Effect of "Meal Eating" Versus "Nibbling" on Body Composition and Digestive Organ Weight of Normal and Cropectomized Chickens

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ALTHOUGH much attention has been given to the quantitative aspects of food ingestion in relation to performance and metabolic function, relatively few studies have been concerned with the pattern of food intake.[1–3] Cohn and Joseph[4] studied and clearly differentiated two feeding patterns for rats—"meal eating" (restricted access to food) and "nibbling" (unrestricted access to food)—and reported that the former led to increased deposition of body fat and decreased deposition of carcass water and protein. In the chicken, Lepkovsky and co-workers[5–7] and Leveille and Fisher[8] have also studied certain peripheral aspects of eating pattern. Again, Cohn and associates[9] focused direct attention on the importance of meal eating versus nibbling in relation to atherosclerosis in the chicken.

The present study was undertaken to (1) evaluate the role of the crop in achieving meal eating through restricted feeding time, and (2) compare body composition of chickens under the two feeding patterns. The latter seemed particularly necessary since Cohn et al.[9] apparently assumed the chicken to behave similarly as the rat whereas Feigenbaum[10] had observed a marked difference in energy metabolism between chicken and rat during starvation and realimentation.

PROCEDURE

A hundred one week old female chickens from a cross of Columbian females with New Hampshire males were divided into two groups. From one group the crops were excised[11] while the other group served as controls. In chicks, surgical crop removal is a harmless operation, with no observable ill effects in later life. A conventional starting ration was used throughout this study.

In the first experiment both the normal and cropectomized birds were maintained for an additional week on an *ad libitum* feeding schedule. Both groups were then further divided into two subgroups of twenty-five birds each. One subgroup was allowed to eat *ad libitum* (hereafter referred to as nibbling) while the other was restricted to two one-hour feeding periods (8 to 9 A.M. and 4 to 5 P.M.) daily (hereafter referred to as meal eating). Water was available to all groups at all times. The four groups were maintained on their respective feeding patterns until they weighed approximately 1,200 gm. At that time five birds were selected from each group and killed with chloroform. Their digestive tracts were removed and divided into the following segments: crop (when present), esophagus, proventriculus plus gizzard, and intestine. Each segment was rinsed clean, blotted dry and weighed. The whole remaining carcass was then dried at 105°C. to constant weight. Next the dried carcass was finely ground and mixed and samples taken for nitrogen analysis by a modified Kjeldahl method. Crude protein content was calculated by multiplying the carcass nitrogen by 6.25. Fat was determined gravimetrically after extracting other carcass samples with chloroform:methanol (2:1) and re-extraction with petroleum ether.

Experiment 2 was carried out with the remaining

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TABLE I

Body Weight and Food Consumption Values of Normal and Cropless Chickens on Two Food Ingestion Patterns (Experiment 1)

Experimental Groups		Body Weight (gm.)			Food*	
Crop	Eating Pattern	6 wk.	10 wk.	Final	Consumption (gm./bird)	Utilization (gm. gain/gm. consumed)
Control	Nibbling	602 ± 22†	1,227 ± 24	1,227 ± 24 (73‡)	2,221	0.28
Control	Meal eating	419 ± 20	888 ± 16	1,222 ± 24 (93)	1,508	0.31
Cropectomized	Nibbling	605 ± 21	1,293 ± 32	1,293 ± 32 (73)	2,242	0.31
Cropectomized	Meal eating	217 ± 16	480 ± 59	1,172 ± 35 (136)	1,092	0.24

NOTE: Birds were two weeks old at start of experiment.
* Food consumption and utilization values refer to period between six and ten weeks of age.
† Mean value with its standard error.
‡ Numbers in parentheses represent days required to reach final body weight.

birds in the cropectomized and control subgroups from experiment 1. When they reached a body weight of approximately 1,950 gm., they were placed on two one-hour feeding periods. Within three days feed consumption had leveled off at 40 gm. per bird per hour. At this time the birds in both groups were again subdivided into two groups (ten birds per group). One group of each remained on the restricted schedule (meal eating) while the other was restored to the *ad libitum* (nibbling) schedule. For this experiment, however, feed intake was restricted to 80 gm. per bird per day. Each morning this amount of feed was weighed out for each bird on the *ad libitum* schedule. For the birds on the time-restricted schedule, 40 gm. per bird was weighed out at each of the two one-hour feedings. We observed that the birds fed *ad libitum* still had some feed in their feeders by 4:00 P.M. (when the birds in the time-restricted groups received their second meal) but this was invariably gone by 5:00 P.M. (when the feeders were removed from the restricted groups). The birds in the restricted groups always consumed all of their feed. At the end of two weeks, five birds from each group were killed and analyzed as previously described except that no measurements were made of the digestive tract.

RESULTS

Experiment 1

At the beginning of this experiment (when the birds were two weeks old), the average weight of the control chickens was 166 gm. and that of the cropectomized chickens 150 gm. Table I shows the body weights of all four groups after four and eight weeks on the experimental regimens (ages six and ten weeks). Feed consumption per bird during the period from six to ten weeks of age is also given. On the *ad libitum* feeding schedule (nibbling) the cropectomized birds overcame their original weight handicap. By the time they were ten weeks old, these birds actually weighed more than the control chickens. The control birds on the restricted feeding periods (meal eaters) weighed approximately two-thirds of that of the birds fed *ad libitum* and their feed consumption followed the same proportion. The cropectomized chickens on the restricted feeding regimens (meal eaters) weighed approximately one-third as much as their counterparts who were fed *ad libitum* although their feed consumption was approximately halved. This indicates that crop removal compounded the stress of restricted feeding. As would be expected, this added stress is also demonstrated in the time needed to attain the predetermined weight. The two groups of birds that had been nibbling reached the desired body weight after eight weeks of the experiment. The meal-eating control chickens reached the same weight three weeks later, and the meal-eating cropectomized chickens required seventeen weeks on the restricted

TABLE II
Effect of Cropectomy and Food Ingestion Pattern on Digestive Organ Weights and on Body Composition

Measurements	Experimental Group				Analysis of Variance*		
	Control		Cropectomized		Effect of		
	Nibblers	Meal Eaters	Nibblers	Meal Eaters	Eating Pattern	Crop	Interaction
Digestive organ weights							
Esophagus (gm.)...	4.2 ± 0.2†	5.8 ± 0.08	4.8 ± 0.3	8.7 ± 0.3	+++	+++	+++
Proventriculus plus gizzard (gm.)....	36.8 ± 2.0	43.4 ± 1.6	34.6 ± 1.5	56.4 ± 5.5	+++	+++	+++
Intestine (gm.)....	48.1 ± 2.0	45.6 ± 1.7	55.2 ± 2.5	42.9 ± 2.8	+	...	+
Crop (gm.).....	3.1 ± 0.1	6.5 ± 0.1	...	...	+++	...	...
Body composition							
Moisture (%).....	67.1 ± 0.7	69.5 ± 0.4	67.6 ± 0.3	71.8 ± 0.6	+++	+	...
Fat (% wet weight)	6.9 ± 0.6	4.6 ± 0.4	7.0 ± 0.7	3.0 ± 0.2	+++	+++	+++
Protein (% wet weight).....	20.1 ± 0.4	19.7 ± 0.2	19.8 ± 0.3	19.8 ± 0.5	...	...	...

NOTE: All analyses were carried out on five birds from a starting group of twenty-five.
* Probability 0.05 +
0.01 ++
0.001 +++
† Mean value with its standard error.

feeding schedule to reach the final body weight.

Table II shows the results of the body composition analyses and the weights of the digestive organs. Also shown are the probability values from an analysis of variance carried out on the experimental parameters. There was little difference between the two groups of chickens that had been nibbling, except in the weight of the intestine. The effects of meal-eating as compared to nibbling were increased weight of crop, esophagus and proventriculus plus gizzard with decreased intestine weight; slightly increased moisture content; greatly reduced fat content and no change in carcass protein content. The most profound effects in all cases resulted from the food ingestion pattern, with presence or absence of crop of less but still significant importance.* All differences noted between the two control groups were exaggerated for birds in the cropectomized groups. These results demonstrate the increased stress of meal eating in the cropectomized birds.

Experiment 2

The results of experiment 2 are shown in Table III. Although all birds ate the same amount of food (80 gm. per bird per day) the "meal eaters" lost weight while the "nibblers" gained weight. The differences in body composition are qualitatively similar to those of experiment 1. The moisture content increased, the fat content decreased with no significant change in the protein content of the body due to meal-eating as compared to nibbling. In this study, the only significant effect was due to the food ingestion pattern except for a difference in starting weights between the control and cropectomized birds.

COMMENTS

The results of experiment 1, indicating that there were no great differences between the two groups of chickens that had been nibbling,

* This may not be readily apparent from a comparison of the levels of significance as shown for the analysis of variance in Table II; however, the F values for the effect of eating pattern are from five to ten times as great as those for effect of crop.

TABLE III
Effect of Cropectomy and Food Ingestion Patterns on Body Weight and Composition

Measurement	Experimental Group				Analysis of Variance*		
	Control		Cropectomized		Effect of		
	Nibblers	Meal Eaters	Nibblers	Meal Eaters	Feeding Time	Crop	Interaction
Body weight (gm.)							
Original	1,932 ± 50†	1,930 ± 46	1,958 ± 27	1,958 ± 47	...	+	...
Final‡	2,044 ± 74	1,906 ± 55	2,066 ± 43	1,866 ± 54	++	...	...
Body composition							
Moisture (%)	63.9 ± 0.7	65.6 ± 0.7	64.2 ± 0.5	66.6 ± 0.8	+	...	...
Fat (% wet weight)	9.4 ± 0.6	6.0 ± 0.6	9.1 ± 0.4	5.9 ± 0.7	+++	...	...
Protein (% wet weight)	21.3 ± 0.4	21.3 ± 0.5	20.3 ± 0.5	21.5 ± 0.2	...	...	...

NOTE: All groups had an equal food intake of 80 gm./bird/day. Analyses were carried out on five birds from a starting group of twenty-five.

* Probability 0.05 +
0.01 ++
0.001 +++

† Mean value with its standard error.

‡ After seventeen days.

support the earlier findings of Fisher and Weiss[11] who found that the crop does not play a major role in influencing food consumption when food is continually available. The effects of meal eating indicate an important role for the crop when food is only sporadically available.

The results of experiment 2 show that the chicken, unlike the rat,[4] is less efficient in energy utilization when meal eating than when nibbling. Not only did the "meal eaters" lose weight whereas the "nibblers" gained weight, but there was also a significant decrease in the carcass fat content of the meal-eating chicken. The meal-eating rat, on the other hand, stores considerable quantities of fat compared to the rat that nibbles. This difference in energy utilization between meal-eating rats and chickens corroborates certain observations of Feigenbaum[10] on fatty liver studies. He found that in the chicken a fatty liver did not develop during starvation but did develop on realimentation with a high energy carbohydrate diet. In the rat, a fatty liver developed during starvation which could be overcome by feeding it glucose.

On the basis of the results of both experiments, we conclude that the presence of the crop in the chicken reduces the effectiveness of the meal-eating system of food ingestion.

SUMMARY

The crop was surgically removed from one week old chickens. The effects of meal eating (two one-hour feeding periods per day) versus nibbling (food available continuously) was then studied in cropectomized and normal birds. In one experiment, birds remained on their particular feeding schedule until they attained a given body weight. In a second experiment, food intake was equalized among all four groups with two groups consuming it in two one-hour periods, the other two throughout the day.

Meal eating significantly increased the weight of the esophagus and gizzard plus the proventriculus. Body fat was significantly reduced and body water increased on meal eating. Protein content of carcass remained unaltered. Crop removal in the chicken greatly exaggerated the effects of meal eating. The effects of meal eating versus nibbling on body

composition are the reverse of those observed in the rat.

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