EFFECT OF NUTRITION AND ENVIRONMENTAL VARIATIONS ON CHOICE FEEDING OF BROILERS

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Summary

Two experiments were carried out to determine the possibility of alleviating heat stress on broilers performance by offering the chickens complete diets or free choice of diets with extra illumination. Three week old broiler cockerels were divided into groups and randomly assigned in two control temperature rooms. In one room, the temperature was held at a constant 20±1°C during the cool period (4 pm - 9 am) and 33±1°C during the hot period (9 am - 4 pm). I each room, ten groups of chickens were randomly distributed to each of two nutritional treatments, either a complete finisher diet or a choice of whole sorghum and protein concentrate. Feed and water were offered ad libitum, and light was provided for 24 hours in the first experiment and for 16 hours in the second. When light was provided for 24 hours the cockerels in the hot cyclical temperature regimen were able to fully compensate for their reduced feed intake of the complete diet and body weight and feed efficiency were not adversely affected. However, when 16 hours light was provided a 3% depression on body weight was recorded. In both experiments, the choice fed chickens 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 temperature. Body weight of the choice fed chickens were not affected by heat stress although light was provided only 16 hours. Feed efficiency of the choice fed chickens was consistently better than those fed a complete diet when the chickens were exposed to heat stress.

I. INTRODUCTION

The deleterious effect of high environmental temperatures on broilers performance have been reported widely (Adam and Rogler, 1968; El-Husseiny, 1979; Deaton et al. 1983). Generally, as ambient temperature increases, growth rate decreases and this is due largely to reduced feed consumption. Many attempts have been made to overcome this problem by reducing the heat increment of the diet with fat supplementation (Dale and Fuller, 1979), improving the aaino acid balance (Waldroup et al. 1976), improving amino acid:ME ratios (Sinurat and Balnave, 1985), increasing the protein content of 'the diets (Cowan and Michie, 1978, cycled the temperatures (Deaton et al. 1984); Dale and Fuller, 1980) and changing light intensity (Savory, 1978). All the above reports deal with conventional complete diets and the results are controversial.

Mastika and Cumming (1981a,1981b) 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 offered complete diets. However, there are several reports to the contrary in this area (Maurice et al. 1979; Scholtyssek, 1982) and these differences may be due to the different approach used in the experiment.

Cowan and Michie (1977) reported that choice fed broilers kept at constant temperatures of 16, 22, 26 and 31°C grew at significantly slower

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rates than broilers fed complete diets in the same environment. Again to the contrary, Mastika and Cumming (1981b) reported that broiler chickens fed free choice grew as well as the complete fed birds when they were kept at either 20°C or 30°C constant temperature. They further noted that the choice fed birds were significantly more efficient in food conversion than the complete fed broilers at 30°C constant temperature.

Under natural conditions, ambient temperature is not constant but fluctuates considerably and consequently the energy requirement of the chicken throughout the day fluctuates. Theoretically, by offering the chickens a choice of grain as source of energy along with protein concentrate, chickens should have ample opportunity to adjust their energy in varying environmental conditions.

The current experiments aimed to investigate further the possibility of alleviating the growth depressing effects of heat stress by offering chickens a choice of whole grain and protein concentrate in different environments.

II. MATERIALS AND METHODS

(a) Chickens and management

Commercial male broiler chicks (Hyline) were used in both experiments and were vaccinated by the 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). The chickens were reared in electric brooder and during the first ten days of age were fed a commercial chicken starter crumble diet. From 11 to 21 days of age, birds were "trained" on choice feeding by offering them whole sorghum along with protein concentrate (Table 1).

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	11.17
Ca %	1.03	3.12
Pav. %	0.59	1.60
Fat %	3.25	5.29
CF %	3.51	6.22
Methionine %	0.48	0.77
Lysine %	1.05	2.62

In experiment 1, a total of one hundred three week old birds were selected from 200, wingbanded and divided into twenty groups of five birds which were then placed in wire cages (75 cm x 75 cm x 38 cm). Ten such groups were assigned to each controlled temperature room.

In experiment 2, one hundred and twenty 3 week old birds were similarly selected from 200, wingbanded and divided into 20 groups of 6 birds. Ten such groups were randomly distributed to each controlled temperature room.

In each room, ten groups 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 crumble protein concentrate (treatment 2). Feed and water were provided ad libitum throughout.

(b) Experimental rooms

Two controlled temperature rooms measuring 5 x 6 m wide were used. A cyclical tenperature regimen was employed in one room, ranging from 20±1°C during the cool period (4 pm - 8 am) and 33±1°C during the hot period (8 am - 4 pm) and the cool room was held at a constant 20±1°C throughout the experiment. Light was provided for 24 hours in experiment 1 and 15 hours (4 am - 8 pm) in experiment 2.

(c) Diets

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

(d) Observations

Feed intake was measured twice a day, between 8.30-9.00 am in the morning and 3.30-4.00 pm in the afternoon. Chickens were individually weighed at weekly intervals. Experiment 1 was run for four weeks and experiment 2 for three week. At the end of each experiment, two representative birds (nearest to the mean weight from each group were killed and dressed for carcass and organ weight evaluation.

(e) Statistical analysis

All data were subjected to analysis of variance (Snedecor and Cochran, 1967) and when significant treatment effects were found, Duncan's multiple range test was used for comparison (Steel and Torrie, 1960).

III. RESULTS

(a) Experiment 1

When light was provided for 24 hours, neither feeding system nor room temperature had any effect on body weight, feed consumption or feed conversion ratio of the chickens (Tables 2 and 3). Broilers fed the complete diet and kept at 20°C room temperature consumed 20% more feed than those kept in the cyclical temperature regimen during the hot period (9 am - 4 pm) (Fig. 1). However this depression of feed intake was compensated for by the chickens during the cool period (4 pm - 9 am) (Fig. 1), when they consumed more feed.

Table 2 Performance of choice fed broilers kept in different environments with 24 hours illumination

Treatments		3 week body weight (g)	7 week body weight (g)	Body weight gain (g)	F.C.R.
20±1°C	Complete	447 a[1]	2125 a	1678 a	2.19 a
	Choice	448 a	2157 a	1709 a	2.21 a
33±1°C	Complete	447 a	2115 a	1668 a	2.19 a
	Choice	446 a	2138 a	1693 a	2.14 a

[1]Values in the same column having different letters are significantly different ($p<0.05$)

Table 3 Feed, protein and calorie intake of choice fed broilers kept in different environments with 24 hours illumination

Treatments		Feed intake (g)			Protein intake (g)	Calorie intake (MJ)
		Sorghum	Concent.	Total		
20±1°C	Complete		-	3665 a[1]	700 a	45.15 ab
	Choice	2772	1000	3772 a	693 a	46.77 b
33±1°C	Complete	-	-	3648 a	697 a	44.95 ab
	Choice	2591	1033	3624 a	688 a	44.16 a

[1]Values in the same column having different letters are significantly different ($p<0.05$)

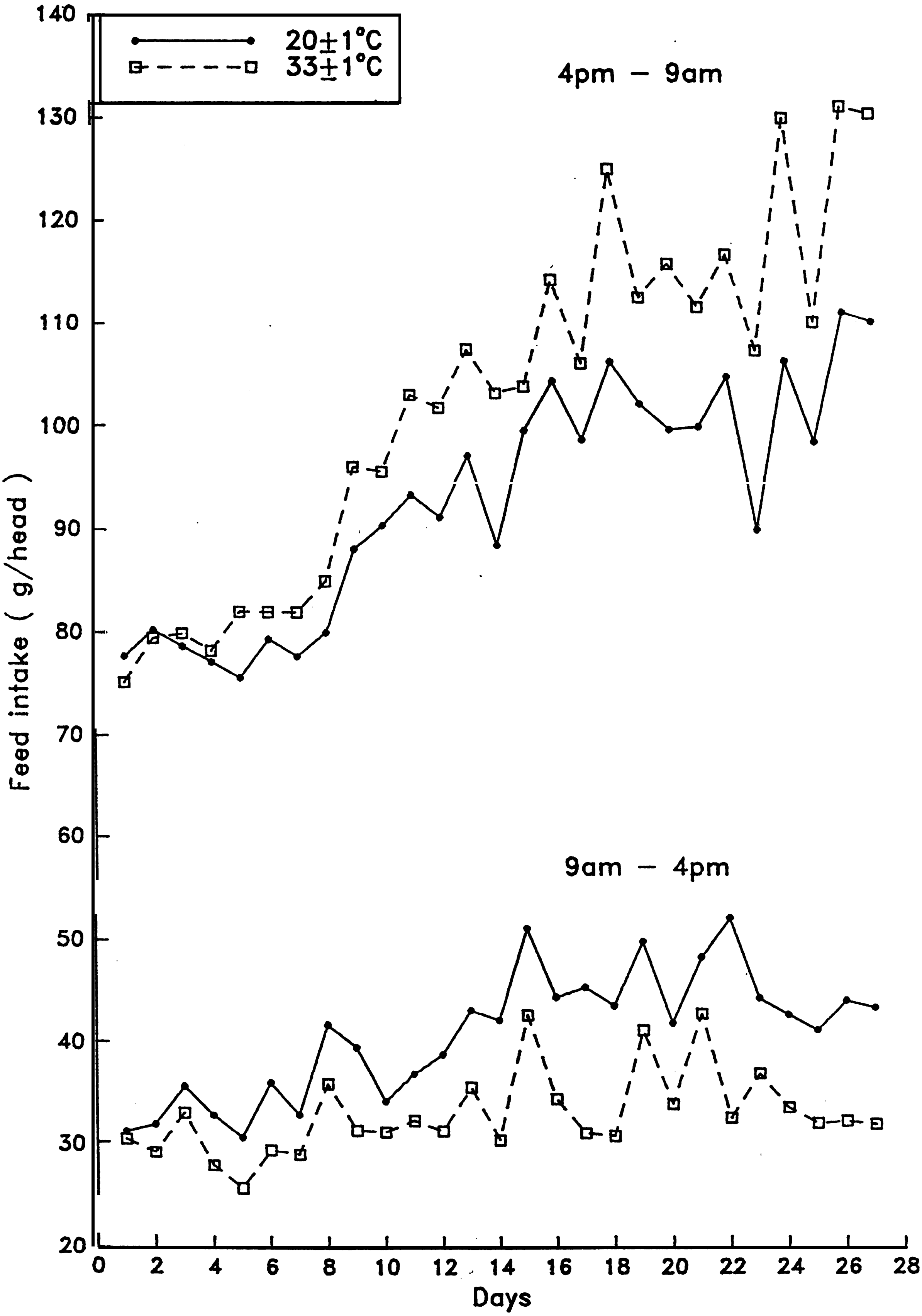

Fig. 1. Daily feed intake (g/bird) of complete diet of broilers housed in constant temperature (●——●) and in a cyclical temperature regimen (□----□) with 24 hours illumination when measured during hot period (9 am - 4 pm) and cool (4 pm - 9 am) period.

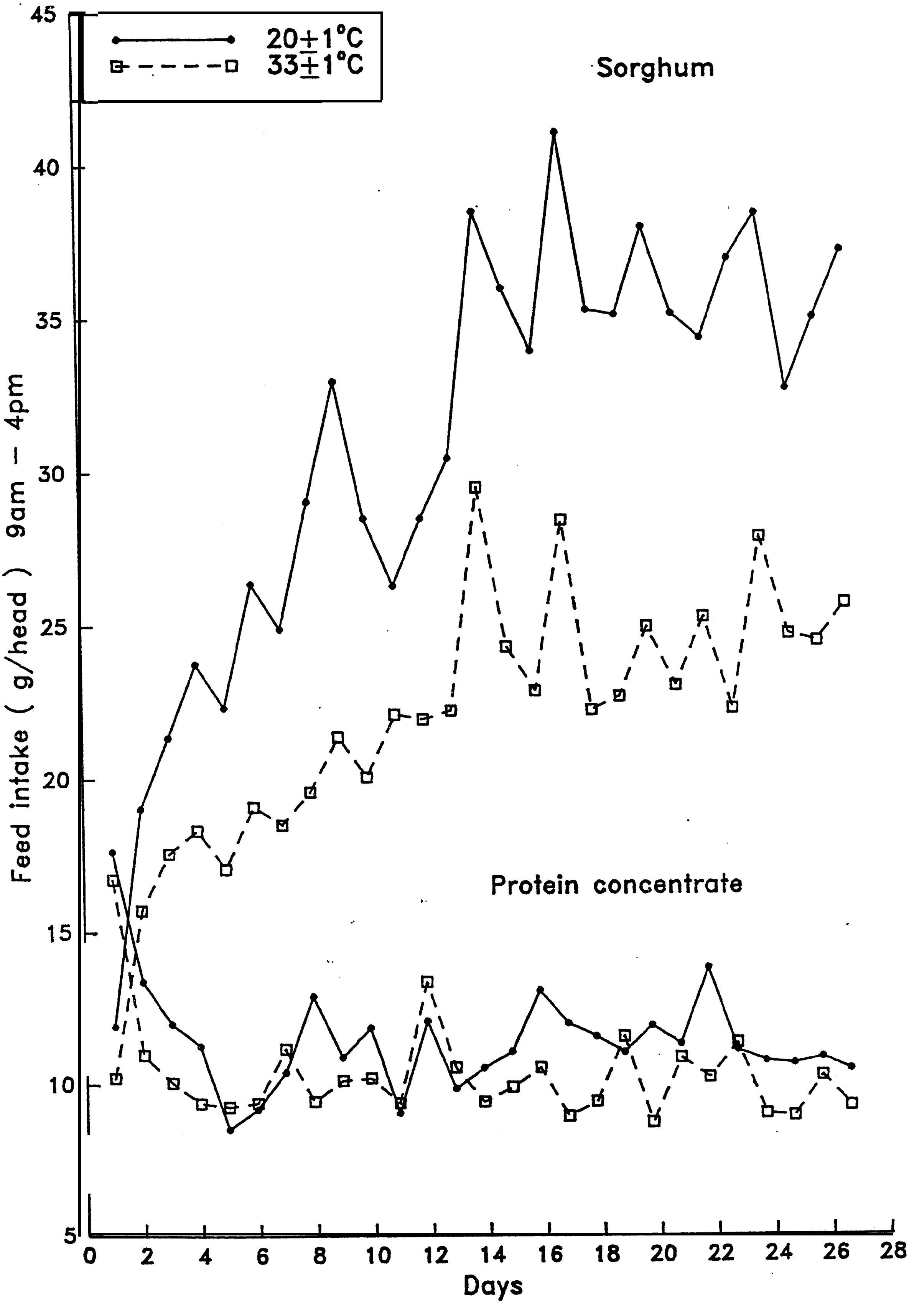

Fig. 2. Daily sorghum and protein concentrate intake (g/bird) of the choice fed broilers housed in constant temperature (●——●) and in a cyclical temperature regimen (□----□) with 24 hours illumination when measured during the hot period (9 am - 4 pm).

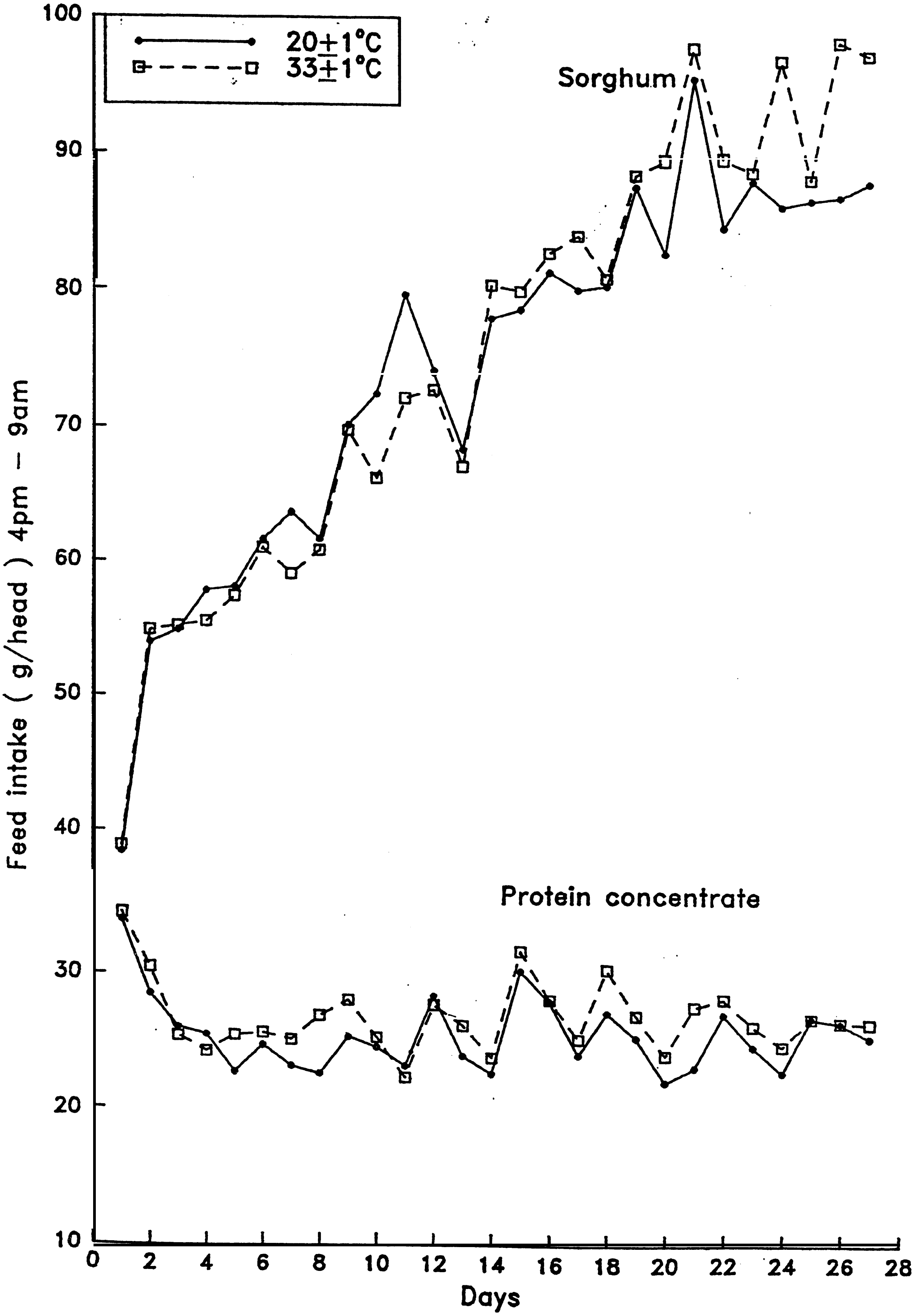

Fig. 3. Daily sorghum and protein concentrate intake (g/bird) of the choice fed broilers housed in constant temperature (●——●) and in a cyclical temperature regimen (□----□) with 24 hours illumination when measured during the cool period (4 pm - 9 am).

Choice fed broilers kept at 20°C consumed 30% more grain than those kept in the cyclical temperature regimen during the hot period (9 am - 4 pm) (Fig. 2), but during the cool period (4 pm - 9 am) the sorghum intake was relatively constant (Fig. 3). The choice fed broilers kept at constant 20°C consumed significantly ($P < 0.05$) more calories than those kept in the cyclical temperature regimen. Overall, the choice fed broilers kept at either a constant 20° or in the cyclical temperature regimen consumed as much protein as their complete diet counterparts (Table 3). Carcass, pad fat or abdominal fat were not affected by either feeding system or room temperature (Table 4).

Table 4 Carcass, fat and organ weight (%) of the choice fed broilers kept in different environments with 24 hours illumination

Treatments		Carcass	Pad fat	Abdominal fat	Heart	Liver	Gizzard+Provent.
20±1°C	Complete	69 a	3.2 a	3.65 a	0.48 a	1.84 a	1.69 a[1]
	Choice	70 a	2.7 a	3.18 a	0.48 a	2.12 b	2.10 b
33±1°C	Complete	70 a	3.1 a	3.46 a	0.43 b	1.95 a	1.62 a
	Choice	70 a	3.3 a	3.98 a	0.43 b	2.14 b	2.09 b

[1]Values in the same column having different letters are significantly different ($p<0.05$)

The hearts of the chickens kept at the constant 20°C room temperature were significantly ($P < 0.05$) heavier than those kept in the cyclical temperature regimen, irrespective of dietary treatment. The livers and gizzards of the choice fed birds were significantly ($P < 0.05$) heavier than those fed a complete diet, irrespective of room temperature.

(b) Experiment 2

Total feed intake of the birds fed either the complete diet or free-choice and kept in the cyclical temperature regimen were reduced by 7.5% compared to those held at constant 20°C (Table 6). Body weights of the chickens fed the complete diets and housed in the cyclical temperature regimen were reduced 3% compared with those similarly fed in the constant 20°C, although this reduction was not significant (Table 5).

Table 5 Performance of choice fed broilers kept in different environments with 16 hours illumination

Treatments		3 week body weight (g)	6 week body weight (g)	Body weight gain (g)	F.C.R.
20±1°C	Complete	481 a[1]	1740 a	1259 a	2.09 a
	Choice	480 a	1761 a	1281 a	2.08 a
33±1°C	Complete	480 a	1689 a	1209 a	2.01 ab
	Choice	480 a	1735 a	1254 a	1.96 b

[1]Values in the same column having different letters are significantly different ($p<0.05$)

Table 6 Feed, protein and calorie intake of the choice fed broilers kept in different environments with 16 hours illumination

Treatments		Feed intake (g)			Protein intake (g)	Calorie intake (MJ)
		Sorghum	Concent.	Total		
20±1°C	Complete	-	-	2628 a[1]	502 a	32.38 a
	Choice	1912	747	2659 a	502 a	32.44 a
33±1°C	Complete	-	-	2429 b	464 b	29.92 b
	Choice	1693	766	2459 b	488 ab	29.72 b

[1]Values in the same column having different letters are significantly different ($p<0.05$)

During the hot period (9 am - 4 pm), broilers kept in the cyclical temperature regimen and fed the complete diet consumed 29% less feed than those kept at constant 20°C (Fig. 4). 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. 5). During the cool period (4 pm - 9 am) the choice fed birds consumed as much sorghum as, and 7% more protein concentrate than, those kept in a constant temperature (Fig. 6).

The uirds kept at the constant 20°C (and fed either a complete diet or free choice) consumed significantly ($P < 0.05$) more calories than those housed in the cyclical tenperature regimen of both the complete and choice diets. The protein consumption in all treatments was similar ($P > 0.05$) (Table 5) except for those kept in the cyclical temperature regimen and fed a complete diet when it was significantly ($P < 0.05$) lower. Overall, the choice fed birds housed in the cyclical temperature regimen converted feed significantly ($P < 0.05$) more efficiently (Table 5) than those housed at a constant temperature and fed either a complete diet or free choice.

Carcass, pad fat or abdominal fat weight and small intestine lengths were not affected by either feeding system or room temperature (Table 7).

Table 7 Carcass, fat and organ weight (%) of the choice fed broilers kept in different environments with 16 hours illumination

Treatments		Carcass	Pad fat	Abdominal fat	Heart	Liver	Gizzard+ Provent.	Intestine length (cm/Kg)
20±1°C	Complete	69 a	2.6 a	3.3 a	0.57 a	2.33 a	1.87 a	82 a[1]
	Choice	70 a	2.7 a	3.4 a	0.54 a	2.51 a	2.47 b	80 a
33±1°C	Complete	70 a	2.7 a	3.2 a	0.48 b	2.20 a	1.86 a	82 a
	Choice	70 a	2.5 a	3.2 a	0.47 b	2.30 a	2.40 b	83 a

[1]Values in the same column having different letters are significantly different ($p<0.05$)

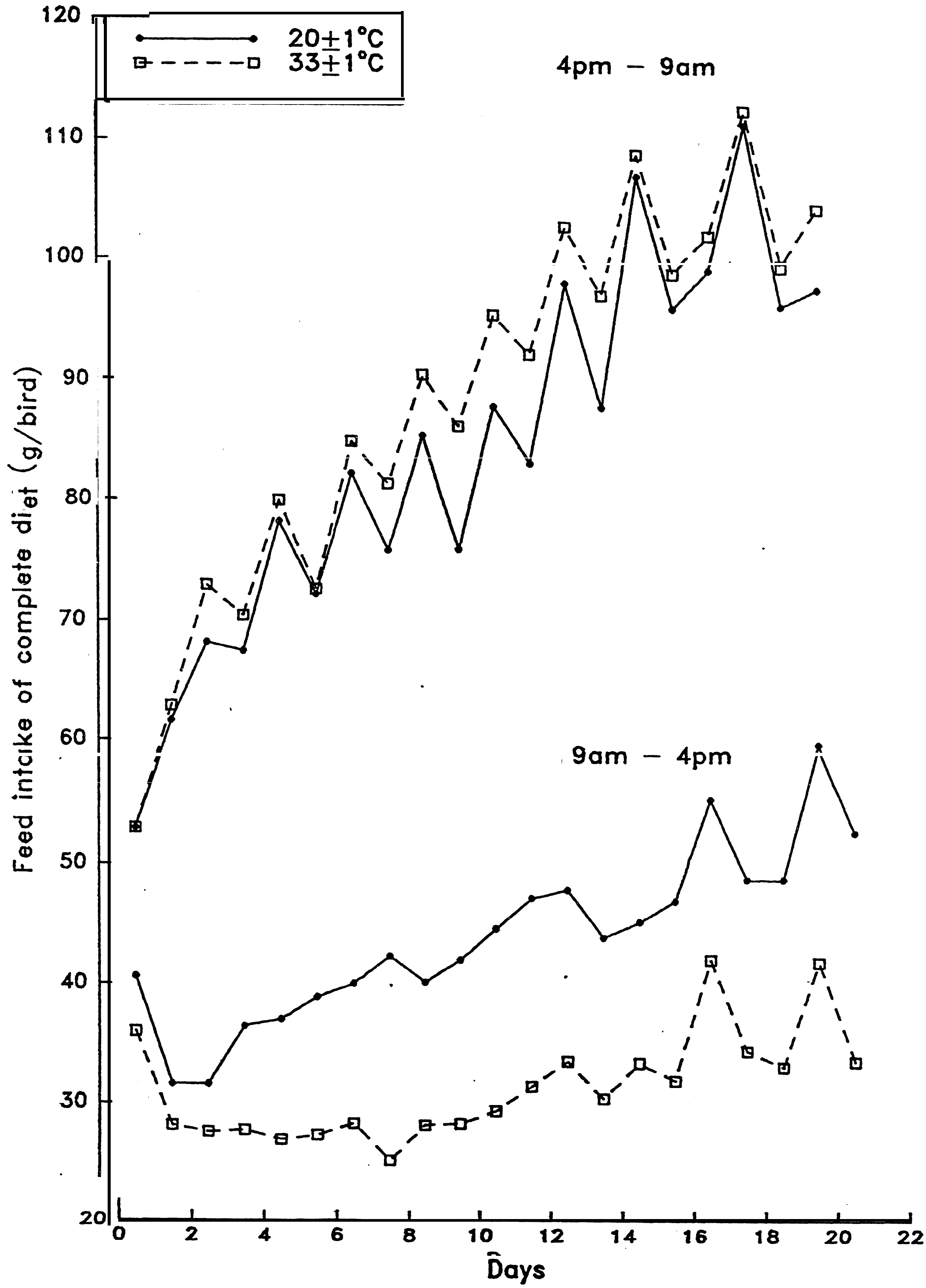

Fig. 4. Daily feed intake (g/bird) of complete diet of broilers housed in constant temperature (●——●) and in a cyclical temperature regimen (□----□) with 16 hours illumination when measured during hot period (9 am - 4 pm) and cool period (4 pm - 9 am).

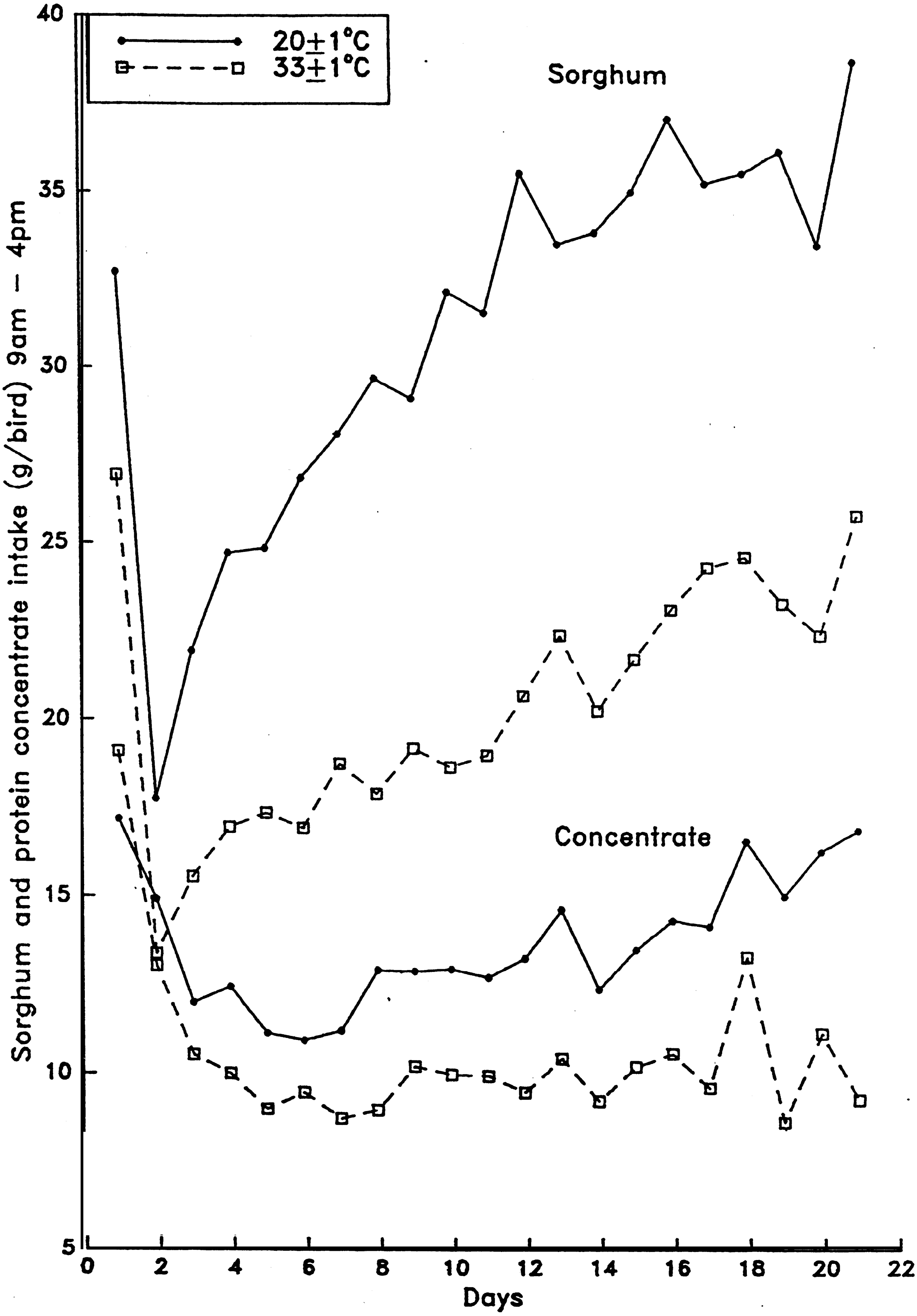

Fig. 5. Daily sorghum and protein concentrate intake (g/bird) of the choice fed broilers housed in constant temperature (●——●) and in a cyclical temperature regimen (□----□) with 16 hours illumination when measured during the hot period (9 am - 4 pm).

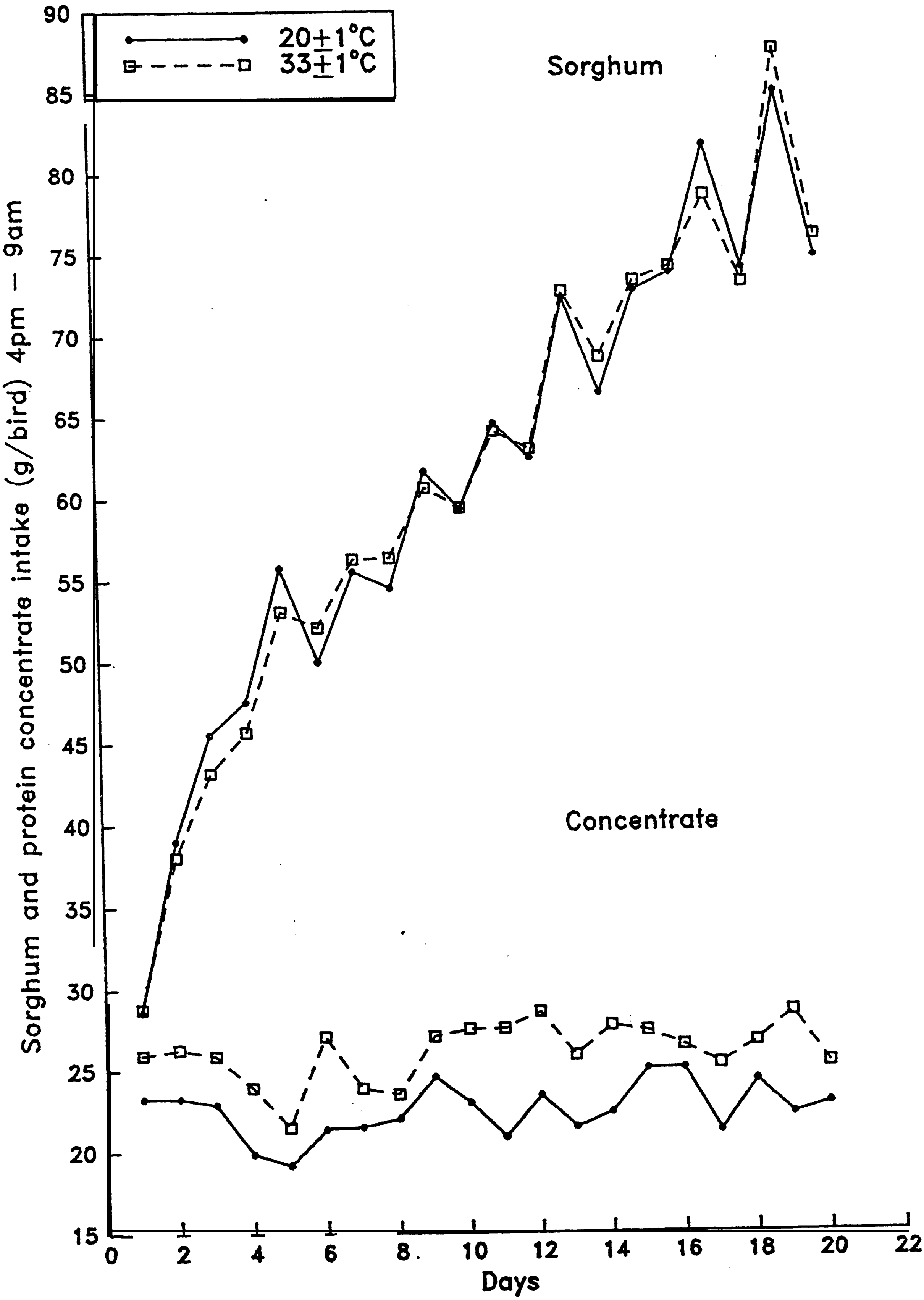

Fig. 6. Daily sorghum and protein concentrate intake (g/bird) of the choice fed broilers housed in constant temperature (●——●) and in a cyclical temperature regimen (□----□) with 16 hours illumination when measured during the cool period (4 pm - 9 am).

Gizzards of the choice fed birds were significantly ($P < 0.05$) heavier than those fed a complete diet. The hearts of the birds kept in the cyclical temperature regimen were significantly ($P < 0.05$) lighter than those kept at constant 20°C.

IV. DISCUSSION

In broiler chickens fed conventional diets the depression of feed intake during hot weather is associated with a depression of body weight (Adam and Rogler, 1968). The results of these experiments suggest that the depression of feed intake which caused loss of weight due to heat stress (33°C from 9 am - 4 pm) may be overcome 'by providing the chickens with continuous light and bringing the room temperature down to 20+1°C for the rest of the 24 hours (Fig. 1). When 16 hours light was provided only from 4 am to 8 pm, al though compensation of feed intake did occur (Fig. 4), it was not sufficient to compensate totally for the depression of feed intake which occurred during the hot period (Fig. 4), resulting in a 3% depression in body weight of broilers fed the complete diet (Table 5).

In both experiments, the choice fed broilers in the cyclical temperature regimen consumed significantly less sorghum (30-34%) during the hot period (9 am - 4 pm) than those kept at a constant 20°C (Figs. 2 and 5). However during the cool period (4 pm - 9 am) (Figs. 3 and 6) the birds in the cyclical temperature regimen consumed as much sorghum as those in the cooler 20°C for the same **period**.

An interesting finding is that the choice fed chickens in the cyclical temperature regimen consumed as much protein as the broilers kept at a constant 20°C. This pattern of feed intake clearly shows that choice fed broil er 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), but further to regulate their protein requirements.

This was most clearly demonstrated in the second experiment where the cho ic e fed broilers reduced their protein concentrate intake by 8% during the hot period, when compared with choice fed birds kept at constant 20 C. During the cool period these birds in the cyclical temperature regimen consumed 7% more protein concentrate than their counterparts kept at a constant 20°C.

The other interesting point is that in the cyclical temperature regimen the choice fed chickens converted feed more efficiently than those fed the complete diet (**Tables** 2 and 5). This is in agreement with the work of Mastika (1981) 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 empties much faster from the gizzard and intestines than choice fed birds eating whole grain (Mastika, 1981). This may result in some nutrients being incompletely absorbed by the chickens, Further McIntosh et al. (1962) reported that whole grains resulted in a higher energy being absorbed by chickens than similar grains fed crushed or pelleted.

The **above** evidence, along with the rapid responses to dietary energy and protein alterations previously described (Mastika and Cumming, 1985) clearly suggest that choice feeding of broilers may have considerable advantages in the field and especially in hot environments.

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