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GROWTH AND LAYING PERFORMANCE OF MEDIUM-TYPE PULLETS SUBJECTED TO QUANTITATIVE AND QUALITATIVE FOOD RESTRICTION

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OPSOMMING: GROEI EN LÊPRESTASIE VAN GEMIDDELDE TIPE JONGHENNE ONDERWERP AAN KWANTITATIEWE EN KWALITATIEWE VOERBEDEKKING

Die groeitempo van gemiddelde tipe jonghenne is gevarieer deur verskillende kwantitatiewe en kwalitatiewe voerbeperkings toe te pas met die doel om vas te stel watter van hierdie metodes die mees ekonomiese resultate tot gevolg sou hê. Die resultate is gebaseer op voerinname gedurende die groeiperiode, die getal en massa eiers geproduseer, die finale liggaamsmassa en karkasanalise by verskillende stadiums van groei. Die grootmaak-behandelings het 'n kontrole ingesluit waar jonghenne 'n grootmaakdieet tot 7 weke ouderdom het, daarna 'n jonghen ontwikkelingsrantsoen tot 20 weke ouderdom; 'n jonghen ontwikkelingsbehandeling soortgelyk aan die kontrole, maar waar 'n derde lae-proteïendieet gevoer is vanaf 12 weke ouderdom; 'n lae proteïenbehandeling waar proteïenkonsentrasie verlaag is met gereelde en kort tussenposes dwarsdeur die groeiperiode; en 3 kwantitatiewe voerbeperkingsbehandelings so ontwerp om die liggaamsmassa van jonghenne by 6, 12 en 18% benede die kontrole liggaamsmassa by 20 weke ouderdom te verlaag, ontvang het. Die ontwikkelingsprogram het geen voordeel bo die kontrole tot gevolg gehad nie, maar die laeproteïenbehandeling en die kwantitatiewe voerbeperkingsbehandeling was hoogs bevredigend wat betref 'n verlaging in beide voerinname en liggaamsmassa tot 20 weke ouderdom, 'n vertraging in geslagsrypheid en in 'n verbetering van piek eierproduksie en totale eierproduksie. Op die basis van ontwikkelingskoste en lêprestasie was die strengste peil van kwantitatiewe beperking, naamlik 18% benede die volgevoede kontrolegroep, die mees gunstige ontwikkelingsbehandeling van dié wat in die proef gebruik is. Die resultate van die laeproteïenbehandeling was ook baie gunstig en verdere navorsing van hierdie aard is geregverdig op grond van die resultate.

SUMMARY

The growth rate of medium-type pullets was manipulated by various quantitative and qualitative food restriction treatments in order to ascertain which of these methods produced the most satisfactory economic results. The results were based on food intake during the growing period, the number and mass of eggs produced, the final body mass and carcass analyses at various stages of growth. The rearing treatments included a control, where pullets were fed a rearing diet to 7 weeks then a growing diet to 20 weeks of age; a pullet developer treatment similar to the control, but where a third, low protein diet was fed from 12 weeks of age; a low protein treatment, where protein concentration was lowered at regular and short intervals throughout the growing period, and 3 quantitative restriction treatments designed to reduce body mass of pullets by 6, 12 and 18% below the control body mass at 20 weeks of age. The developer programme did not result in any advantage over the control treatment but both the low protein treatment and the quantitative food restriction treatments proved highly satisfactory in reducing both food consumption and body mass to 20 weeks of age, in delaying sexual maturity and in improving peak rate of lay and overall production performance. On the basis of rearing costs and laying performance the most severe level of quantitative restriction, namely 18% below the fully-fed control group, proved the most favourable rearing treatment of those used in this experiment. The results of the low protein rearing treatment were also very favourable, however, and more work of this nature is warranted on the basis of these results.

Many studies have been made on quantitative and qualitative methods of food restriction, and the success achieved in manipulating nutrient intake, thereby controlling body mass and age at sexual maturity, can be measured in terms of laying performance. (Lee, Gulliver & Morris, 1971; Gous & Stielau, 1976).

The protein requirement of growing pullets remains controversial since the inconsistencies of both breed and environment play an important role in the protein level that will give the most satisfactory results. In recent years the tendency has been to rear pullets on low protein diets, or to restrict the intake of a diet which is balanced in respect of protein and other nutrients. (Lee *et al.*, 1971).

Protein, amino acid and energy levels are the important factors which control the density of diets, and the cost of diets used for rearing pullets. Nutrient density affects the growth rate of the pullet, which in turn plays an important role in determining body mass and age at sexual maturity. These 2 factors play a vital role in determining the production potential of the pullet. The object of the present experiment was to compare various protein levels in iso-energetic rearing diets fed *ad libitum*; a conventional rearing treatment; and quantitative food restriction treatments resulting in three levels of body mass restriction.

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Materials and Methods

Rearing treatments

1400 day old medium type pullets (Saunders S101) were reared in a controlled environment house subdivided into 18 floor pens each measuring 4,26 x 4,57 m. Each pen housed 133 pullets. Six treatments (Table 1) with 3 replications per treatment, were randomly allocated to the 18 pens.

Table 1

Treatments and diets fed during rearing

Treatment		Diet	Period fed (weeks)
1	Control	1	0–7
		2	8–20
2	Pullet Developer	1	0– 5
		2	6–11
		3	12–20
3	Low Protein	1	0– 2
		2	3– 4
		3	5– 8
		4	9–20
4	Quantitative Restriction (6% Body mass reduction)	1	0– 5
		5	6–20
5	Quantitative Restriction (12%Body mass reduction)	1	0– 5
		5	6–20
6	Quantitative Restriction (18% Body mass reduction)	1	0– 5
		5	6–20

The diets used in the experiment are shown in Table 2. All diets were computed on an iso-energetic basis. The protein contents of the diets used in Treatment 4 were based on theoretical calculations for growth and maintenance as proposed by Scott, Nesheim & Young (1969). These figures were then related to expected food consumption, resulting in the required dietary protein level. Diet 5, used for quantitative restriction, was similar to Diet 2 (Poultry Growing Mash) except that the levels of vitamins and minerals in Diet 1 were doubled in Diet 5. The coccidiostat level was increased by 20% in Diets 1 and 5.

The quantitative food restriction programme was implemented as follows:

At 6 weeks of age, Groups 4, 5 and 6 were restricted to the amount of food consumed daily during the previous week. Twice this daily amount was allocated to the pullets every second day. From 6 weeks of age body mass was determined weekly of birds on Treatments 1, 4, 5 and 6. A target of 6, 12 and 18% below the body mass of birds on Treatment 1 was set for Treatments 4, 5 and 6 respectively. Whenever the body mass was above the target figure, food allocation remained the same as during the previous week. When body mass was below target, food allocation was increased by 10%.

Table 2

Composition (g/kg) of rearing diets

	1	2	3	4	5
Maize	280	322	357	327	322
Sorghum	160	160	160	160	160
Germ meal	195	195	195	260	195
Wheat bran	147	164	206	140	164
Sunflower meal	100	73	11	–	73
Fish meal	93	54	35	25	54
Monocalcium Phosphate	5	9	11	13	9
Limestone Powder	17,4	18,5	19,5	19,5	18,4
Salt	1	3	4	4	3
Molasses	–	–	–	50	–
Vitamin Premix*	0,5(A)	0,5(B)	0,5(B)	0,5(B)	1,0(A)
Mineral Premix*	0,5	0,5	0,5	0,5	1,0
Coccidiostat	0,6	0,5	0,5	0,5	0,6
Analysis (calculated)					
Protein %	19,0	16,0	13,1	11,5	16,0
Methione %	0,47	0,37	0,25	0,21	0,37
TSAA %	0,77	0,63	0,47	0,42	0,63
Lysine %	0,95	0,72	0,55	0,45	0,72
Tryptophan %	0,23	0,19	0,16	0,13	0,19
Arginine %	1,11	0,90	0,68	0,53	0,90
Fibre %	6,31	6,08	5,50	5,10	6,08
Calcium %	1,20	1,20	1,20	1,20	1,20
Phosphorus ( ) %	0,45	0,45	0,45	0,45	0,45
ME MJ/kg %	11,04	11,04	11,04	11,04	11,04
Food cost/kg (c)	4,371	4,071	3,943	3,586	4,128

*Provides per kg of diet:

Vitamin Premix A: 7024 I.U. Vit. A; 2198 mg pyridoxine; 8,5 mg tocopherol; 2,0 mg Menaphthone; 1,0 mg thiamin; 4,0 mg riboflavin; 7,9 mg calcium plantothenate; 24,7 mg nicotinic acid; 0,3 mg folic acid.

Vitamin Premix B: 7028 I.U. Vit. A; 2180 mg pyridoxine; 1,0 mg menaphthone; 1,0 mg thiamin; 3,0 mg riboflavin; 7,9 mg clacium pantothenate; 19,9 mg nicotinic acid.

***Mineral *Premix*: 4 mg $CuSO_4$; 40 mg $Zn0_2$; 2 mg I; 80 mg MnO_2.

The body mass of all pullets was measured fortnightly when consumption of food was determined.

The pullets were reared on a decreasing light pattern, starting at 16 h and 40 m/day, being reduced by 20 m/week, until a terminal photoperiod of 10 h which represented the natural day length at 20 weeks of age was reached.

A representative sample of 12 pullets per treatment was removed at 2, 13 and 20 weeks of age for analysis of carcass moisture, protein and fat.

A total of 24 birds per pen was transferred at 21 weeks of age to laying cages, where records were kept of egg production, egg mass, body mass and mortality. Due to management difficulties no figures were kept on food consumption during the laying period. The experiment was terminated when the birds reached 54 weeks of age.

Results and discussion

Rearing period to 20 weeks of age

Variates measured during the rearing period are presented in Table 3.

The pullet developer programme (Treatment 2) did not result in any reduction in body mass below the control group (T1). This is due to the increased food consumption by pullets on such a developer programme. The increase in consumption occurred from 6 weeks of age which coincided with the change to the lower protein feed. Lee *et al.*, (1971) showed that when a marginal deficiency in an essential amino acid exists, an increased food consumption is experienced to compensate for such a deficiency. Table 2 indicates such marginal deficiencies for Diets 2 and 3. Once the deficiencies are severe, as in the case of low lysine and very low protein diets food consumption decreases. This is illustrated by comparing food consumption by pullets in Treatments 1 and 3 : low protein feeding resulted in 278 g less food being consumed per pullet than by the controls, this difference being statistically significant ($P < 0,05$). The body mass of pullets on the low protein diet was 15% below that of the controls.

In the quantitative food restriction group (Treatments 4, 5 and 6) growth depression was directly proportional to the level of restriction. Each 5% reduction in food intake resulted in a corresponding reduction in body mass. Consequently, food conversion for Groups 1, 4, 5 and 6 was similar. This is somewhat contrary to what has been reported previously (Lee *et al.*, 1971; Gous & Stielau 1976), since food restriction is believed to result in a better utilisation of food for growth. A possible reason for this deviation is that in the present trial birds were housed in a controlled environment. Due to the lower maintenance requirement, more energy per unit of food consumed was available for growth. The food intake by pullets in Treatment 1 (control) was much lower than would be expected in open houses, with the result that this treatment showed a lower feed conversion than is usually experienced (Lee *et al.*, 1971). The poorest food conversion was noted amongst groups fed the low protein diets. The birds satisfied their maintenance requirements with less protein available for growth, resulting in a higher food intake per unit gain compared with the quantitative restriction treatments (Group 4, 5 and 6).

The feeding costs shown in Table 3 indicate that the developer programme (Treatment 2) is only 2 cents more expensive per pullet to 20 weeks than is Treatment 1. The rearing cost for Group 3 to 20 weeks of age was 6,4 cents per pullet less than for Treatment 1. Low protein feeding resulted in a saving similar to that of a group restricted physically to reach a comparable body mass (Treatment 5). This illustrate that low protein feeds could be used successfully in reducing rearing costs. Mortality for the various treatments showed no statistically significant differences. The coefficient of variation indicates that the variation within treatments was low with respect to body mass and food consumption.

Rearing to 10% production

It is known that age at sexual maturity is affected by restricting the feeding of pullets (Lee *et al.*, 1971; Balnave, 1973; Gous & Stielau, 1976), and consequently this variate was recorded for each of the rearing treatments used in the present experiment. Age at 10% production (hen-day) was used as the criterion to measure sexual maturity. The ages to sexual maturity are shown on Table 4.

Table 3

Rearing results to 20 weeks of age

Treatment		1	2	3	4	5	6	SEM	CV (%)	LSD (0,05)
Body mass	(g)	1 535^{a}	1 548^{a}	1 311^{c}	1 409^{b}	1 340^{c}	1 254^{d}	15,53	1,11	28,3
Body mass change	(%)	0	+ 0,8	– 14.6	– 8,2	–12,7	18,3		–	
Food consumed	(g)	8 029^{b}	8 345^{a}	7 751^{c}	7 315^{d}	7 015^{e}	6 618^{f}	103,60	1,38	188
Feed conversion		5,23^{c}	5,42^{b}	5,91^{a}	5,20^{c}	5,23^{c}	5,27^{c}	0.05	0,95	0.10
Feed Cost/pullet	(c)	46,5^{b}	48,5^{a}	40,1^{d}	42,7^{c}	40,9^{d}	38,8^{e}	0,61	1,41	1.1
Mortality	(%)	2,8	1,9	1,6	3,0	1,9	3,5	1,03	42.0	NS

a, b, c etc., = values with same superscript in each row do not differ significantly ($P < 0,05$)

SEM = Standard Error of treatment means

CV = Coefficient of variation (%)

LSD = Least significant difference between 2 treatment means

Table 4

Rearing results to 10 per cent production

Treatment	1	2	3	4	5	6	SEM	CV (%)	LSD
Age at sexual maturity (days)	159,6[a]	158,9[a]	170,0[d]	163,7[b]	167,0[c]	170,2[d]	2,16	1,31	2,60
Body mass at sexual maturity (g)	1 765	1 727	1 742	1 732	1 695	1 701	60,62	3,51	NS NS
Gain/bird day 20 weeks to sexual maturity (g)	11,7	11,0	14,2	13,1	13,2	14,8	2,16	16,6	NS NS
Food consumption day old to sexual maturity (g)	9 746[bc]	9 940[b]	10 526[a]	9 569[dc]	9 544[d]	9 403[d]	225,12	2,30	269,0
Food consumption/ bird day, 20 weeks to sexual maturity	87,6[b]	84,4[a]	92,6[c]	94,1[c]	93,3[c]	93,2[c]	1,64	1,80	2,01
Food cost/pullet to sexual maturity (cents)	57,6	58,8	58,0	57,3	57,3	56,6	0,70	1,22	NS

a, b, c; SEM; CV; LSD : See footnote to Table 3

Age at sexual maturity was reached simultaneously by pullets on Treatments 1 and 2. Quantitative restriction, however, resulted in a delay in sexual maturity, compared with Treatment 1 of 4,1; 7,4 and 10,6 days for treatments 4,5 and 6 respectively. This indicates that for every 10% body mass restriction to 20 weeks of age, a delay of between 5 and 6 days in sexual maturity can be expected, confirming findings of Lee *et al.*, (1971), Balnave, (1973) and Gous & Stielau (1976). The low protein diet (Treatment 3) which resulted in a 15% reduction in body mass at 20 weeks of age caused pullets to reach sexual maturity at the same time as the group restricted quantitatively by 18% (Treatment 6).

Body mass of pullets at 10% production showed no significant differences between treatments, neither did the daily gain in body mass from 20 weeks to sexual maturity. It should, however, be noted that compensatory growth occurred in Treatments 3, 4, 5 and 6 during the period 20 weeks to sexual maturity. The differences in body mass of pullets at 20 weeks and at sexual maturity for Treatments 1 to 6 were 230, 179, 431, 323, 355 and 447 g respectively.

Sexual maturity is therefore related to body mass, and it appears that laying will commence only when a particular body mass is reached.

When daily consumption per bird is calculated for the period 20 weeks to 10% production, the birds on low protein diets and those quantitatively restricted to 20 weeks of age consumed more food than did the control group. Due to the increased food consumption and delay in maturity, no differences existed in feeding costs from day old to 10% production. Feeding cost to onset of production was therefore not affected by food restriction. The delay in maturity caused an increase in food consumption to this period, thereby nullifying earlier gains.

Carcass analysis

The chickens removed at 2, 13 and 20 weeks of age were killed and their body mass was measured. The loss in mass over a 7 day period in a forced draught oven at 95°C served as the measurement of body water content. Dried carcasses were then minced, and protein and fat determinations were performed on this material, using the method of du Preez, Wessels, Stokoe and van der Merwe, (1971). The results of these analyses are presented in Table 5.

In all cases there was a decrease in body water content and an increase in body fat content as the pullets aged. At 2 weeks of age the carcass protein content was lower than at 13 or 20 weeks of age, this value being constant at the latter two ages.

By 13 weeks of age the dietary treatment had not exerted any effect on the protein content of the pullet, though fat content showed a tendency to decrease with an increased severity of body mass restriction. These differences were, however, not statistically significant. Body water content increased as the body fat decreased, illustrating the negative correlation between body water and body fat content (Gous, 1972; 1975).

Quantitative food restriction from 6 weeks of age resulted in birds having a reduced body fat content at 20 weeks of age with a simultaneous increase in body water content as the severity of restriction increased. The low protein feeding regime (Treatment 3) fed *ad lib.* reduced the body fat content compared with the control but not to the same extent as did quantitative

Table 5

Carcass analysis of pullets at 2, 13 and 20 weeks of age

Age	Treat-ment	Carcass water (%)	Carcass protein (%)	Carcass fat (%)
2 weeks		69,97	16,05	8,65
13 weeks	1	64,44[a]	20,54[a]	10,01[a]
	2	65,02[a]	20,38[a]	9,56[a]
	3	64,51[a]	19,98[a]	10,29[a]
	4	64,49[a]	19,80[a]	11,20[a]
	5	66,83[a]	20,00[a]	8,21[a]
	6	66,12[a]	20,23[a]	8,75[a]
SEM		1,82	0,50	2,08
CV (%)		3,00	2,47	21,49
20 weeks	1	60,11[a]	20,65[a]	14,35[c]
	2	60,50[a]	20,50[a]	14,25[c]
	3	62,90[a]	20,09[a]	11,07[b]
	4	63,43[a]	21,45[a]	9,33[ab]
	5	64,10[a]	20,72[a]	8,27[a]
	6	65,40[a]	20,60[a]	8,23[a]
SEM		2,55	1,19	1,58
CV (%)		6,10	5,17	13,66

a, b, c; SEM: CV : see footnote to Table 3

restriction. Treatments 3 and 5 had the same boy mass at 20 weeks of age (Table 3) but at that stage carcasses of pullets on the low protein feeding regime (Treatment 3) contained about 2% more fat than did the quantitatively restricted group (Treatment 5).

It is clear that quantitative restriction, as well as the feeding of low protein diets during rearing does not affect the carcass protein content of pullets. At 20 weeks of age food restriction does, however, result in a significant reduction in body fat content, this reduction being related to the degree of restriction. This results in a simultaneous increase in carcass water content. The above observations support the results obtained by Gous (1972) on broiler breeder replacement pullets.

Distribution of individual body mass

The individual body mass of 100 birds per treatment was measured at 20 weeks of age, to determine the degree of variation of body mass from the mean of each treatment. The results are presented in Table 6.

The distribution of body mass in Table 6 indicates that all the food restriction treatments caused greater uniformity among pullets than the fully-fed treatments. This greater uniformity in body mass, and hence sexual maturity, is responsible for the higher peak-lay achieved by restricted pullets during the laying period.

Laying performance

Table 7 presents the average egg mass at 10% production, the mass of the first 100 eggs and the egg mass at 30 weeks of age.

Initial egg size apparently increased as a result of the delay in sexual maturity due to the feed restriction programme. This increase in egg size was, however, not statistically significant. At 30 weeks of age, the average individual egg mass for the restricted birds was lower than that of the control group, the egg mass difference between the 2 groups being, however, much less (1,7 g) than at sexual maturity (2,8 g).

Egg size is a function of the chronological age of the bird rather than the state of its physiological development or rate of lay (Gous, 1975). Differences in egg size are due to differences in maturity. This concept is confirmed by the mean egg mass at 10% production. The progressive increase in egg size as the sexual maturity of the pullets is delayed is due to the

Table 6

Deviation of individual body mass from the mean

Treatment	Mean body mass (g)	Deviation from mean (per cent)						
		-26 and more	-16 to -25	-6 to -15	± 5	+ 6 to +15	+16 to +25	+26 and more
1	1 535	0	4	27	39	22	8	0
2	1 548	0	3	38	35	19	4	1
3	1 311	1	14	32	33	12	7	1
4	1 409	0	4	32	35	22	6	1
5	1 340	0	5	27	40	22	5	1
6	1 254	0	3	25	43	24	3	2

Table 7

Mean egg mass at 10 per cent production, mass of first 100 eggs produced, and mean mass of eggs at 30 weeks of age

Treatment	Egg mass at 10% (g)	Mass of first 100 eggs (g)	Egg mass at 30 weeks of age (g)
1	43,7[a]	4 625[a]	56,2[a]
2	45,1[a]	4 632[a]	56,1[a]
3	46,1[a]	4 771[a]	56,1[a]
4	46,5[a]	4 614[a]	54,9[a]
5	46,5[a]	4 711[a]	54,4[a]
6	46,3[a]	4 728[a]	54,7[a]
SEM	1,78	110,99	1,11
CV (%)	3,89	2,37	2,00

a; SEM; CV : see footnote to Table 3

restricted feeding programme during rearing. The increase in egg size was however, not statistically significant. There is a general increase in the total mass of the first 100 eggs as maturity is delayed, these results being a consequence of the increasing mean egg mass.

Egg production data to 378 days of age are presented in Table 8 together with the age at which peak production was reached. The production of eggs to 54 weeks of age indicated very little difference due to rearing treatment. Treatment 6 did produce more eggs than the other treatments, but this was not statistically significant. In general, peak rate of lay increased progressively as sexual maturity was delayed. The most severe food restriction programme (Treatment 6) reached the highest peak production (83,2% hen-day).

The peak productions recorded can be positively correlated with the degree of uniformity in body mass at 20 weeks, as this has been shown to be responsible for the higher peak production (Lee *et al.*, 1971; Balnave, 1973). The restriction treatments all showed greater uniformity (Table 6) than the fully-fed pullets at 20 weeks of age, and this was responsible for the subsequent higher peak rates of lay reached by the restricted treatments.

In order to establish whether the increase in peak production was maintained over the entirely laying period of 34 weeks, the production over the last 4 weeks (i.e. 50 to 54 weeks of age) was calculated and defined as the terminal rate of lay. These data (Table 8) confirm a higher rate of lay for restricted birds. A correlation coefficient of 0,843 was obtained between age at 10 % production and production at 52 weeks of age. The linear regression equation for these data is:

$$Y = -21{,}5 + 0{,}54\,X$$

where Y = production at 54 weeks (%)

and X = age at 10% production (days)

The data in this experiment illustrate that birds maturing at 170 days lay at a rate 5,4% higher at 52 weeks of age than pullets maturing at 160 days. From the above equation, therefore, a delay of 10 days at sexual maturity (160 vs 170 days) could be expected to result in an increased peak production of 3,8% and an increased rate of lay at 52 weeks of age of 5,4%.

It should, however, be remembered that the lighting pattern during rearing and lay, different breeds, seasons and management will affect maturity and production. These data are therefore applicable to the conditions in this experiment only and need not be similar under different conditions.

On the basis of rearing costs and laying performance the most-severe level of restriction, namely, 18% below the fully-fed control group, would appear to be

Table 8

Egg production to 54 weeks of age; age at peak production; peak and terminal rates of lay and body mass at 42 weeks of age

	Treatment							
	1	2	3	4	5	6	CV (%)	SEM
Hen-day production (%)	65,7[a]	67,2[a]	65,4[a]	66,2[a]	66,5[a]	70,2[a]	4,41	2,95
Peak rate of lay (%)	78,3[a]	77,9[a]	81,2[a]	78,2[a]	78,8[a]	83,2[a]	4,98	3,97
Terminal rate of lay at 52 weeks (%)	65,5[a]	65,8[a]	69,0[a]	66,0[a]	71,5[a]	73,0[a]	4,01	3,00
Age at peak (days)	217[a]	224[a]	243[a]	236[a]	229[a]	243[a]	4,11	9,53
Body mass at 42 weeks of age (g)	2 184[a]	2 181[a]	2 092[a]	2 186[a]	2 076[a]	2 110[a]	3,71	79,81
Mortality 20–54 weeks (%)	0[a]	2,8[a]	1,4[a]	2,8[a]	1,4[a]	0[a]	–	–

a; SEM; CV : see footnote to Table 3

the most favourable rearing treatment of those used in this experiment. On the basis of published results (Gous, 1975) it would appear that an even greater degree of restriction might be more advantageous than the 18% used here. Future experiments should investigate more-severe quantitative restriction treatments, as well as a low protein dietary treatment such as that used in the present experiment which proved to be worthy of future investigation.

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