CALORIMETRIC MEASUREMENTS OF CHICKENS SELECTED FOR INCREASED GROWTH, FOOD CONSUMPTION OR FOOD CONVERSION EFFICIENCY

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SUMMARY

Calorimetric measurements were made on male chickens that had been selected for ten generations for increased 5 to 9 week weight gain (line W), increased 5 to 9 week food consumption (line F) and decreased 5 to 9 week FCR (food/gain, line E). A control line selected at random was also measured (line C).

Line differences in growth and food conversion efficiency were due, in part at least, to differences in metabolisability of dietary energy, in net availability of metabolisable energy (NAME) and in maintenance energy requirements. In the four lines W, F, E and C respectively, metabolisability of dietary energy was 0.71, 0.62, 0.70 and 0.68, NAME was 0.68, 0.76, 0.85 and 0.73, and daily maintenance energy requirements were 669, 861, 699 'and 740 kJ ME/kg W.

INTRODUCTION

A knowledge of the underlying effects upon energy metabolism is basic to an understanding of the direct and correlated responses in performance traits to selection for growth or food conversion efficiency. There is, however, a paucity of information on the effect of such selection upon the components of energy metabolism in broiler chickens.

In a previous report (Pym and Farrell 1977) calorimetric measurements were made on broiler chickens that had been selected for three generations for increased liveweight gain, food consumption or food conversion efficiency. An unselected control line was also measured. Line differences in growth rate, feed efficiency and body composition have developed considerably since that study (Pym 1982).

In the study reported here, measurements were made on birds from the tenth generation of the selection experiment using open circuit respiration chambers much larger than the closed circuit chambers used in the previous study.

EXPERIMENTAL PROCEDURE

The selection lines

Birds used in the study were sampled from four lines that had been selected for ten generations for : increased 5 to 9 week liveweight gain (line W), increased 5 to 9 week food consumption (line F), decreased 5 to 9 week food conversion ratio (FCR = feed/gain, line E), or at random (controls, line C). Details of the selection experiment were given by Pym and Nicholls (1979).

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Management of birds in respiration chambers

Following rearing to 35 d of age on a commercial broiler starter diet and transfer then to the broiler finisher selection diet containing 210 g crude protein and 13.0 MJ ME/kg, 16 male birds from each line were weighed and placed in one of the three respiration chambers and calorimetric measurements commenced at 41 d and continued for 3 d.

The three open circuit respiration chambers described by Johnson. and Farrell (1983), were used. A constant sample was continuously taken from the effluent air of each chamber and stored in a 12 ℓ glass cylinder. Initially the cylinder was filled with liquid paraffin and this was pumped into a reservoir at a fixed rate of about 400 ml/h for 22 h. A gas sample was then withdrawn in a gas-tight syringe and analysed on a Haldane analyser. Birds were placed in the chambers 4 d prior to 'commencement of measurements and given either unrestricted amounts of food or an amount calculated to be 70% of their ad *libitum* intake. The control line was included in each run. There were two experimental runs of each pair combination of the selected lines at each of the two feeding levels.

Birds were weighed at the start and finish of each run. Food intake, corrected for spillage, was recorded for the 3 d period and a representative sub-sample of excreta collected daily and stored at $-20^{\circ}C$ prior to freeze drying.

RESULTS

To provide a reference point for line differences in the performance traits, mean initial and final body weights, weight gain, food consumption and FCR measured in male chickens from the four lines during testing of the four hatches of the tenth selected generation are presented in Table 1 below.

TABLE 1   Mean 5 and 9 week body weights and 5 to 9 week body weight gain, food consumption and food conversion ratio (FCR) in male chickens from the four lines under test in generation ten.

			Means and (standard errors)		
Line	5 week wt (g)	9 week wt (g)	5 to 9 week wt gain (g)	5 to 9 week food con- sumption(g)	5 to 9 week FCR
W	547 (6)	1662 (11)	1114 (7)	2743 (19)	2.47 (.01)
F	575 (6)	1581 (14)	1007 (10)	3211 (25)	3.24 (.03)
E	452 (4)	1396 (9)	944 (7)	2127 (15)	2.26 (.01)
C	480 (4)	1288 (8)	808 (6)	2213 (16)	2.77 (.02)

There were significant line differences for all traits.

Differences between the four lines in the performance and metabolic traits measured in the feeding experiments are given in Table 2. On ad *libitum* feeding considerable differences were observed between line F and lines E and C which were similar. The F line ate 60% g more food and produced twice as much excreta as the E and C lines. Metabolisability of dietary energy was, however, considerably higher in lines E and C. Line W was intermediate for most of the traits with the exception of metabolisability, which was high.

Table 2 Performance and metabolic traits measured in groups of 16 male chickens from each of the four lines for three days in the calorimeters when given food either *ad libitum* or restricted to approximately 70% of *ad libitum*.

Means and (standard errors)

Feeding level	Line	n*	Body weight (kg)	Food intake (kg)	Excreta (kg)	Metabol- isability of diet	ME intake (kJ/kgW/d)	Heat production (kJ/kgW/d)	Energy balance (kJ/kgW/d)
ad libitum	W	4	14.26(0.26)	3.46(0.09)	1.054(0.029)	0.71	982 (26)	767 (13)	215 (23)
	F	4	12.71(0.26)	4.46(0.09)	1.653(0.029)	0.62	1275 (26)	960 (13)	315 (23)
	E	4	12.52(0.26)	2.81(0.09)	0.843(0.029)	0.70	913 (26)	733 (13)	180 (23)
	C	5	11.10(0.23)	2.86(0.08)	0.919(0.025)	0.68	1019 (23)	816 (11)	203 (20)
Restr- icted	W	4	12.89(0.15)	2.34(0.03)	0.714(0.010)	0.68	733 (16)	694 (12)	40 (14)
	F	4	12.27(0.15)	3.14(0.03)	1.165(0.010)	0.64	939 (16)	879 (12)	59 (14)
	E	4	11.26(0.15)	1.90(0.03)	0.567(0.010)	0.71	689 (16)	694 (12)	- 5 (14)
	C	6	10.37(0.12)	1.90(0.02)	0.611(0.008)	0.68	725 (12)	736 (9)	-10 (10)

*n = number of experimental runs per line.

Even with body weight differences eliminated, the F line still ate 40% more food, produced 30% more heat and retained 70% more energy in their bodies than the E line. The W and C lines were similar and intermediate.

There were significant linear regression equations relating ME intake to energy balance (measured as the difference between ME intake and heat production) where both were expressed per kg body weight per **day**   The plots for the four lines together with the regression equations are shown in the Figure.

There were significant (*P*<0.001) differences between the lines in intercept and significant difference (*P*<0.05) between lines W and E in slope. The net availability of metabolisable energy (NAME) in the four lines was 0.68 ± .05, 0.76 ± .04, 0.85 ± .06 and 0.73 ± .04 in lines W, F, E and C respectively.

From the above regression equations, daily maintenance energy requirements were calculated to be 669, 861, 699 and 740 **kJ ME/kg** W in lines W, F, E and C respectively.   There were significant (*P*<0.001) differences in intercept for the inverted regression of ME intake on energy balance indicating significant line differences in maintenance energy requirements.   Daily maintenance energy requirements calculated in this manner were 671 ± 15,   866 ±14, 701 ± 13 and 742 ± 11 KJ **ME/kgW** in the W, F, E and C lines respectively.
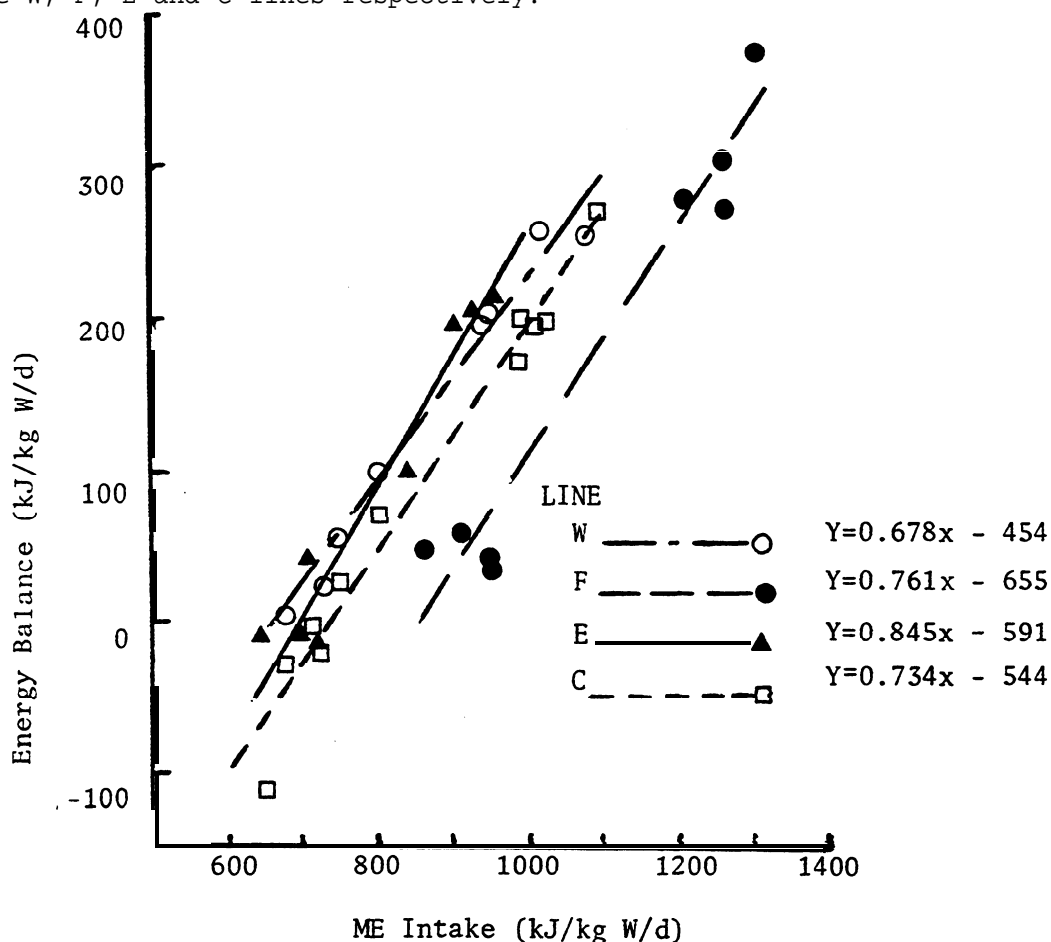

Fig. The relationship between energy balance and
     ME Intake in the four lines.

DISCUSSION

From the responses shown in Table 1, whilst there was considerable correlated increase in food consumption in the W line, the substantial increase in weight gain resulted in a moderate improvement in food conversion efficiency.   In the F line, however, the very large direct response in food consumption swamped the moderate increase in weight gain resulting in a substantial increase in FCR. The considerable improvement in food conversion efficiency in the E line was achieved as a result of a moderate increase in weight gain combined with a slight decrease in food consumption.

The very high FCR obtained in the F line (Table 1) is attributable in some measure to their very low metabolisability of dietary energy and their high maintenance energy requirement.   It is generally held that there is little variation in digestibility or metabolisability of nutrients between different strains or breeds (Blaxter 1968, **Sutherland** et *al.* 1974).   There have been, however, reports of differences in metabolisability of dietary energy between strains and breeds of chickens **(eg.Sibbald** and Slinger 1963) and between lines of chickens selected for divergent 8 week body weight (Proudman et *al.* 1970).   It is interesting to note that there was little difference in metabolisability between the lines at generation three and that the depression in this trait in the F line is only a relatively recent occurrence. It is, however, not surprising that such selection would favour birds with an inability to digest or **metabolise** nutrients.

The higher maintenance requirement in this line must be due, in part at least, to their very poor feathering.   All individuals in this line are now homozygous for ultra-slow feathering, a dominant allele of the sex linked recessive gene k for rapid feathering. Selection for high food consumption in this line has favoured individuals with poor feathering because of the high body heat maintenance requirement.   This line is also considerably fatter than the other lines (Pym and Solvyns 1979) (the E line is leanest) which contributes to their poor food **conversi** on efficiency. Notwithstanding the relatively high efficiency of utilisation of ME for fat deposition (Pym and Farrell 1977) the high energy density of fatty tissue and its low water content means that muscle tissue is deposited at about one third to one quarter the cost of fatty tissue.

Recent results have shown the E line to have superior food conversion efficiency to the W line when measured over a weight constant period corresponding to the **5** and 9 week' weights of the W line. The E line has exhibited this superiority notwithstanding the significantly **increased** time taken to achieve that weight gain.   From the results of the present study it would appear that the only component measured which could contribute **to that** difference is the very much higher **NAME** in the E line.   Since this line is relatively lean compared to the W line, it is difficult to reconcile this difference in NAME given the much higher value for fat than **protein,** (0.89 *cf* 0.66, **Pym** and Farrell 1977).   It may be that protein turnover rate is lower in the E line which would result in an elevated NAME in this line.   A study of protein turnover in the lines using excretion of **3-methyl** histidine is presently underway. Any beneficial effect of a slight saving in

maintenance requirement in the W compared to the C line would appear to be offset by a somewhat lower NAME in the former line.   Given similar fatness in the W and C lines (Pym 1982) the improved food conversion efficiency in the W line (Table 1) would seem to be due largely to an increase in food consumption allowing relatively more energy to be used for growth after maintenance requirements have been met.   Such beneficial effect in the F line has been swamped by their increased fat, poor metabolisability of dietary energy and high maintenance energy requirements associated with lack of feather cover.

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