Quantitative feed restriction of Pekin breeder ducks during the rearing period and its effect on subsequent productivity

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Six male and 24 female Pekin ducks per pen were randomly allocated to 12 pens to test the effects of quantitative feed restriction during the rearing period on subsequent reproductive performance. The feed treatments during the rearing periods were *ad lib.*; 80% of *ad lib.*; 60% of *ad lib.*; and 40% of *ad lib.* with three replicates of each treatment. During the laying period a duck breeding diet was fed *ad lib.* to all groups.

As the degree of quantitative feed restriction during the rearing period increased: (i) Body mass at 22 weeks of age decreased, these differences becoming negligible at 62 weeks of age; (ii) feed intake to 22 weeks of age was lowered, the reduction in intake being proportional to the degree of restriction; (iii) the number of days to sexual maturity was delayed, resulting in an increase in average egg mass; (iv) the percentage fertility and hatchability of eggs set increased; (v) the mortality during the laying period decreased; (vi) significant differences were found between treatments with regard to carcass moisture and carcass fat. There were also significant differences between treatments in respect of the adjusted and unadjusted viscera masses giving some idea of the physiological phenomena that accompany feed restriction; and (vii) the economic advantage of restriction increased.

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Ses manlike en 24 vroulike Pekin-eende per hok is ewekansig aan 12 hokke toegewys, om die effek van kwantitatiewe voerbeperking op die daaropvolgende reproduksie-periode te toets. Die voerbehandelings gedurende die groeiperiode was *ad lib.*; 80% van *ad lib.*; 60% van *ad lib.*; en 40% van *ad lib.*; met drie herhalings van elke behandeling. Gedurende die lêperiode is 'n teeltdieet vir eende *ad lib.* aan al die groepe gevoer.

Soos die kwantitatiewe voerbeperking gedurende die grootmaakperiode verhoog is, het: (i) Liggaamsmassa op 22-weke-ouderdom verminder. Hierdie verskille was op 62-weke-ouderdom nie meer beduidend nie; (ii) die voerinname tot 22-weke-ouderdom verminder. Die afname in voerinname was proporsioneel tot die graad van beperking; (iii) die aantal dae tot geslagsrypheid verminder, wat 'n verhoging van gemiddelde eiermassa teweeggebring het; (iv) die persentasie vrugbaarheid en uitbroeibaarheid van eiers gelê verhoog; (v) die mortaliteit gedurende die lêperiode verminder; (vi) betekenisvolle verskille tussen behandelings voorgekom vir karkasvog en karkasvet. Daar was ook betekenisvolle verskille tussen behandelings betreffende die aangepaste en nie- aangepaste visceramassa wat 'n aanduiding gee van die fisiologiese-verskynsel wat saamhang met voerbeperking; en (vii) die ekonomiese voordeel van voerbeperking verhoog.

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Introduction

Various methods of restricting the feed of broiler breeding stock have been employed to improve their reproductive performance. However, according to Lee, Gulliver & Morris (1971a), one of the most successful ways of reducing nutrient intake of growing pullets is by quantitative feed restriction. Other methods such as restricting the birds' access to food are unsatisfactory according to Lee *et al.* (1971a), as the birds quickly learn to eat normal quantities of feed in a short time.

Earlier work by Olver, Kuyper & Mould (1978) on the quantitative feed restriction of Pekin breeder ducks showed: A reduction of total feed intake per duck proportionate with the amount of feed restriction applied during the rearing period; a delay in sexual maturity (50% production) according to the degree of feed restriction during the rearing period resulting in an increase in average egg mass; and increased fertility and hatchability of incubated duck eggs owing to restricted feed intake. The present study was aimed at verifying these earlier claims with a larger experiment consisting of three replications per treatment.

Procedure

Pekin breeder ducklings from the Cedara strain were used in the experiment. From day-old to 2 weeks of age the ducklings were fed a commercial crumbled broiler starter diet. From 2 – 7 weeks of age a commercial pelleted broiler finisher diet was fed. At 7 weeks of age the mass of the ducklings was measured and they were wing-banded and randomly allocated to one of the 12 pens. These pens were open-sided deep litter pens measuring 7 m × 6 m and were used for housing the ducks for the duration of the experiment from 7 – 62 weeks of age. Six male and 24 female ducks were used per pen.

Treatments were randomly allocated to the different pens. The feed treatments during the rearing period (7 – 22 weeks) were (i) *ad lib.*; (ii) 80% of *ad lib.*; (iii) 60% of *ad lib.*; and (iv) 40% of *ad lib.* There were three replicates of each treatment. The diet fed during the rearing period was a pelleted 14% protein commercial diet. The amount of feed required for the restricted groups was calculated from the *ad lib.* consumption during the previous 7-day period and the restricted birds were fed on alternate days. Starting at the end of the rearing period, a commercial 19% protein pelleted duck breeders' diet was fed *ad lib.* to all groups to the end of the laying and breeding period at 62 weeks of age. The body mass of the ducks was measured every second week until the termination of the experiment at 62 weeks of age. Feed consumption was measured weekly throughout the experiment.

Daily egg production records were kept for each pen, involving an egg count, the mass of each egg, and a record of the number of eggs in each of four classes graded according to egg mass. Since there are no officially specified size categories laid down for duck eggs in this country, the following masses were used: Extra large, >89 g; large, 80 – 89 g; medium, 70 – 79 g; and small, <70 g.

All the duck eggs were incubated at weekly intervals in a forced draught Mayfair incubator at 37,5°C and 75% RH. The eggs were turned five times a day and on the 24th day the eggs were transferred to the hatching trays in the same incubator. The hatch was taken off on the 29th day. Egg numbers, infertile eggs, fertile eggs, dead embryos, and ducklings hatched were recorded for each of the 12 pens.

At the same time as the six male and 24 female ducks were placed in the 12 pens, ten male ducks were placed in five other smaller pens measuring 4 m × 3 m. The male ducks were fed (i) *ad lib.;* (ii) 80% of *ad lib.;* (iii) 60% of *ad lib.;* (iv) 40% of *ad lib.;* and (v) 20% of *ad lib.* The male ducks were fed measured allowances of feed equivalent to 80, 60, 40 or 20% of that consumed by the *ad lib.* fed males. The allowances were calculated from the *ad lib.* consumption during the previous 7-day period and were fed on alternate days. The restriction to 20% of *ad lib.* treatment was found to be too severe and was discontinued after the 16th week. It was obvious from the state of the drakes that they would not live much longer at this rate of restriction, so they were fed *ad lib.* and allowed to recover. The results of this level of restriction are thus omitted from the results.

At 22 weeks of age, six males were randomly selected from each of the four treatments and killed by dislocation of the neck. Three drakes per treatment were dissected to remove the intestines, heart, liver, and gizzard for weighing and measuring. The remaining three drakes per treatment were ground — including feathers — into a smooth paste before sampling for moisture and fat content.

Analysis of variance procedures followed that of Rayner (1967).

Results and Discussion

Body mass

The average body masses at 7, 22, 28, and 62 weeks of age are shown in Table 1.

As the ducklings were randomly allocated to the 12 pens the body mass results showed no significant differences at 7 weeks of age as expected. At 22 weeks of age, however, highly significant ($P \leqslant 0{,}01$) differences were observed in body mass between the treatments. These results were similar to those of the earlier study (Olver *et al.*, 1978) except that the earlier study showed no significant differences between the *ad lib.* and 80% of *ad lib.* group. Since there were no replications per treatment in the earlier study, more confidence can be placed in the results of the new trial. Ducklings on the 40% of *ad lib.* treatment were on average 364 g lighter at 22 weeks than they were at 7 weeks. This loss was also noticed in the earlier study (Olver *et al.*, 1978) except that the loss was not as great (223 g). This gave a percentage loss in mass from the 7-week mass of 16 and 12 for the present and 1978 experiment respectively. These large losses in average mass during the rearing period appeared rather drastic, but no mortality was observed in any treatment during the rearing period. This was probably because extra feeding space was provided for the restricted groups so that all the ducks could feed at the same time during the feeding period.

Live body mass as a percentage of the *ad lib.* treatment at 22 weeks is also shown in Table 1. The body mass of the ducklings on the 80, 60, and 40% of *ad lib.* treatments were 89,6; 73,5; and 55,9% respectively of those ducklings fed *ad lib.*. These figures were lower than the 95, 78, and 59% obtained with a lighter strain of Pekin ducks in the 1978 study. However the figures obtained in the present study are almost identical to those obtained by Pym & Dillon (1974) with broiler breeder pullets. These researchers fed the same levels of restriction namely 80, 60, and 40% of *ad lib.* and obtained body masses expressed as a percentage of birds fed *ad lib.* of 90, 72, and 55% respectively.

At 28 weeks of age after only 6 weeks on the *ad lib.* breeding diet the average mass differences obtained at 22 weeks had almost disappeared. Although the ducks fed restricted diets during the rearing period were still lighter than the *ad lib.* group, the gap was much less. The *ad lib.* group ducks were on average 211 g heavier than the 40% of *ad lib.* group at 28 weeks compared to the 1415 g difference at 22 weeks. From 22 – 28 weeks of age, the percentage increase in mass for the *ad lib.*, 80, 60, and 40% of *ad lib.* groups was 2, 11, 24, and 42% respectively.

At 62 weeks of age there were no significant differences in average body mass between the *ad lib.* and the restricted groups although the restricted ducks obtained final body masses which approached those of the *ad lib.* group but did not exceed them. The 40% of *ad lib.* rearing treatment still provided the lighter ducks at the termination of the experiment and this was also noticed in the 1978 experiment (Olver *et al.*, 1978). Pym & Dillon (1974) working with broiler breeders also found that the birds restricted during the rearing period but fed *ad lib.* during the laying period were marginally lighter at 62 weeks of age than those fed *ad lib.* Thus one can conclude that treatments during the rearing period did not affect the body mass of the ducks at the end of the experiment.

Food consumption

Food consumption of the ducks on the different rearing treatments is shown in Table 2.

From 7 – 22 weeks of age the feed consumed by the duck-

Table 1 Body mass of ducks during the experiment

Treatment	Body mass (g) 7 Weeks	22 Weeks	28 Weeks	62 Weeks	Body mass at 22 weeks as % of fully fed
Ad lib.	2152[a]	3209[d]	3280[b]	3239[a]	100
80%	2164[a]	2874[c]	3229[b]	3190[a]	89,6
60%	2156[a]	2359[b]	3124[a]	3218[a]	73,5
40%	2158[a]	1794[a]	3069[a]	3140[a]	55,9

[a,b,c,d] Results not bearing same letters in columns are significantly different ($P \leqslant 0{,}01$)

Table 2 Average food consumption figures of the ducks at different periods during the experiment

Treatment	Food consumption per duck (kg) 7 – 22 Weeks	50% production	22 – 28 Weeks	22 – 62 Weeks	7 – 62 Weeks	Food consumed from 7 – 62 weeks as % of fully fed	Cost of feed per duck (R)
Ad lib.	20,5^{d}	31,2^{d}	7,6^{a}	53,4^{a}	73,9^{d}	100	18,48
80%	16,4^{c}	26,7^{c}	8,5^{b}	53,9^{a}	70,3^{c}	95,1	17,56
60%	12,3^{b}	24,2^{b}	9,5^{c}	55,5^{b}	67,8^{b}	91,7	16,95
40%	8,2^{a}	21,3^{a}	11,0^{d}	56,8^{b}	65,0^{a}	87,9	16,25

^{a,b,c,d} Results not bearing the same letters in columns are significantly different ($P \leqslant 0,05$)

lings on the different restriction treatments were significantly different ($P \leqslant 0,05$) from each other. This can be expected as the ducks were given a quantitative amount of feed at this time. At sexual maturity (50% production) significant differences ($P \leqslant 0,05$) between treatments were also observed. The 40% of *ad lib.* ducks reached sexual maturity on almost 10 kg less feed than did the *ad lib.* group. Similar results were obtained by Olver *et al.* (1978) except that the 40% of *ad lib.* group only consumed 4,24 kg less feed than the *ad lib.* group. Lee *et al.* (1971b) also found a stepwise decrease in the amount of feed needed for broiler breeder pullets to reach 50% production as the severity of the restriction during the rearing period increased.

The ducks which had been restricted during the rearing period and were then allowed *ad lib.* feed from 22 weeks of age, showed compensatory food consumption for the following 6 weeks. This compensatory food consumption was significantly different ($P \leqslant 0,05$) between treatments and this compensation was proportional to the degree of restriction during the rearing period. The *ad lib.* ducks showed no change in feed consumption whereas the 80, 60, and 40% of *ad lib.* groups ate a larger amount for 2, 4, and 6 weeks respectively before leveling out until the end of the experiment at 62 weeks.

The food consumed per duck during the laying period (22 – 62 weeks) showed significant differences between the *ad lib.* and 60 and 40% of *ad lib.* groups and also between the 80% of *ad lib.* group and the 60 and 40% of *ad lib.* groups, but no significant differences between the *ad lib.* and 80% of *ad lib.* or between the 60 and 40% of *ad lib.* levels. This is probably due to the compensatory food consumption that occurred during the 4 to 6 weeks after the restricted birds were fed *ad lib.* Lee *et al.* (1971b) found no significant differences between the food intakes of the birds during the laying period, although these birds had been restricted by 85 and 70% of *ad lib.* respectively during the rearing period. Pym & Dillon (1974) stated that significant differences in food intake during the rearing period probably only occurred in broiler breeder pullets restricted more severely than 70% of *ad lib.* during the rearing period. This certainly applied to the ducks in the present experiment as both the 60% of *ad lib.* group and the 40% of *ad lib.* group showed significant differences. The relative increase in food consumption during the laying period of broiler pullets fed 80, 60, and 40% of *ad lib.* respectively in the experiment of Pym & Dillon (1974) was approximately 1,9; 5,8; and 8,9% respectively. In the present duck experiment the relative increase in feed consumption of the 80, 60, and 40% of *ad lib.* ducks were 0,9; 3,9; and 6,4% respectively. From 7 – 62 weeks of age there were also significant differences ($P \leqslant 0,05$) in food consumption between treatments. There was a stepwise decrease in the amount of feed consumed by the ducks during this period as the severity of restriction increased during the rearing period. Lee *et al.* (1971b) with broiler chickens also observed this effect. Pullets from all the restricted feed treatments ate, in total, significantly less food than those fully fed during the rearing period.

Egg production

The effect of the different rearing treatments on the egg production characteristics of ducks is shown in Table 3.

Sexual maturity was progressively delayed by increasing severity of restriction during rearing. There were significant differences ($P \leqslant 0,05$) between treatments in days to first egg and days to 10% production. Although there was a slight stepwise increase in the number of days required to reach 50% production, there were no significant differences between treatments at this stage. The delay in reaching 50% production between the 40% *ad lib.* ducks and the *ad lib.* ducks was 13 days whereas in the 1978 experiment (Olver *et al.*, 1978) it was 28 days. This was the only major difference between the results of the two experiments. The delay between the *ad lib.* and 80% and 60% of *ad lib.* was 4 and 7 days respectively in the 1978 experiment compared with 3 and 9 days in the present experiment. This delay in sexual maturity as the degree of restriction during the rearing period increased was also

Table 3 Sexual maturity, egg production, egg mass, egg sizes, and rate of lay in Pekin ducks under different rearing treatments.

Treatment	Days to 1st egg	Days to 10% prod.	Days to 50% prod.	Average egg no's per replicate (24 ducks)	Egg sizes (%) XL	L	M	S	Egg masses (g) First month	Last month	Total average	Peak* Prod. (%)	Terminal** Prod. (%)
Ad lib.	146^{a}	161^{a}	207^{a}	2328^{a}	22,9^{a}	47,0^{a}	26,3^{c}	3,8^{c}	70,5^{a}	84,8^{a}	84,7^{a}	77^{a}	22^{a}
80%	168^{b}	175^{a}	210^{a}	2353^{a}	27,5^{a}	50,3^{a}	20,0^{b}	2,2^{b}	71,6^{ab}	86,1^{ab}	86,1^{ab}	83^{ab}	28^{ab}
60%	183^{bc}	192^{b}	216^{a}	2475^{ab}	39,2^{ab}	46,4^{a}	13,3^{a}	1,1^{a}	78,1^{c}	89,5^{b}	88,1^{ab}	87^{b}	34^{b}
40%	192^{c}	204^{b}	220^{a}	2683^{b}	45,9^{b}	44,7^{a}	8,9^{a}	0,5^{a}	77,0^{bc}	90,0^{b}	90,2^{b}	92^{b}	43^{c}

^{a,b,c,d} Results not bearing same letters in columns are significantly different ($P \leqslant 0,05$); * Rate of lay for best 7-day period; ** Rate of lay for last 7 days.

observed by Lee *et al.* (1971b) and Pym & Dillon (1974) with chickens.

The average total number of eggs per replicate also increased as the rate of restriction during the rearing period increased, and the ducks on the 40% of *ad lib.* treatment laid an average of 255 more eggs than the *ad lib.* group during the laying period. This was an average of more than ten eggs per duck during this period. Lee *et al.* (1971b) and Pym & Dillon (1974) also found that the restricted hens laid more eggs than did the fully fed birds.

The sizes of the eggs laid by the different groups is also shown in Table 3. The difference in egg size was noticed especially in the medium and small egg classes where the restricted birds laid fewer of these eggs than the *ad lib.* group. There was a stepwise decrease in the amount of medium and small eggs laid as the degree of restriction in the rearing diet was increased. This was also evident with the extra large eggs but not the large eggs. Pym & Dillon also found that the chickens fed according to the severest restriction programme during the rearing period produced the highest percentage of extra large eggs. Lee *et al.* (1971b) also noticed that a greater number of hatchable eggs were produced by hens restricted during the rearing period than the hens fully fed.

The average egg mass of all eggs laid showed a stepwise increase as the degree of feed restriction in the rearing period increased. There was a significant ($P \leqslant 0{,}05$) increase in egg mass between the *ad lib.* and 40% of *ad lib.* treatment. In the earlier study (Olver *et al.*, 1978) the restricted group also had a larger egg mass than the *ad lib.* group. This can probably be attributed to the greater number of small and medium eggs laid by the *ad lib.* group.

This could be clearly seen when the average egg masses for the first month of production were taken into account. It can be seen (from Table 3) that during the first month the egg mass of the 60 and 40% of *ad lib.* treatments were significantly different ($P \leqslant 0{,}05$) from the *ad lib.* treatments with the egg mass of the latter two restricted groups being an average of 7 g heavier than the *ad lib.* group. This early difference in egg mass because of a delay in sexual maturity seemed to continue right to the end of the experiment, as the results of the last month of production (Table 3) also showed a larger mass for the restricted groups although the difference was not as great as during the first month of production. As with the results of Lee *et al.* (1971b) with broiler breeder hens, the peak and terminal production was highest for the restricted groups as compared to the *ad lib.* group. The terminal production figures of the ducks in this experiment are rather low but this can be attributed to the fact that no artificial light was available in the duck pens and the daylight hours at this stage were decreasing.

Mortality

There was no mortality during the rearing period but a few ducks died during the laying period. All the ducks that died during the laying period were females and the mortality results are shown in Table 4.

Table 4 Mortality of ducks during the laying period

Treatment	Mortality (%)
Ad lib.	10,0^{b}
80%	7,8^{ab}
60%	5,6^{ab}
40%	2,2^{a}

^{a,b} Results not bearing same letters are significantly different ($P \leqslant 0{,}05$).

The laying house mortality of the *ad lib.* fed ducks was significantly ($P \leqslant 0{,}05$) higher than the 40% of *ad lib.* fed ducks. There was a stepwise decrease in mortality as the degree of restriction during the rearing period increased. Lee *et al.* (1971a) reported that mortality levels in the laying period of restricted-reared pullets are usually lower than pullets fed *ad lib.* during rearing. They found that only 28 out of 92 reported comparisons found this not to be so, and that birds restricted during the rearing period showed an average of 1,44% lower mortality during laying than those fully fed during the rearing period.

Although no mortality was experienced during the rearing period this was probably due to extra hopper space being made available to the restricted ducks so as to enable all the ducks to feed at the same time. Any duck in the heavily feed restricted groups that was unable to eat its quota during the limited feeding period would be expected to suffer and perhaps even die of starvation. When it was noticed that some ducks in the restricted groups climbed into the troughs and ate more than their quota of feed these troughs were removed and replaced with other troughs that were protected by a wire guard. On every alternate day just before the ducks were fed their allocated amounts of feed, the troughs were removed from the pens and the feed was then evenly distributed along the troughs before the troughs were simultaneously replaced in the pen and the ducks allowed to eat. Thus although the documented literature (Lee *et al.*, 1971a) observed a higher mortality during the rearing period in groups of chickens in which food intake was restricted, it was probably attributable to bad management rather than the treatment itself.

Fertility and Hatchability

The results obtained with the incubated eggs are shown in Table 5.

The ducks restricted during the rearing period had significantly ($P \leqslant 0{,}05$) better fertility than did the ducks fed *ad lib.*. These results are similar to the results obtained by Olver *et al.* (1978) with ducks and Lee *et al.* (1971b) with broilers. It appears that the lower fertility of the ducks fed *ad lib.* could have been due to their overeating during the rearing period. No significant differences were observed between treatments with regard to hatchability of fertile eggs although there was a slight stepwise increase in hatchability of fertile eggs as the degree of restriction during the rearing period increased. The

Table 5 Percentage fertility and hatchability of duck eggs

Treatment	Fertility (%)	Hatchability of fertile eggs (%)	Hatchability of eggs set (%)
Ad lib.	68,5^{a}	59,7^{a}	40,9^{a}
80%	76,1^{b}	61,6^{a}	46,8^{ab}
60%	81,8^{b}	62,0^{a}	51,0^{ab}
40%	80,3^{b}	65,9^{a}	53,0^{b}

^{a,b,c,d} Results not bearing same letters in columns are significantly different ($P \leqslant 0{,}05$)

Table 6 Mean masses of viscera adjusted and unadjusted for differences in body mass of drakes on the different rearing treatments

Treatment	Length of intestine (mm)	Mass of Intestine (g)		Mass of Heart (g)		Mass of Gizzard (g)		Mass of Liver (g)	
		Unadjusted	Adjusted*	Unadjusted	Adjusted*	Unadjusted	Adjusted*	Unadjusted	Adjusted*
Ad lib.	204,7^{a}	57,3^{ab}	1,73^{a}	20,5^{c}	0,62^{a}	69,2^{a}	2,09^{a}	57,3^{b}	1,73
80%	205,3^{a}	61,5^{b}	2,07^{b}	17,5^{b}	0,60^{a}	71,5^{a}	2,24^{a}	57,0^{b}	1,90^{a}
60%	206,7^{a}	62,3^{b}	2,36^{b}	17,0^{b}	0,64^{a}	81,0^{b}	3,07^{b}	55,3^{b}	2,09^{b}
40%	203,3^{a}	53,8^{a}	2,70^{c}	12,8^{a}	0,64^{a}	68,0^{a}	3,45^{b}	46,3^{a}	2,32^{c}

^{a,b,c,d} Results not bearing same letters in columns are significantly different ($P \leqslant 0,05$).

* Organs as % of body mass.

hatchability of eggs, as pecentage of eggs set in the incubator of the *ad lib.* treatment, was significantly lower ($P \leqslant 0,05$) than that of the 40% of *ad lib.* treatment, but not significantly lower than that of the 80 and 60% restriction treatments. There was however, again a slight stepwise increase in the hatchability of eggs set as the level of restriction during the rearing period increased. The same trend was also observed in the earlier experiment with ducks (Olver *et al.,* 1978) and with broiler breeder pullets (Lee *et al.,* 1971b).

Carcass analysis

Adjusted and unadjusted viscera masses of drakes under the different rearing treatments is shown in Table 6.

There were no significant differences ($P \leq 0,05$) between treatments with regard to length of intestine, but there were significant differences ($P \leqslant 0,05$) between treatments with regard to mass of intestine. There was a slight increase in intestinal mass from the *ad lib.* treatment to the 60% of *ad lib.* treatment but thereafter there was a drop, even lower than the *ad lib.* intestinal mass, with the 40% of *ad lib.* treatment. However, when the intestine mass was adjusted as a percentage of live mass there was a stepwise increase in intestinal mass as the degree of restriction during the rearing period increased. From these results one can assume that the heavier the intestine in relation to body mass, the better the absorption of nutrients which would be necessary with the restricted ducks. Lee *et al.,* (1971b) also found that the relative increase in intestinal mass increased as the degree of restriction during the rearing period increased with broiler breeder pullets.

The mass of the heart was found to be smaller for the restricted ducks than for those fully fed. There was a stepwise decrease in the mass of the heart as the severity of restriction increased during the rearing period. However, when the heart mass was adjusted for differences in body mass the difference between treatments was eliminated. Hollands, Gowe & Morse (1965) obtained similar results on their work with chickens.

The mass of the gizzard was least for the 40% of *ad lib.* treatment but there was a stepwise increase in mass from the *ad lib.* to the 60% of *ad lib.* treatment. Hollands *et al.,* (1965) also observed this stepwise increase in gizzard mass between the fully fed and restricted fed chickens. They, however, only restricted the feed up to 70% of *ad lib.* and one could assume that up to a certain degree of restriction, for example 60%, the mass of the gizzard would increase but thereafter because of the severity of restriction — resulting in a smaller bird — the gizzard mass would be reduced. When the gizzard mass was adjusted for body mass there was again a stepwise increase in mass as the degree of restriction during the rearing period increased. The 60 and 40% of *ad lib.* treatments were significantly different ($P \leqslant 0,05$) from the *ad lib.* and 80% of *ad lib.* treatments. Lee *et al.* (1971b) also noticed this stepwise trend with their broiler breeder pullets. The explanation for this relative increase in gizzard size mentioned by Hollands *et al.,* (1965) is that since the gizzard is a muscular organ, its large size at the end of the restriction period indicates a relatively greater amount of activity by this organ in the restricted ducks.

The liver showed a slight decrease in mass as the degree of feed restriction during the rearing period increased. The consistency of these differences may indicate that the restricted ducks do not use the liver as a storage organ to the same extent as do the fully fed ducks. Any fats, taken into the body by the restricted ducks, would have been converted into energy rather than stored. The fully fed ducks would therefore have had fatter and heavier livers. When the liver mass was adjusted for differences in body mass there was again a stepwise increase in liver mass as the rearing period restriction increased. It appears that since the liver is a vital organ, liver development would have priority over muscle and fat development, and this would account for the relative increase in liver mass when adjusted as a percentage of live mass.

The proportion of moisture and fat in the carcass of the Pekin drakes reared under the different treatments is shown in Table 7.

There were highly significant differences ($P \leqslant 0,01$) in percentage carcass moisture between the different treatments. There was a large stepwise increase in percentage moisture as the degree of restriction during the rearing period increased. This is in agreement with the work done on broilers by Lee *et al.,* (1971b).

As expected, since moisture has a strong negative correlation with fat, the percentage fat in the carcass was also highly significantly different ($P \leqslant 0,01$) between treatments. There was a large stepwise decrease as the degree of restriction during the rearing period increased. It can be seen from the results that the ducks on the 40% of *ad lib.* treatment had hardly

Table 7 Moisture and fat in the whole carcass of Pekin drakes on the different rearing treatments

Treatment	Moisture in carcass (%)	Fat in carcass(%)
Ad lib.	47,0^{a}	30,7^{d}
80%	50,0^{b}	26,8^{c}
60%	54,6^{c}	20,8^{b}
40%	65,4^{d}	7,3^{a}

^{a,b,c,d} Results not bearing same letters in columns are significantly different ($P \leqslant 0,01$).

Table 8 Economic evaluation of feeding programmes for Pekin breeder ducks reared differently

Treatment	Cost of feed per duck	Eggs laid per duck	Hatchability of eggs set (%)	Number of ducklings hatched	Income from day-old ducklings sold at 50c each	Income from duck sold at end of experiment at R1,25/kg live mass	Profit per duck. Income — feed cost
Ad lib.	R18,62	97	40,9	40	R20,00	R4,05	R 5,43
80%	R17,56	98	46,8	46	R23,00	R3,99	R 9,43
60%	R16,95	103	51,0	53	R26,50	R4,02	R13,57
40%	R16,25	112	53,0	59	R29,50	R3,93	R17,18

any fat when compared to those on the other treatments. This shows that the 40% of *ad lib.* treatment was fairly severe and the ducks were probably using up their body fat, deposited before the restriction treatments started, as an extra supply of energy.

Economic evaluation

The effects of rearing treatments on the economics of the ducks are shown in Table 8.

The economic evaluation of the results as shown in Table 8 are purely hypothetical as certain aspects have not been mentioned, such as feed eaten up to 7 weeks, cost of brooding, incubation, labour, etc. However the hypothetical results are interesting enough, and the largest profits were obtained from the restricted ducks. As with many of the former results there was a stepwise increase in profit as the degree of restriction during the rearing period increased. There was an increase in profit of R11,75 per duck between the *ad lib.* and 40% of *ad lib.* ducks, which is some considerable saving on a large enterprise. It appears that a quantitative feed restriction programme is vital during the rearing period for profitable duck farming. Good management practices are however necessary for the 40% treatment to be successful on a commercial scale and a safer method would be the 60% of *ad lib.* treatment.

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