experiment 3)

Treatments		Feed intake (g/bird)			Protein intake (g/bird)	ME intake (MJ/bird)
		Sorghum	Concent.	Total		
20±1°C	Complete	-	-	2628a	502a	32.38a
	Choice	1912	747	2659a	502a	32.44a
33±1°C	Complete	-	-	2429b	464b	29.92b
	Choice	1693	766	2459b	488ab	29.72b
SEM				43.5	11.6	0.52
Effect of feeding				NS	NS	NS
Effect of temperature				***	*	***
Feeding vs temperature				NS	NS	NS

* Values in the same column with different letters are significantly different ($p<0.05$).

Experiment 4

TABLE 8 Effects of daily temperature fluctuations on the performance, carcass and organ weights of broilers fed free choice and complete diets (Experiment 4)

Treatments		Body wt. (6 weeks) (g)	Body weight gain (g)	FCR	Car-cass (%)**	Fat pad (%)	Abd. fat (%)	Gizzard + Provent. (%)	Proven-triculus hyper-trophy
20±1°C	Complete	1724a*	1277a	2.05a	70a	2.87a	3.63a	1.90a	5/16
	Choice	1724a	1278a	2.02a	71a	3.20a	3.81a	2.30b	0/16
33±1°C	Complete	1650b	1205b	1.97b	71a	2.94a	3.43a	1.74a	6/16
	Choice	1682ab	1236ab	1.94b	71a	2.69a	3.26a	2.30b	0/16
SEM		13.7	13.6	0.016	0.36	0.19	0.22	0.05	
Effect of feeding		NS	NS	-	NS	NS	NS	***	
Effect of temperature		***	***	***	NS	NS	NS	NS	
Feeding vs temperature		NS	NS	NS	NS	NS	NS	NS	

* Values in the same column with different letters are significantly different ($p<0.05$)

** Expressed as % of liveweight

Results are presented in Tables 8 and 9 and Fig. 5. Broiler chicks fed the complete diet and housed at a cyclical temperature grew more slowly ($p<0.05$) than those fed the complete or free choice diet housed at a constant 20°C temperature. The choice-fed birds housed in a cyclical temperature regime grew as well as those housed at constant 20°C, regardless of the feeding system. Both complete and choice fed broilers in the cyclical temperature regime converted feed more ($p<0.05$) efficiently than those housed at a constant 20°C. Broiler chicks fed either complete or free choice diets and housed at a constant 20°C consumed more ($p<0.05$) feed than those housed in the cyclical temperature regime. The choice-fed broilers housed in the cyclical temperature regime consumed 10% less sorghum, and consumed as much protein concentrate as the choice-fed birds housed at a constant 20°C. When the temperature was raised to 33°C (every second day) in the second half of the experiment) the pattern of feed intake of both complete and choice-fed birds followed the pattern of the daily temperature fluctuations (Fig. 5a,b,c). During the 'cool period' of the day (4pm-9am) the choice-fed birds consistently increased their protein concentrate intake but not their sorghum intake.

TABLE 9 Effects of daily temperature fluctuations on feed and nutrients intake of broilers fed free-choice and complete diets (Experiment 4)

Treatments		Food intake (g/bird) Whole sorghum	Prot. concent.	Total	Protein (g/bird)	Metabolizable energy (MJ/bird)	Lysine (g/bird)	Methionine (g/bird)
20±1°C	Complete	-	-	2613a*	499a	32.19a	27.44a	10.71a
	Choice	1864	714	2578a	483ab	31.49a	22.44c	7.92c
33±1°C	Complete	-	-	2378b	454c	29.30b	24.97b	9.57b
	Choice	1673	727	2400b	467bc	29.11b	22.40c	7.82c
SEM				25.35	6.5	0.32	0.41	0.12
Effect of feeding				NS	NS	NS	***	***
Effect of temperature				***	***	***	**	***
Feeding vs temperature				NS	-	NS	-	-

* Values in the same column having different letters are significantly different ($P<0.05$)

Calculated nutrient intakes (Table 9) showed that the complete-fed broilers housed at the cyclical temperature consumed significantly ($p<0.05$) less protein than those birds fed either complete or free choice diets housed at a constant 20°C. On the other hand, the choice-fed birds housed at the cyclical temperature room consumed as much protein as those fed similarly and housed at a constant 20°C. Broiler chicks fed either complete or free-choice

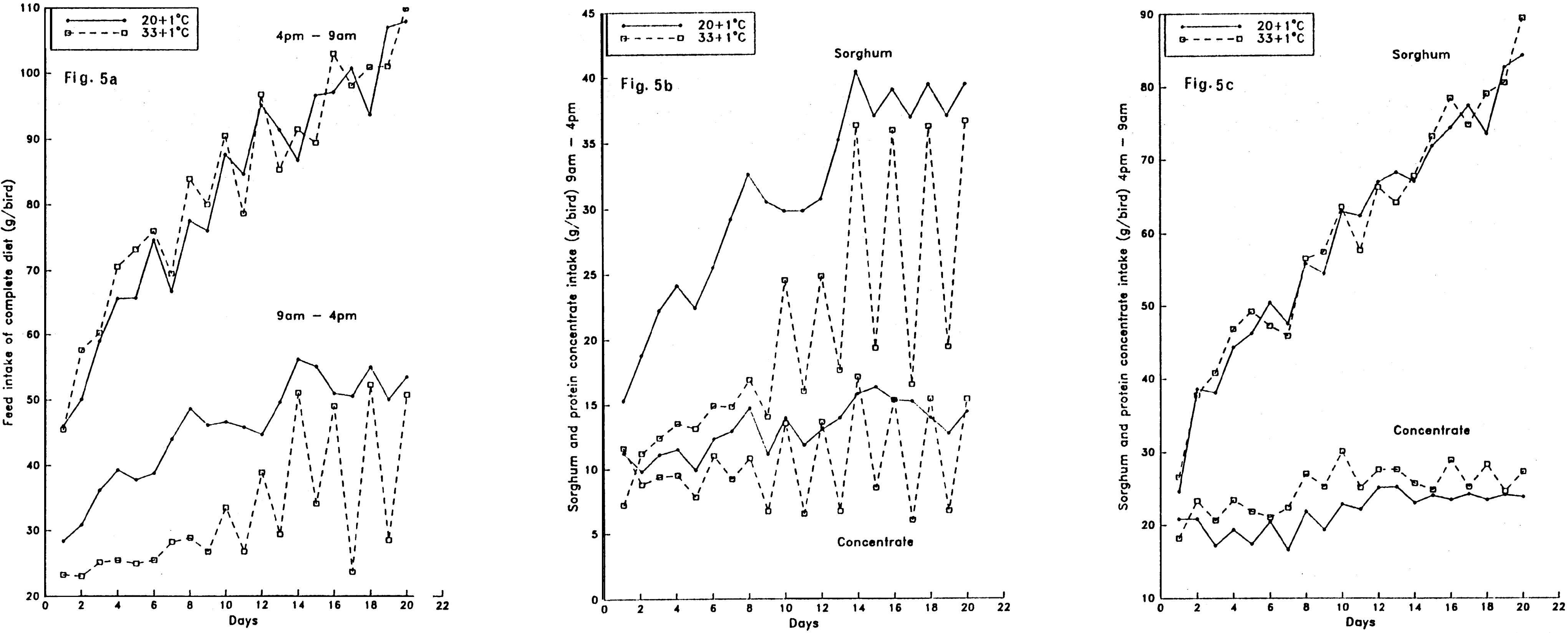

Fig. 5 Feed intake of a complete diet of birds at 20°C and in a cyclical temperature during the hot (9am-4pm) and cool (4pm-9am) period (5a), intake of sorghum and protein concentrate of birds at 20°C or in a cyclical regime during the hot (9am-4pm) period (5b) and cool (4pm-9am) period (5c) in Experiment 4 with 16h lighting.

diets and housed in the cyclical temperature regime consumed less ($p<0.05$) energy than those housed at a constant 20°C. The choice fed birds in both temperature regimes consumed less ($p<0.05$) lysine and methionine than the complete-fed birds housed either at a constant 20°C or at the cyclical temperature. Carcass, fat pad and abdominal fat weights were not affected by either feeding or temperature treatments. Regardless of the temperature regimen, gizzard weights of the choice fed birds were heavier ($p<0.05$) than those fed the complete diet. Five out of 16 and 6 out of 16 birds fed the complete diet at the two temperatures had proventriculus hypertrophy, while none were found in any of the choice fed birds.

Experiment 5

Results are presented in Tables 10 and 11 and Fig. 6. Body weight of the choice-fed birds housed in the cyclical 10°C temperature were significantly ($p<0.05$) heavier than those fed the complete diet housed either at the same cyclical temperature or at a constant 20°C. Regardless of the temperature regime, the choice-fed birds converted feed more ($p<0.05$) efficiently than those fed the complete diet. Overall, feed intake of the birds housed at the cyclical 10°C was significantly ($p<0.05$) higher than those housed at a constant 20°C, irrespective of the feeding system. The choice-fed broilers housed in the cyclical 10°C temperature regime consumed 6.5% more sorghum, and consumed as much protein concentrate as the choice-fed birds

TABLE 10 Effect of cool stress on performance, carcass and organ weights of broilers fed free choice or complete diets (Experiment 5)

Treatments		Body wt. (7 weeks) (g)	Body weight gain (g)	FCR	Carcass (%)**	Fat pad (%)	Abd. fat (%)	Gizzard + provent. (%)	Proventriculus hypertrophy
$20 \pm 1^{o}C$	Complete	2216a*	1809a	2.16a	68a	1.89a	2.36a	1.38a	6/16
	Choice	2274ab	1868ab	2.07c	68a	2.89b	3.44b	2.19b	0/16
$33 \pm 1^{o}C$	Complete	2213a	1807a	2.29b	67a	1.67a	2.05a	1.26a	7/16
	Choice	2301b	1895b	2.13ac	68a	2.77b	3.38b	2.30b	0/16
SEM		20.1	19.5	0.03	0.34	0.15	0.15	0.04	
Effect of feeding		**	***	***	NS	***	***	***	
Effect of temperature		NS	NS	**	NS	NS	NS	NS	
Feeding vs temperature		NS	NS	NS	NS	NS	NS	-	

* Values in the same column with different letters are significantly different ($p<0.05$)

** Expressed as % of liveweight

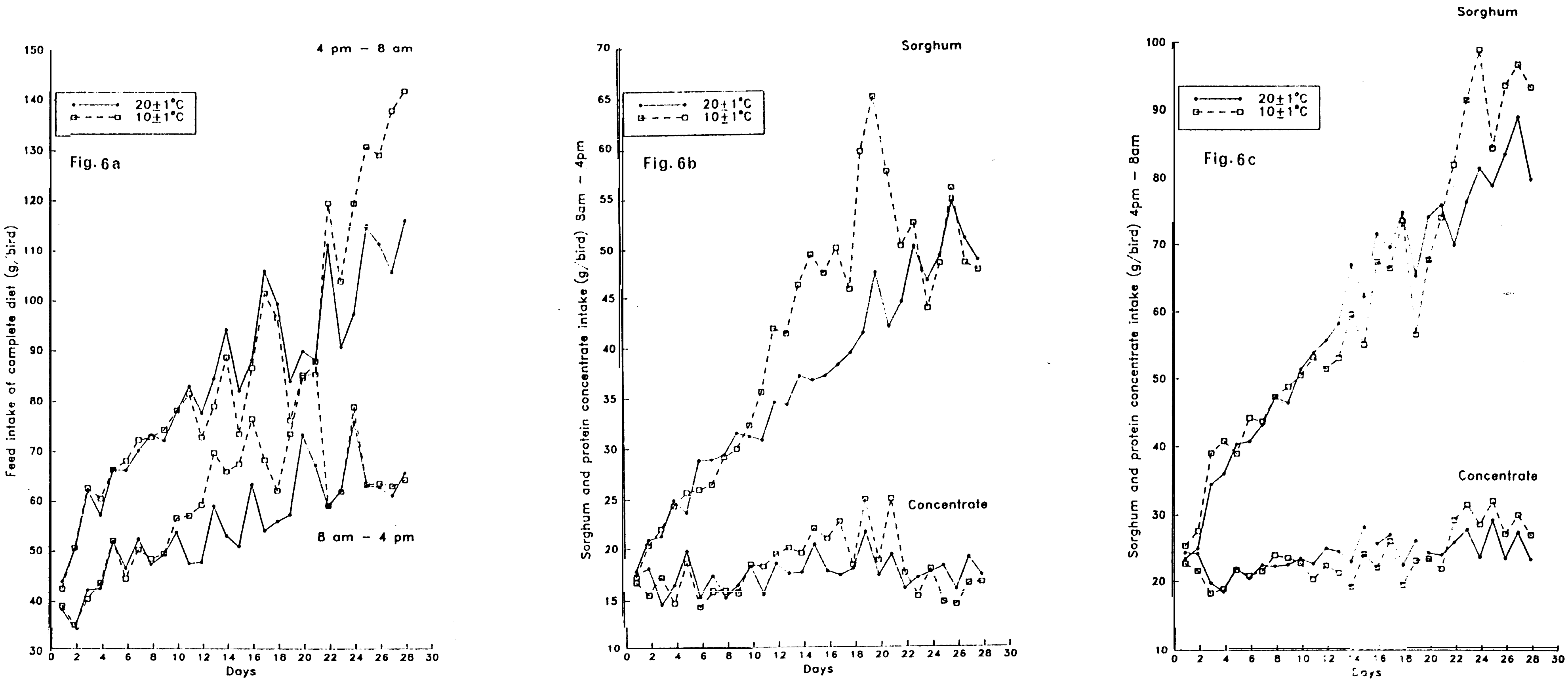

Fig. 6 Feed intake of a complete diet of birds at 20°C in a cyclical regime during the cold (10°C, 8am-4am) and cool (20°C, 4pm-8am) periods (6a); intakes of sorghum and protein concentrate of choice fed birds in a cyclical regime at 10°C (8am-4pm)(6b) and at 20°C (4pm-8am)(6c) in Experiment 5 with 16h lighting (see text for more details).

housed at a constant 20°C. Broiler chicks fed complete diets adjusted their intake very rapidly when the temperature decreased from 20 to 10°C from 8am-4pm and the reverse was true when the temperature was altered from 20 to 10°C from 4pm-8am (Fig. 6a). The same rapid adjustment of sorghum intake was also exhibited by the choice-fed birds when the temperature was altered as above (Fig. 6b,c). Broiler chicks housed at the cyclical 10°C temperature and fed complete diet consumed more ($p<0.05$) protein than those similarly fed and housed at a constant 20°C. The choice-fed broilers housed at either a constant 20°C or in a cylical 10°C temperature regime consumed as much protein as the complete fed birds. Chicks housed in the cyclical 10°C temperature and fed either complete or free choice diets consumed more ($p<0.05$) energy than those housed at a constant 20°C temperature.

Regardless of the temperature regime, the choice fed birds consumed less ($p<0.05$) methionine and lysine than those fed the complete diet. Carcass weights were not affected either by feeding treatments or temperature regimes. Fat pad, abdominal fat and gizzard weights of the choice-fed birds were significantly ($p<0.05$) heavier than in the complete-fed birds, regardless of the temperature regime. There was no proventriculus hypertrophy found in the choice-fed birds on either temperature regimes, but in 6 out of 16, and 7 out of 16 birds sampled on complete diet and housed at constant 20°C and cyclic81 10°C temperatures respectively.

TABLE 11 Effect of cool stress on feed intake and calculated nutrient intake of broilers fed free choice or complete diets (Experiment 5)

		Feed intake (g/bird)			Total protein intake (g/bird)	Metabolizable energy (MJ/bird)	Methionine intake (g/bird)	Lysine intake (g/bird)
		Grain	Conc.	Total				
20±1°C	Complete	-	-	3911a	747a*	48.41a	16.03a	41.06a
	Choice	2687	1171	3858a	755ab	48.43a	12.51c	36.05b
10±1°C	Complete	-	-	4102b	789b	51.15b	16.94b	43.38a
	Choice	2862	1166	4028b	771ab	50.64b	12.70c	36.26b
SEM				39.5	10.8	0.69	0.22	0.61
Effect of feeding				NS	NS	NS	***	***
Effect of temperature				**	*	**	*	*
Feeding vs temperature				NS	NS	NS	NS	-

* Values in the same column with different letters are significantly different ($P<0.05$)

DISCUSSION

Although body weights between experienced and inexperienced birds when offered free choice were not affected by treatment, the component of the diets selected were remarkably different (Tables 2 and 3, Fig. 1a). The experienced birds consumed 22.5% more sorghum and 36% less protein concentrate and so more ($p<0.05$) efficiently utilized protein, and amino acids than the inexperienced birds (Table 3, Figs 1c, 1d, 2a, 2b, 2c). This different pattern of feed intake between experienced and inexperienced choice-fed broilers was probably due to the fact that the inexperienced birds were not familiar with whole sorghum as an energy source so they consumed more protein concentrate, when in a form similar to the previous complete diet,than the experienced birds from day 1 to day 10 of the experimental period. Gradually, the inexperienced birds increased their sorghum consumption to close to that of the experienced birds (Fig. 1a).

A sudden change in the physical form of a complete broiler diet (from starter crumble to finisher crumble) offered to broiler chickens resulted in a significant reduction in feed intake and a decrease in body weight gain (Walker, 1978). Further, chickens that are used to consume either whole or cracked corn may fail to eat the whole barley that replaces the corn (Arscott 1979). Thus, habits and experience of broiler chickens will influence feed intake and hence efficiency of nutrient utilization. The results therefore confirm that the experience of choice feeding in broilers is a very important factor in order to achieve the optimal performance in a free-choice feeding system. The ability of the experienced choice-fed broilers to regulate and correctly alter their nutrient intakes was clearly demonstrated in Expts 2,3,4 and 5 when the birds were exposed to different environmental temperatures and the choice-fed birds performed consistently more efficiently than those fed the complete diet.

A major factor that is responsible for the depression in body weights of broilers fed complete diets in hot weather is the reduction in feed intake (Adams and Rogler, Scott et al 1976; Austic 1985). The results of Expt. 2 suggest that the depression of feed intake of the complete fed birds due to heat stress ($33^{\circ}C$ from 9am to 4pm) may be overcome by providing the chickens with continuous light and bringing the room temperature down to $20+1^{\circ}C$ for the remaining 24 h (Fig. 3a). However, when only 16 h light was provided (from 4pm to 8pm, Expt. 3) although some compensation of feed intake did occur (Fig. 4a), it was not sufficient to compensate totally for the depression of feed intake which occured during the hot period (Fig. 4a) resulting in a 3% depression in body weight of broilers fed the complete diet (Table 6). Similar results were recorded in experiment 4 in that feed intake of broilers housed in the cyclical temperature regime and fed the complete diet were lower ($p<0.05$) than those housed at a constant $20^{\circ}C$, resulting in a significantly lower body weight.

On the other hand, in Expts 2 and 3 the choice-fed birds in the cyclical temperature regime consumed significantly less sorghum (30-34%) during the hot period (9am-4pm) than those kept at a constant $20^{\circ}C$ (Fig. 3b, 4b). Further, during the cool period (4pm-9am) (Fig. 3c, 4c) the birds in the cyclical temperature regimen consumed as much sorghum as those at the constant $20^{\circ}C$ for the same period. This ability of the chickens to regulate their energy intake was even more clearly demonstrated in Expt. 4 (Fig. 5b) where the daily sorghum intake fluctuated widely with the daily temperature fluctuations. Finally, the ability of choice-fed broiler chickens to adjust their energy intake applied to the cooler environment (10°C) as well. In this experiment (Expt. 5) birds consumed more of the sorghum than those housed at a constant 20°C. The rapid adjustment by the broiler-chickens of sorghum intake as source of energy in both hot and cool environments and even when the daily temperature fluctuated was remarkably consistent.

An additional important finding is that the choice-fed chickens in the cyclical temperature regimen consumed as much protein concentrate as the broilers kept at a constant 20°C. This was more clearly demonstrated in Expt. 3 where the choice-fed broilers reduced their protein concentrate intake by 8% during the hot period (9am-4pm), when compared with choice-fed birds kept at a constant 20°C. However, during the cool period (4pm-9am) the birds in the cyclical temperature regimen consumed 7% more protein concentrate than their counterparts kept at a constant 20°C thus largely compensating for their reduced protein intake during the hot period (Fig. 4b, 4c). A similar pattern of protein concentrate intake was demonstrated by the choice-fed birds in Expt. 4 (Fig. 5b,5c). Finally the broiler chicks fed free choice and housed in the cyclical 10°C (Expt. 5) consumed as much protein concentrate as those housed at a constant 20°C (Table 11). These patterns of feed intake clearly show that choice-fed broiler chickens have the ability to regulate their feed intake, firstly to satisfy their energy requirement as reported by Mastika (1981), Mastika and Cumming (1981a,b), Mastika (1983) but further to regulate and maintain their protein requirements (Mastika and Cumming 1985).

The other interesting point is that the choice-fed broilers in all these experiments converted feed more efficiently than those fed the complete diet and the differences were more marked when the birds were housed in the cyclical hot (20 to 33 °C) or cool (20 to 10°C) temperature regimes (Tables 2,4,6,8, and 10). This is in agreement with and an extension of the work of Mastika and Cumming (1981b) who showed that broiler cockerels housed at a constant 30°C converted feed more efficiently if choice-fed than if offered complete diets. This increased efficiency may be due in part to the fact that the complete diet which in finely ground and pelleted form empties much faster from the gizzard than the choice-fed birds eating whole grain (Mastika 1981, Mastika unpublished), perhaps resulting in some nutrients being incompletely absorbed by the chickens. Further, McIntosh et al (1962) reported that whole grain resulted in more energy (6.8-10.8%) being absorbed by chickens than similar grains fed crushed or pelleted.

In Expt. 1,2,3 and 4, the choice-fed birds laid down similar amounts of pad or abdominal fat as those fed the complete diet. In Expt. 5 the choice-fed broilers laid down significantly more pad or abdominal fat than the complete fed birds and this discrepancy is probably due to the genetical variation of the birds used in the experiments. The broiler chickens used in Expt. 1,2,3 and 4 were commercial broiler cockerels, while in Expt. 5, broiler breeder (sire line) cockerels were used, which are usually selected only for maximum body weight. Similar genetic variations were reported by Mastika (1981) and Cumming (1983), that Tegel birds laid down more fat when choice-fed than when fed complete diets while Steggle birds, which were leaner did not. The effects of strain differences on fat content of broilers fed complete diets have been reported by several investigators (Washburn et al 1975, Van Middelkoop et al 1977, Griffiths et al 1978). Overall, genetics probably play an important role in affecting the results of the choice-fed birds.

The incidence of proventriculus hypertrophy and gizzard atrophy in the complete fed birds was consistent and all choice fed birds had a 'normal' development of the digestive tract. Whether proventriculus hypertrophy and gizzard atrophy related to any loss in efficiency of nutrient utilization requires further investigation.

Results of temperature fluctuation on feed intake of choice-fed broilers is of major significance to the Australian poultry industry, both layers and broilers, where very marked seasonal and daily temperature fluctuations are so frequently recorded.

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