JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR VOLUME 5, NUMBER 2 APRIL, 1962

# FOOD SATIATION IN THE PIGEON

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The experiment was designed to find the shape of food satiation curves of the pigeon as a function of hours of deprivation or percentage of free-feeding weight, and to study the fluctuation in free-feeding weight as a function of deprivation and satiation. At a systematically and progressively increased number of hours' deprivation, eight birds were allowed to satiate on grain presented contingent upon the emission of a pecking response. In the second part of the experiment, in which two birds were used, a similar procedure was followed except that the independent variable was percentage of free-feeding weight. These were the conclusions.

1. Approximately 64% of the satiation curves were classified as straight with an abrupt stop. The next highest percentage of curves was 18% for curves classified as straight with a curvilinear stop. No "classic" satiation curves, curvilinear with curvilinear stop, were found.

2. The pigeons responded at fairly constant rate during the early part of each satiation session, or they did not respond at all. The critical weight, above which they did not respond, was 85% of free feeding.

Skinner (1932) described the rat's rate-of-eating curve with the equation $N = Kt^n$, where $N$ is the number of pellets eaten, $t$ is the time from the beginning of the period, and $K$ and $n$ are constants. He found that the rat's rate of eating declined as a function of time: The more it ate, the slower it ate. Because the rat was allowed to eat until it satiated, *i.e.*, until the rate of eating was zero for a period of time, some investigators (including the authors and also Bousfield, 1933) have considered the general shape of the curve found in this experiment as the "model" for satiation curves.

However, satiation curves of different shapes have been obtained in this and other laboratories. We have some indication that at longer periods of deprivation the white rat will give a curvilinear eating curve similar to that obtained by Skinner; but at shorter periods of deprivation, will give a straight-line curve. In other words, under shorter deprivation periods, rats will eat at a regular rate and then stop eating abruptly. Smith and Smith (1939) reported that a straight-line curve was characteristic for cats that were allowed to satiate on milk. Furthermore, in an experimental psychology classroom experiment performed in this laboratory, human subjects gave satiation curves of a variety of shapes.

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The present experiment was designed to systematically study food satiation in the pigeon. We wished to obtain the shape of the satiation curve as a function of hours of deprivation and to determine the fluctuation in free-feeding weight of the birds as a function of deprivation and satiation. The literature contains no report of a study of satiation in the pigeon.

## METHOD

### *Subjects*

The subjects were 10 male, Silver King pigeons with a mean age of 7.9 years. The pigeons were housed in separate home cages where grit and water were available at all times.

### *Apparatus*

The apparatus used was similar to that described by Ferster (1953). The experimental box was an aluminum portable icebox with a hinged top, which was propped open about 2 in. during experimentation so that the bird could be observed. When the bird pecked a translucent window, a light behind the window was illuminated, and the food tray was raised to a level of the eating aperture for 4 sec. Thus, each time the pigeon pecked the

window, grain was presented for a period of 4 sec. A kymograph recorded cumulative responses as a function of time.

*Procedure*

The birds were divided into two groups: eight in Group A and two in Group B. The procedure followed for each of the eight birds in Group A consisted of shaping its pecking behavior at 80% free-feeding weight in the experimental box 2 days before the deprivation schedule was to begin; putting the bird on free feeding for 2 days; and, finally, allowing it to satiate in the experimental box at each of a systematically and *progressively* increased number of hours of deprivation. The deprivation and satiation schedules were carried out as follows. After a 2-day period of free eating, all food was taken from the home cage. After 5 hr the bird was put into the experimental box and left there until the satiation criterion had been reached, *i.e.*, until no pecking-eating responses had occurred for 30 min. Then, 11 hr after the first satiation, the bird was again put into the box and allowed to satiate. The same procedure was followed at hours of deprivation increasing by 12 hr up to 95 hr and increasing by 24 hr from 95 to 191 hr of deprivation. Thus, the deprivation times were progressively increased, with the bird satiating to the criterion once between each deprivation period. All of the birds were experimentally satiated following 5, 11, 23, 35, 47, 59, 71, and 119 hr of deprivation; but not all of the birds were run at the longer deprivation times. Therefore, the graphs of group data for the birds in Group A do not extend beyond 119 hr of deprivation.

Percentage of free-feeding weight (rather than deprivation time) was the independent variable with the two birds in Group B. After shaping at 80% free-feeding weight, these birds were fed up to free-feeding weight and then deprived of food until they reached a scheduled percentage of this weight, at which time they were allowed to satiate in the experimental box according to the above procedure. After the first satiation, the birds were again fed up to free-feeding weight and then deprived of food until they reached the next scheduled percentage weight. One bird was run at 95, 90, 85, 80, 75, and 70% free-feeding weight; the other bird was run at 88, 85, 80, 75, and 70% free-feeding weight.

## RESULTS AND DISCUSSION

Because one aim of the experiment was to find the shape of pigeon satiation curves, it was necessary to find a way to readily describe the curves. Averaged curves have not been presented, because plotting Vincent curves, and thus averaging the curves obtained at each of the hours of deprivation, served only to obscure the shapes of the original curves. The curves fell into several types. Each one was thought of as existing in two segments: the main curve and the way it stopped; or, in other words, the way the bird ate and the way it stopped eating. Each of the curves was also classified in one of four categories: curvilinear with a curvilinear stop, curvilinear with an abrupt stop, straight with a curvilinear stop, and straight with an abrupt stop. Figure 1 shows these four curves in idealized form.

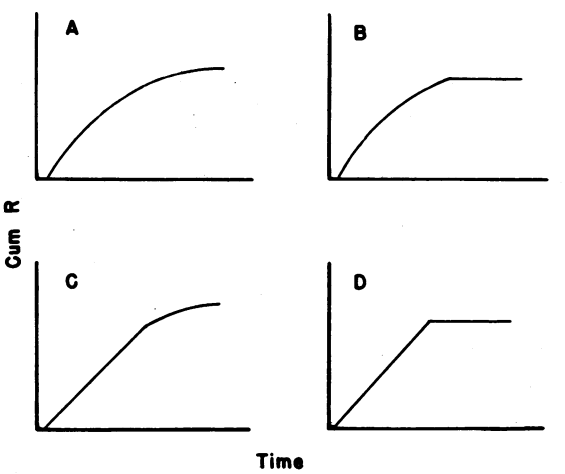


Fig. 1. Classification of satiation curves, idealized form. A: Curvilinear with curvilinear stop; B: Curvilinear with an abrupt stop; C: Straight with a curvilinear stop; D: Straight with an abrupt stop.

Each of the 110 curves found in the experiment could be classified into one of these four categories when they were smoothed over large curve areas, as the 191-hr curve in Fig. 2. We classified the curves independently, and disagreed in only two cases. For the birds in Group A, the highest percentage of curves was in the "straight with an abrupt stop" category, except at 11 and 23 hr of deprivation. Of the total number of curves, 63.6% were classified as straight with an abrupt stop. The next highest percentage, 18.2%, was for curves classified as straight with a curvilinear stop.

Two curves in the experiment were classified as curvilinear with an abrupt stop. The curve Skinner obtained for the rat's rate of eating would be classified here as curvilinear with a curvilinear stop; however, we didn't find any in this category. (The remaining curves in this experiment, 16.4%, contained no responses, because the birds were not sufficiently deprived, and thus could not be classified.)

Figure 2 shows several of the individual curves for one bird (No. 1238). The number of hours of deprivation since the last satiation period and the percentage of free-feeding weight at the beginning of the satiation period are noted in each curve. For example, the curve at the right in Fig. 2 was obtained 5 hr after a 2-day, free-eating period with the bird at 102.9% free-feeding weight. The next record (not shown) was obtained 11 hr after the end of the 5-hr satiation curve; and the 23-hr record was obtained 23 hr after the end of the 11-hr record. The satiation curves for the following deprivation times were classified as "straight with an abrupt stop: 5, 35, 59, 71, and 143 hr. The curves for 23, 95, and 191 hr of deprivation were classified as straight with a curvilinear stop.

A word of explanation is needed on the classification of some of the curves, for example, the 5- and 35-hr curves in Fig. 2. Sometimes, particularly at low deprivations or near the end of a curve, the birds would peck but not eat. All the birds were watched all the time they were in the experimental box, and the experimenter would indicate pecking but not eating by a "pip" above the curve. In the 5-hr deprivation curve, then, the bird did not eat following 15 of the first 26 responses; then it began to peck and eat regularly, but stopped abruptly. It did not eat after the last four

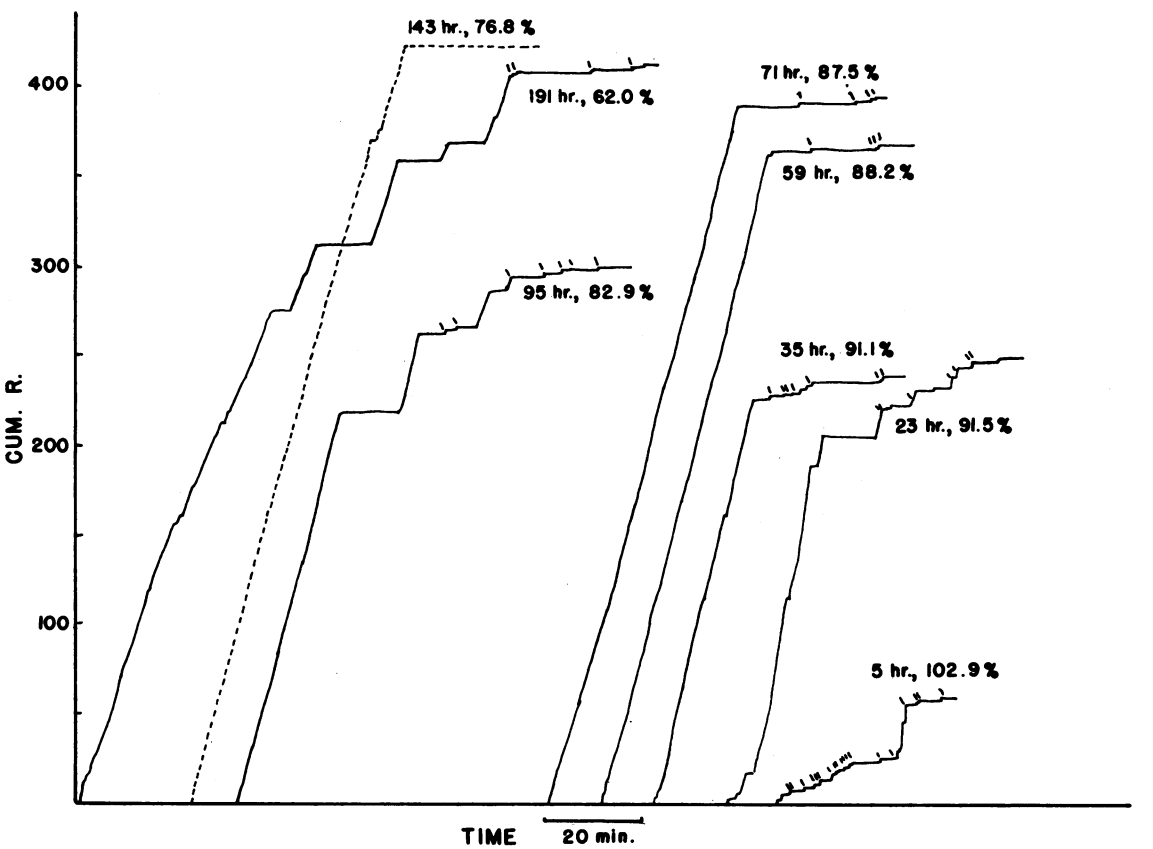


Fig. 2 Individual satiation curves for Bird No. 1238. Each curve contains a notation giving the hours of deprivation since the last satiation period and the percentage of free-feeding weight at the beginning of the curve. Curves for 5-, 35-, 59-, 71-, and 143-hr deprivation classified straight with a curvilinear stop; curves for 23-, 95-, and 191-hr deprivation classified straight with a curvilinear stop. A "pip" above the curve indicates that the bird did not eat following that pecking response.

pecking responses, as the "pips" above the record of these responses indicate. This eating curve, then, has a marked positive acceleration followed by a straight-line curve with an abrupt stop. The 35-hr curve shows a very regular rate of eating and an abrupt stop. The seven "pips" indicate that the bird ate only five times after the last 12 pecking responses.

Thirteen of the curves in the experiment showed an initial positive acceleration. (In this laboratory we have sometimes found an initial acceleration in the satiation curves of the rat; and the classroom experiment with human subjects at Mount Holyoke College, mentioned above, also produced some curves with an initial acceleration.) No curve had an initial positive acceleration when the bird had emitted responses in the three previous experimental sessions, or, with one exception, when the bird was at a percentage of free-feeding weight less than 84%. (Also, one of the two birds from Group B, in which percentage of free-feeding weight was the independent variable, gave curves with an initial positive acceleration at 90% and 85% weight.) Perhaps, a curve with an initial positive acceleration is a function of percentage of free-feeding weight rather than lack of experience in the experimental box.

The rank-order correlation between hours of deprivation and the group mean total number of pecking-eating responses was 0.98; the correlation between the group mean total number of pecking-eating responses and mean percentage weight gain during satiation was 0.95; and the correlation between group mean total number of responses and group mean total time to the last response was 0.95.

In order to study the fluctuation in free-feeding weight as a function of hours of deprivation, the percentage of free-feeding weight before and after satiation was plotted as a function of hours of deprivation for each of the Group A birds. Figures 3-5 show the data for three birds. The curves for all of the eight birds were of this same general shape. Further graphs can be found in Hogenson (1960),[2] as well as tables giving the deprivation time required for the birds to reach scheduled percentages of free-feeding weight, the time to regain free-feeding weight, and the various measures discussed here.) These curves show, first of all, that with 5 or 11 hr of deprivation, the weights were not much different before and after satiation. The birds did not respond in the experimental box, and therefore did not gain weight, until the percentage of free-feeding weight was dropped to approximately 85%. After approximately 23 hr of deprivation the curves separate as the bird responded and ate during the experimental session. The curves from this point on maintain an approximately equal separation on the *y*-axis. As the hours of deprivation increased, the bird lost weight relative to the previous level of deprivation even though it continued to gain

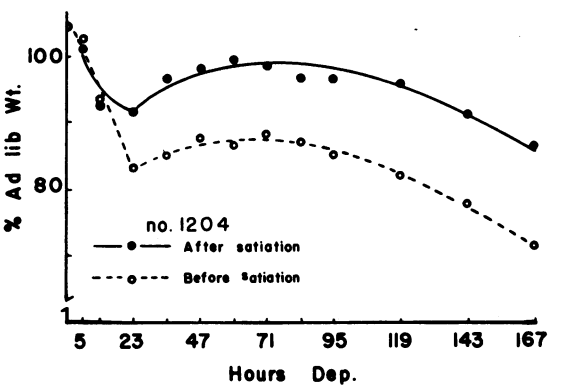


Fig. 3 Percentage of free-feeding weight before and after satiation as a function of hours of deprivation, Bird No. 1204.

an approximately equal percentage of weight during satiation. The bird did not gain enough weight during satiation to regain its free-feeding weight, nor did it gain enough to maintain its weight at a stable percentage of free-feeding weight.

Figure 6 is a plot of the mean percentage weight loss during deprivation as a function of hours of deprivation. We cannot interpret the decrease in weight loss between hours 11 and 35; however, because it occurred with nearly all the birds, it appears to be reliable.

In order to see how the pigeon's rate of response varies with deprivation time and with percentage of free-feeding weight, we computed the rate of response for the 5th through 15th minute for the birds in Group A. Figures 7 and 8 show the group median rate of response for this early part of the satiation curve. According to these graphs, the pigeon responds either at a fairly constant rate or does not respond at all. The critical weight, above which

[2]This thesis may be obtained from the Mount Holyoke College Library on an Interlibrary Loan.

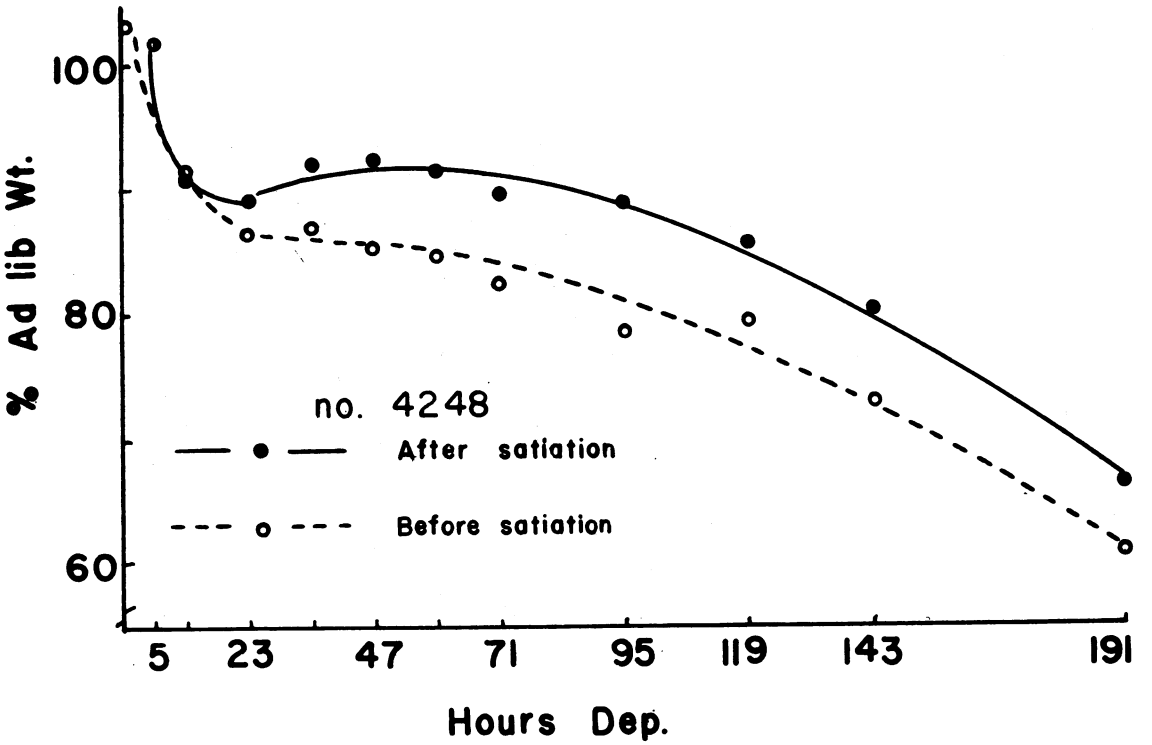


Fig. 4. Percentage of free-feeding weight before and after satiation as a function of hours of deprivation, Bird No. 4248.

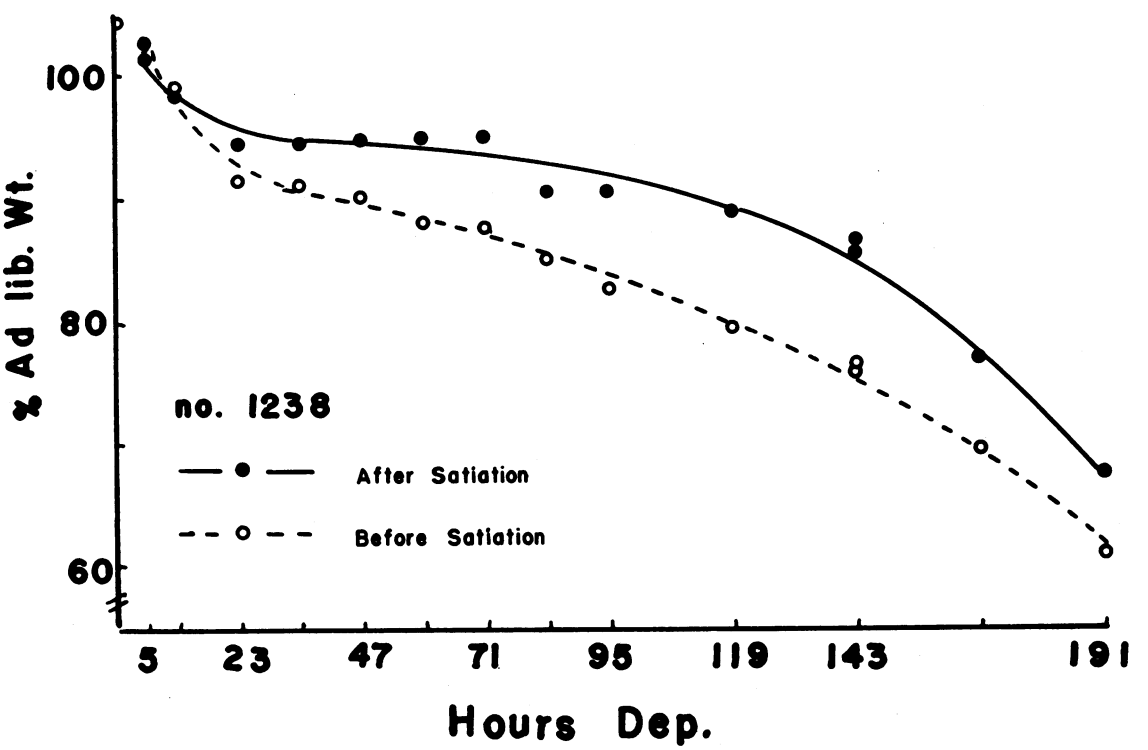


Fig. 5. Percentage of free-feeding weight before and after satiation as a function of hours of deprivation, Bird No. 1238. (This is the same bird whose individual curves are given in Fig. 2.)

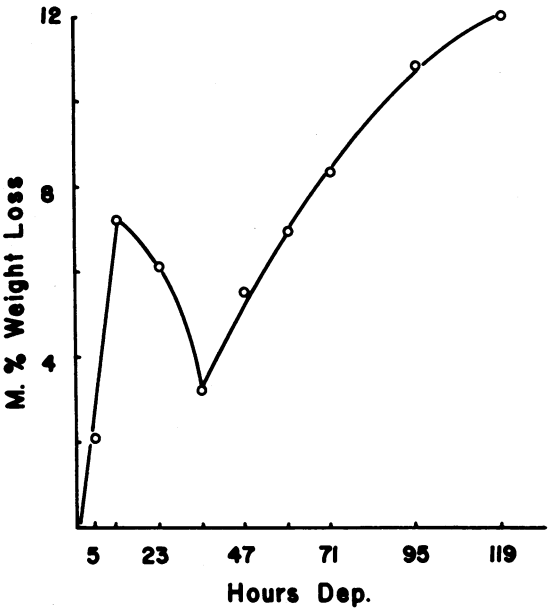


Fig. 6. Group mean percentage wieght loss during deprivation plotted as a function of hours of deprivation, $n = 8$.

it does not respond, appears to be approximately 85% free-feeding weight; the critical deprivation time (under the conditions of this experiment) is 35 hr. However, Ferster and Skinner (1957) report that birds can sometimes work at close to 100% free-feeding weight if they have been used in experiments for some time.

At some time during the experiment, all of the birds emitted pecking responses after which they did not eat. There was no systematic relation between the hours of deprivation and the number of noneating responses the Group A birds emitted.

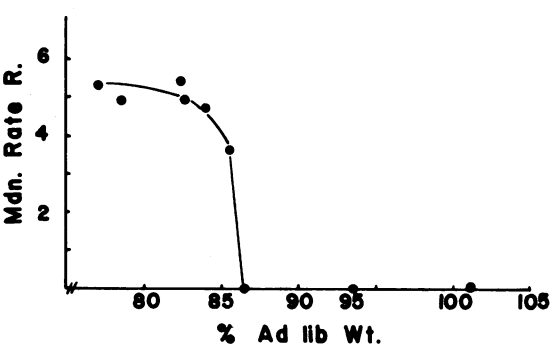


Fig. 7. Group mean rate of response during early part of satiation session plotted as a function of percentage of free-feeding weight, $n = 8$.

Two birds were run in the latter stages of the experiment at approximately 53% free-feeding weight. At this low weight, one bird emitted only 161 responses, gaining only 2.6% free-feeding weight; and the other emitted only 54 responses, gaining 1.0% free-feeding weight. After 2 further days of deprivation, the birds were apparently in the first stages of inanition. Because no useful data for this experiment would result from starving the birds to death, they were put on free feeding. In 18 days, they gained back to 90% free-feeding weight. Another bird which was run at 62%

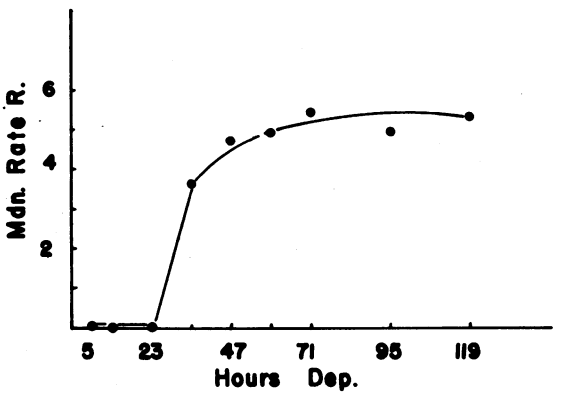


Fig. 8. Group mean rate of response during early part of satiation session plotted as a function of hours of deprivation, $n = 8$.

free-feeding weight died 3 days later. On the day before death, at 57.9% free-feeding weight, this bird showed no symptoms of inanition. In some of the graphs relating percentage of free-feeding weight before and after satiation to hours of deprivation, there is possible evidence of approaching inanition before any apparent clinical symptoms. At least, this is how we interpret these curves, that both continue to decline and at the same time approach each other. This represents a continued decrease in weight *and in inability to gain back the same amount as before.* Figure 4 shows some suggestion of this phenomenon and Fig. 5 is a more obvious example. At 167 hr of deprivation for two other birds, the weight functions for before and after satiation began to approach each other rather than maintain an equal distance on the $y$-axis.

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*Received September 8, 1961*