Route 1
Mound, Minnesota
September 3, 1949

Dr. Ralph Manley
Director of Research
General Mills Research Laboratory
2010 East Hennepin
Minneapolis, Minnesota

Dear Dr. Manley:

Enclosed is our first progress report describing as of September 1 the status of our experiments on psychological factors in feeding. Much of our first six weeks' work has of course been taken up with the preparation of apparatus needed for various aspects of these and other experiments and with the raising of birds with known or controlled backgrounds.

Although the described experiments have not as yet been completed and the conclusions are therefore still tentative, we feel that we have made a beginning on some of our problems and have in addition hit upon some interesting questions for future study.

I hope you will let us have your reactions to these experiments, and if there are any points discussed about which you would like further information, please let me know.

Very truly yours,

Keller Breland

Experiment 1
Feeding Schedules

This experiment was undertaken to investigate various psychological aspects of the feeding schedule, such as times of feeding and previous exposure to or deprivation of food. The psychological conditions attendant upon a continuous exposure to feed, such as is encountered in the ad libitum feeding method, are quite different from those attendant upon feeding methods wherein peaks of drive are encountered, the organisms being deprived of all or of certain types of feed for a certain length of time. It might be expected that groups raised under different drive conditions would show different rates of weight gain.

It is further known that chickens are competitive in their eating behavior; for example, a chicken satiated in isolation, when placed with another chicken which is eating, will commence to eat again. Conditions of feeding which provide a group of satiated chickens with a continual supply of sufficient food are quite different with respect to this competitive aspect of eating behavior than conditions which present a group of chickens hungry for all feed or one particular feed with an amount of feed which is not sufficient for the entire group.

The method and initial results of setting up some of these conditions in four fairly uniform groups of birds are described below.

Subjects. The birds used in this experiment were 78 White Rock chickens of mixed sex, hatched June 23, 1949. They were 30 days old at the time of their purchase and had been raised prior to that date on Nutrena broiler mash. After their purchase they were housed for approximately two weeks in two compartments of a standard four-deck broiler battery and were fed upon Larro broiler mash. Broiler pellets, chick size, were begun at 5 weeks and by August 5 all pellets were being fed.

On August 5 the birds were weighed and banded. The weight and number of each bird was recorded, and the chickens were then divided into four groups by drawing numbers at random from this supply. Each group was then housed in a separate deck of the battery and provided with feed and water troughs.

Method and Apparatus. Groups B and D were designated as the control groups. Group B was fed on a schedule of continual access to mash in the meal or powder form, with pellets scattered on top of this ration twice a day, morning and evening. The amount of pellets varied somewhat from day to day, variation being based upon the amount cleaned up the previous day, or the occasional failure to clean up a feeding of pellets. The amount given was weighed each time. Group D was given unlimited access to broiler pellets only.

Groups A and C, the experimental groups were fed pellets from two specially constructed automatic hoppers which delivered every 30 minutes a small supply of pellets to the feed troughs. These hoppers are 40 inches long, constructed of plywood, and mounted above the feeding troughs in such a position that the feed released falls into the trough. The design of a suitable release mechanism required considerable experimentation. As finally developed, this

mechanism consists of a hinged door running the length of the hopper and fitted with a right-angle retaining flap. The door when opened releases a sheet of pellets into the trough. The amount delivered each time is controlled by an adjustable screw arrangement which changes the width of the opening at the base of the hopper. To overcome jamming and leaking the door is so arranged that it will effectively close off the flow of pellets even when the clearance between all parts of the door and hopper is greater than the size of the pellets.

The door is operated by a 110 volt solenoid which is controlled by a specially built electrical timer. This timer closes the circuit to the solenoid for a fraction of a second every 30 minutes. The hopper is giving very satisfactory performance in delivering chick size and hen size broiler pellets both singly and in combination. A side-view diagram of the hopper is shown below:

For this experiment the hoppers were regulated to deliver a quantity of pellets such that at the end of the 30 minutes the chickens would have them almost entirely cleaned up. The next impulse of the timer would then deliver a fresh feeding. The amount of pellets was small enough in each case so that it was an insufficient ration for the entire group. It was thought that this might maximize their competition for the feed and increase their tendencies to eat, thus resulting in the consumption of more feed.

Group C, in addition to being fed pellets from the automatic hopper, was given unlimited access to mash in the meal or powder form. Chick size pellets were fed to all groups during the first week of the experiment. Hen size pellets were begun on August 20, and after August 26 all hen size pellets were fed.

The birds were weighed at the end of each week, and the feed consumption for the week was recorded at the same time. During the course of the experiment it was occasionally necessary to remove a bird because of cannibalistic tendencies in the flock. Generally 12 to 24 hours isolation were sufficient to heal up the wounds and allow the bird to return to the flock, but in a few instances birds were taken out for the duration of the experiment. Mean weights and gains in the following tables exclude all the birds which were eventually rejected for more than 24 hours.[1] However, the feed consumption figures include all the birds which were present during the week in question.

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[1] Mean weights and gains including the rejects are only very slightly different from those excluding them, never exceeding 0.2 ounces.

Table 1
Mean Weights and Gains in Ounces of Experimental and Control Groups

	Group A: Pellets every 30 min. N = 17		Group D: Ad lb. pellets N = 17		Gr.C: Mash, pel. every 30 min. N = 21		Gr.B: Mash, pel. twice a day N = 18	
	Mn.Wt.	Mn.Gn.	Mn.Wt.	Mn.Gn.	Mn.Wt.	Mn.Gn.	Mn.Wt.	Mn.Gn.
Initial	15.94		16.88		16.38		15.83	
		4.88		4.88		4.57		4.78
End Wk.1	20.82		21.76		20.95		20.61	
		5.18		5.82		4.57		5.67
End Wk.2	26.00		27.58		25.52		26.28	
		4.06		2.71		4.10		3.89
End Wk.3	30.06		30.29		29.62		30.17	
Total Gain		14.12		13.41		13.24		14.34
Mean weekly gain		4.71		4.47		4.41		4.78

Results. It will be noted from Table 1 that the birds were at the start of the experiment (in fact were at the time of their purchase) and still are somewhat substandard in weight for their age. They turned out, in addition, to have marked cannibalistic tendencies, and to be very wild and easily startled by any movement near their cage, in spite of continual exposure to conditions which should lead to quick emotional adaptation.

The main result of the experiment to date is that practically no differences have been obtained between any of the groups. Statistical tests will be made at the conclusion of the experiment, but they are hardly necessary to demonstrate the near identity of all the procedures for putting weight on the chickens. The groups were at most only an ounce different in weight (Groups D and B) at the start of the experiment, and even less difference can be observed at the end of the third week. Group D (Ad lib. pellets) was somewhat heavier to start with and their gains for the first two weeks were somewhat greater, but some unknown variable cut their weight gain for the third week so that they end up very little ahead of the other groups in mean weight and somewhat lower than Groups A and B in mean gain for all three periods.

It would seem that within the conditions of this experiment, at least, varying schedules and time intervals between feedings make little difference in the rate of gain of broiler birds at these ages. The experiment is being continued with some variations, and a more detailed report will be presented at its conclusion.

In view of the difficulties encountered with this particular strain of birds and the necessarily experimental stage of the apparatus, the study must be considered as purely exploratory. It has, however, demonstrated to us the reliability of the special timing and feeding apparatus developed and opens the way for additional experiments on the temporal variable.

Table 2
Weekly Feed Consumption in Pounds and Ounces for Experimental and Control Birds

Week	N	Mash	Pellets	Oz. per bird
		Group A: Pellets every 30 minutes		
1	19		18 lbs. 1 oz.	15.2 oz.
2	18		21 14	19.4
3	17		15 3	14.3
		Group D: Pellets ad libitum		
1	19		17 lbs. 13 oz.	15.0 oz.
2	17		21 3	19.9
3	17		15 0	14.1
		Group C: Mash and pellets every 30 minutes		
		Mash	Pellets	Total Oz. per bird
1	21	1 lb. 14 oz.	12. lbs. 13 oz.	14 lbs. 11 oz. 11.2 oz.
2	21	7 10	21 0	28 10 21.8
3	21	6 2	11 10	17 12 13.5
		Group B: Mash and pellets twice a day		
1	19	3 lbs. 12 oz.	13 lbs. 4 oz.	17 lbs. 0 oz. 14.3
2	18	4 13	16 2	20 15 18.6
3	18	5 15	11 9	17 8 15.6

Experiment 2
Pellet Eating as an Operant

The purpose of this experiment is to test whether we can by appropriate reinforcement increase the consumption of pellet mash; in other words, whether it is possible for the eating of a particular substance, in this case mash, to become an operant, and whether by increasing the strength of this operant we may appreciably increase the mash intake.

For investigating this problem, two groups of four chickens were used. They were hatched June 29, from a mixed Wyandotte-White Rock strain. On August 11, at about 6 weeks, the chickens were weighed and two groups were matched for initial mean weight. Below are figures for the first two, or preparatory weeks.

Table 1
Mean Weights and Gains in Ounces for Experimental and Control Groups

	Group X Experimental		Group Y Control	
	Weight	Gain	Weight	Gain
Initial	10.00		10.00	
		6.00		6.25
End wk.1	16.00		16.25	
		4.75		5.25
End wk.2	20.75		21.50	

The groups were housed in adjacent cages with wire mesh flooring. They had been fed prior to August 11 on Larro broiler mash. On August 11 they were switched to Larro broiler pellets chick size and were fed on these exclusively for the first 10 days. On August 21 hen size broiler pellets were introduced and by August 30 they were being fed exclusively on the hen size pellets.

Table 2
Feed Consumption, August 11 through August 30

	Group X	Group Y
Pellets consumed	9 lbs. 2 oz.	9 lbs. 5 oz.
Oz. per bird	36.50	37.25
Oz. per bird per day	1.82	1.86

The experimental procedure was begun with Group X on August 27. On this and the following day, a small automatic feed hopper was installed in their cage. This hopper is specially constructed to deliver a small quantity of small-size scratch or growing grain into a wooden trough. A push-button actuates a solenoid which releases the grain from the upper part of the hopper into the trough. Each contact of the button releases on the average 0.74 grams of growing grain. This quantity of growing grain will be termed hereafter the reinforcement.

On August 27 and 28 the automatic hopper was in Group X's cage all day. At intervals during the day when there was activity going on near the cages, the button was pressed several times. About 40 reinforcements were given in this way. The procedure was designed to adapt the chickens both to the sight and the sound of the hopper while they were in their own cage. It was not desired that the chickens secure enough grain to constitute an important addition to their ration. With 40 reinforcements to be divided among 4 chickens, only about 7.4 grams of grain was consumed by each chicken.

On August 29 each chicken was placed for about 15 minutes on an enclosed platform (30" x 60") with the automatic hopper. Each bird was given an opportunity to eat about 15 reinforcements, but only two birds were really conditioned to the sound of the hopper, that is, when the solenoid sounded they approached the hopper and ate readily. The other two were not sufficiently adapted.

On August 30 two of these preliminary training periods (10 reinforcements each) were given; by the second, emotional adaptation was completed in all 4 birds and all were conditioned to the sound of the hopper. At 8:30 P.M. August 30 the feed hoppers of both groups were covered, since a moderate drive for the pellets was desired for the following morning. The control group hopper was covered to ensure equal eating time for this group.

On the morning of August 31 the experimental chickens were placed one at a time on the platform with the automatic hopper. The chicken was first given 3 free reinforcements, then we attempted to elicit pellet eating as an operant. Hen size pellets were placed one at a time on the platform next to the feeder. Each time the chicken swallowed a pellet, it was reinforced with grain. After a few reinforcements, the chicken was required to swallow two pellets for each grain reinforcement, and on subsequent days this ratio will be pushed as high as possible. During the early stages of conditioning only small amounts of pellets will be consumed since we do not want the amount of grain consumed in the reinforcement process to be a large factor in the chicken's ration. It is not possible to push the ratio of pellets per reinforcement very rapidly since we must operate at fairly low drive levels.

All we can say at the present time about this experiment is that the pellet eating seems to have good operant characteristics. When each swallowing of a pellet was reinforced with grain the behavior appeared at a quite regular rate in all but one instance (this chicken appeared to have difficulty swallowing the large pellets and has gained only 2 ounces since the hen-size pellet schedule was begun). When the ratio of pellets per reinforcement was raised, the behavior showed the slight extinction characteristic of an operant when a fixed ratio of responses per reinforcement is first required. The rate slowed, competing behavior and approximate responses such as merely pecking at the pellet appeared. The rate and regularity picked up when the ratio was returned to one pellet per reinforcement.

The chickens obtained in this first experimental session on an average of slightly over 1/3 ounce of feed. They were then given free access to hen-size pellets for the rest of the day (as was the control group) and the hoppers were covered again at 8:30 P.M.

Two questions should be answered by the subsequent experiment: will chickens eat pellets in large numbers when reinforced with grain, and will this reinforced behavior lead to greater total pellet consumption, or will they merely eat more pellets in the experimental situation and less in their cages? The experimental situation is, of course, designed to be different from their ordinary living and eating situation so that the pellet eating which may be strengthened by reinforcement with grain in the experimental situation will not extinguish through induction by the pellet eating in the home cage.

Two difficulties are being encountered which must be ironed out, namely, the difficulty one or two of the birds seemed to have with the hen-size pellets, and secondly, the fact that the drive for grain did not seem to be too high; they tended to peck it over, eating selectively at first. A more adequate reinforcement may be necessary in order to constitute dessert for a chicken which is being fed a balanced ration.

Experiment 3
Force Feeding

This experiment is designed to test the basic premise that if one can get more feed into the chicken it will utilize it in added weight gains. Weight gains in two matched groups of broiler birds are being studied to this end. One group is being fed pellets ad libitum; the other is being offered pellets ad libitum and is in addition being force fed twice a day.

The subjects are 30 White Rocks hatched July 13. Prior to the start of the experiment they were fed ad libitum on broiler mash. On August 12 they were switched to ad lib. chick-size pellets. They were weighed and banded on this date also, and weight gains recorded at the end of the week for two subsequent weeks. During this time, large pellets were gradually introduced so that the birds were on 100 per cent. hen size pellets by August 30. At the end of the two weeks two groups of 11 birds each were selected from the 30, paired as closely as possible for weights and gains on all weighing occasions. The remaining eight birds (Group S) were held in reserve as spares to be used if necessary and as an additional control. Mean weights and gains of the experimental (Group F) and control groups (Group L) are given in Table 1.

Table 1
Mean Weights and Gains for Preliminary Weeks, Experimental and Control Groups
(Figures in Oz.)

	Group F: Exp. Weight	Gain	Group L: Contr. Weight	Gain
Initial	9.1		9.1	
		4.8		4.6
End of wk.1	13.9		13.7	
		3.9		4.1
End of wk.2	17.8		17.8	

On August 30 the selected groups and the spares were separated and housed in three adjacent cages. The spare and the control group were fed ad lib. on hen-size broiler pellets. The experimental group was offered hen-size pellets ad lib. and was force-fed morning and evening beginning on the evening of August 30.

For the force feedings, a mixture of broiler mash and water was prepared in a ratio of 227 grams of mash to 345 grams of water, this ratio yielding a mash of suitable consistency to be forced, from a caulking gun with a special fitting, through a rubber hose which was inserted into the chicken's crop. In the first three feedings, the chickens took on an average of over 3 ounces of this mixture per feeding per bird. The following table gives average intake for the first three force feedings:

Table 2
Mean Intake of Force Feeding Mixture by Experimental Birds

Feeding	Mean Ounces Intake
1	2.29
2	3.61
3	3.95
Total	9.85
Average	3.28

Apparently it is going to be possible on the average to put upwards of 6 ounces a day into each of these birds, of which better than 2 ounces will be dry mash. In addition, the birds are consuming some pellets, but the quantity of these per day has not yet been determined. This experiment is being continued checking weights, gains, and feed consumption regularly, and a more detailed report will be submitted at the conclusion of the experiment. It seems logical that this amount of force feeding should produce more rapid weight gains in the experimental group, but whether such will be the case remains to be seen.

Experiment 2 NOTE 9-2-49

On the attached cards will be found records for the third day of the experiment for the four experimental birds. These are cumulative response curves taken on an electrical recording machine. Each response moves the pen up one notch. The height of the ordinate thus represents number of responses, i. e., pellets eaten in this case. The base line represents time in minutes. Reinforcements have not been recorded, but the vertical lines divide the record into sections according to the ratios of pellets to reinforcements required. The numbers under each section indicate these ratios. Thus in the sections labeled "1", the chicken received one reinforcement for each response or pellet swallowed; in the sections labeled "2" the chicken received one reinforcement for each 2 responses, etc. The circled figures give the chicken's band number.

We will not know until the conclusion of the experiment what interpretation must be put these first records. They are remarkably uniform in shape. A stable rate of response emission appears during ratios of 1 and 2 responses or pellets per reinforcement. When the ratio is pushed to 3 pellets per reinforcement, the rate falls off in a fashion typical of response extinction. The extinction process (if that is indeed what has occurred here) was carried on for different periods for the four birds before an attempt was made to recondition the response. When we returned to a ratio of one response per reinforcement, some recovery in rate and regularity seems to occur. One would not expect immediate resumption of the original rate in a response which had just been extinguished.

The extinction curves observed here may be compounded with satiation (which also yields a curve of the negative growth type) but several things make it seem unlikely that this is an important complication: (1) the birds consumed less than an ounce in the 25 minutesexperimental period; (2) when returned to their home cage they ate pellets almost immediately when the hopper was uncovered; (3) behavior typical of extinction appeared--random exploratory behavior, scratching at the automatic hopper, approximate responses such as pecking and tossing the pellets which were occasionally reinforced by accident and in turn had to be extinguished before the complete swallowing act could be elicited.

We will of course take satiation or simple ingestion curves from control birds and study the whole process in much greater detail before any definite conclusions will be drawn.