LOSSES IN VITAMIN B VALUE OF COOKED PEAS HELD AT STEAM TABLE TEMPERATURE

by

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INTRODUCTION

The following report deals with an effort to make quantitative determinations of vitamin B in a food, raw, cooked, and cooked and kept hot in a steam table for a period of time.

The isolation of vitamin B from the various members of the vitamin B complex has established its identity as the heat-labile antineuritic factor necessary for growth, for maintaining the appetite and general well being. Its identity established and its value proven, interest has turned to locating the sources of vitamin B and determining the factors that affect its presence in foods. Previous determinations based on the vitamin B complex have had to be repeated and new estimates made. The biological methods used in making these determinations have required time and effort, and there is still need for more complete data.

In a study made by Funnell (13) it was observed that in a list of 50 of our most commonly used fruits and vegetables for which vitamin values were given, only 13 values were found for vitamin B.

Sources of Vitamin B

Milk: Assays that have been made for the heat-labile factor since its isolation show that much of the potency previously attributed to it has been due to the presence of vitamin G. Milk, for example, was considered to be a good source of vitamin B (40), but the more recent indications are that it is a good source of vitamin G and a relatively poor source of vitamin B. Bender and Supplee (2) quote milk products as a richer source of vitamin G than of vitamin B. Gunderson and Steenbock (14) found the vitamin B value of milk to be always poor and not affected by breed of cow or its diet, but seemingly under the physiological control of the animal.

Vegetables and Fruits: Vitamin B was also previously thought to be widely distributed in all parts of the plant and in liberal amounts (40). Results obtained by Roscoe (33) on leafy vegetables (watercress, lettuce, spinach, cabbage) show them, however, to be a poor source of vitamin B in their natural state when compared with yeast, which, because of its high potency, has been taken as a standard of vitamin B activity. Furthermore, carrots, turnips and potatoes of the root vegetables are reported by Roscoe(34,35) to be less in their vitamin B potency than the leafy vegetables; while of the fruits, apple, banana, orange, and tomato, the orange was the only one equal to the leafy vegetables in its vitamin B value. However Cowgill (8) gives higher values for asparagus, leeks, artichokes and parsnips than for the other vegetables.

Roehm (36), working with Arizona grapefruit and broccoli, reports that both are poor sources of vitamin B but rich sources of vitamin G. Douglass and co-workers (11) found Oregon Bosc pears to be a relatively poor source of vitamin B and a better source of vitamin G.

Animal Tissue: Tests made on certain animal foods show them to be superior to vegetables in this factor. Elvehjem and Sherman (12) report pork muscle, heart, and kidney to be rich sources of vitamin B when compared with the activity of crystalline vitamin B and standard yeast. Brodie and MacLeod (3), making determinations with rat tissue, observed that liver contained gram for gram, ten times as much vitamin B as muscle, and that kidney and brain were one-third as rich, gram for gram, with heart muscle about as rich as liver. Plimmer (30) found liver, kidney, heart, cod-roe, skim-milk powder, and egg yolk to contain more vitamin B than fruits or vegetables in the fresh state, but less than cereals or legumes.

Seeds: In their natural state seeds are demonstrated to be one of our best and most important sources of vitamin B. Of this group, cereals, legumes and nuts rank highest. Hetler and Husseman (21) in a study made on the vitamin B and G content of cereals found that a diet composed of 25% of any of the cereals supplied enough vitamin B for approximately normal growth. Croll and Mendel (9) have shown the concentration of vitamin B to be largely in the embryo of corn. Plimmer (30) has tested the high vitamin content of the germ, bran, and middlings of wheat and states that wheat germ is one of the two very rich sources of vitamin B. Whitsitt (43) in tests made with cotton seed meal found it to be a richer source of vitamin B than whole wheat, weight for weight, and as rich as dried baker's yeast. Considering that 30-60% of the calories of the typical American diet is taken from cereals they become a very important source of vitamin B if taken in the form of whole cereals, but a practically negligible source in the highly refined form such as white flour and farina (39). Dried peas and beans are considered by Cowgill (8) to be a comparatively high source of vitamin B, as are also nuts, with the excêption of the cocoanut. They become an important source when the use of cheaper foods is imperative.

Methods of Determination

The vitamin B value of foods is determined by the following methods: (41) the cure or prevention of polyneuritis in the pigeon, the cure of polyneuritis in the rat, and the one of securing growth response in the rat to graded intakes of the vitamin when all other nutritional elements have been supplied, this being the one most commonly used. One of the more recent procedures is the bradycardia method in which bradycardia, a condition of slow heart beat and a sign of vitamin B deficiency, is cured by the administration of vitamin B containing foods. The amount necessary to effect a cure is taken as the estimate of the vitamin B present.

Standards

The potency of the foods tested may be compared with an International Standard, in which one unit of vitamin B is defined as the anti-neuritic activity of 10 mgs. of the adsorption product (Fuller's earth with vitamin B adsorbed under standard conditions). Ten to 20 mgs. per day are needed to maintain normal growth in young rats and 20 mgs. - 30 mgs. is a pigeon curative dose. (31)

The Sherman Unit (41) is also commonly used in America for measuring the vitamin B potency of foods. It is defined as the amount which, when fed daily will produce an average gain of 3 grams per week in a standard rat during a test period of from 4-8 weeks.

Cowgill (8) gives the following list of foods showing their vitamin B value in terms of Sherman units per gram.

Table I

Potency of Some Foods in Terms of Unit Value
as Indicated by Cowgill (8) (1934)

Food	Sherman-Chase vitamin B unit per gram
Apples, fresh	0.282
Banana, fresh	0.282
Bean, string, fresh	0.317
Cantaloupe	0.282
Cabbage, fresh	0.493
Carrots, fresh	0.282
Collards, raw	1.092
Eggs, whole	0.564
Egg yolk, raw	1.76
Flour, whole wheat	2.18
Flour, graham	2.18
Lemon juice	0.317
Lemon, fresh	0.388
Milk, whole fresh	0.317
Muskmelon	0.282
Oats, rolled	2.18
Onions, fresh	0.211
Orange juice	0.317
Peas, green	2.11
Peaches, fresh	0.282
Potatoes, white, cooked	0.282
Peppers, green	.211
Rutabagas	.282
Spinach, fresh	.775
Prunes, dried	1.34
Tomato	0.423
Turnip greens	1.233
Turnip, fresh	.282

Factors Affecting Losses of Vitamin B

The amount of vitamin B present in a food when it is ready to eat depends upon the treatment it has received. Its physical or chemical properties may be so affected by the method of processing or preparation as to appreciably change its vitamin B activity.

Refining: The process of refining of cereals removes largely the parts of the kernel that are highest in vitamin B, the germ, bran and middlings. The discovery made by Eijkman, Fletcher, and other workers, that diets made up largely of polished rice produced beriberi, indicates the losses due to refining of cereals.

Solubility: Eijkman in 1906 found that the substance now termed vitamin B was soluble in water. Bodansky (5) gives solubility as one of the characteristic properties of vitamin B. Losses of this vitamin in foods might, therefore, be expected to result from soaking in water. Still further losses could be expected from discarding the water in which the food is cooked. Rose (32) believes that as much as 50% of the vitamin is lost in this way. The soluble property of the vitamin is observed also in its penetration to all parts of a cooked product. Aykroyd (1) reports a higher percent of vitamin B in rice that has been soaked and steamed before milling than in rice not soaked and steamed. He believes his results are due to the diffusion of the vitamin into the endosperm from the husk, since less vitamin B was present in the husk of the soaked than in that of the unsoaked. Miller and Robbins (27) of Hawaii, in tests made on radish pickled in a paste of salt and rice bran, an oriental dish, found that vitamin B had penetrated to the inner tissues of the radish.

Acids and Alkali: In the presence of strong acids vitamin B is not readily destroyed. McCollum and Simmonds (26) found yeast could be heated with 20% sulphuric acid for 24 hours without lessening its antineuritic properties. With a lower acidity there was a decreasing activity depending upon the degree of temperature and the length of time heated. In heating tomato juice with a pH of 4.3 at 100° C. for 4 hours Sherman (41) found there was an increasing loss with increase of temperature, 55% being inactivated at 130° C. At a constant temperature of 100° C. the losses after 4 hours increased with decreasing acidity or increasing alkalinity, 65-75% destruction occurring at pH 7.9. Alkali causes destruction at low temperatures (41) but it becomes more serious with increased heat. The addition of soda to the water in which vegetables are cooked increases the rate of vitamin B destruction (32).

Oxidation: This factor is not believed to affect vitamin B potency. Sherman did not find that it played any part in the losses sustained in his tests with tomato juice, since the heating was done in both loosely-stoppered flasks and under strictly anerobic conditions with the same results; however Halliday (20) believes that this vitamin may not be entirely unaffected by oxidation even at pH 3 or 4. She found vitamin B potency was greater when "protein free milk" was shaken with Lloyd's reagent under an atmosphere of nitrogen than when shaken in air.

Dehydration: There seems to be some difference in vitamin B potency after dehydration of food stuffs. Rose (32) reports that tomatoes, spinach, cabbage, turnips, and carrots have been dried without vitamin B destruction. Levine (24) quotes Morgan, who observed that 61% of the vitamin B was retained in Adriatic figs. A greater loss was found in sulphured dried figs of the same variety amounting to 73%.

Fermentation: Vitamin B appears to be seriously affected by fermentation, especially when continued for a period of time. Chachin (10) found that the quantity of vitamin B decreased with the progress of fermentation in the mash of soy cakes, and that no potency was observed in mash fermented for 3 months.

Freezing: As shown in results obtained by Funnell (13), freezing had no measurable effect upon the vitamin B content of fresh peas and fresh lima beans.

Heat: Susceptibility to heat at temperatures above 100° C. is generally agreed to be a distinguishing characteristic of vitamin B. Factors that modify the destruction due to heat are the pH of the food tested, whether the heating medium is moist or dry, the temperature and the length of time heated.

Keenan and co-workers (22) have shown that the antineuritic potency of liver and yeast are almost completely destroyed after autoclaving in the fresh state at 100°C. for 24 hours, and partly destroyed by moistening and drying at 65°C. for 24 hours. When dry heat was used at 100° C. for 24 hours there was no vitamin B destruction.

Pasteurized milk is not generally thought to suffer vitamin B loss since the highest temperature used in pasteurizing is 74°C. maintained for 1 minute (37), but Krauss (23) reports a 25% loss in pasteurizing of milk. Guerrant and Dutcher (16) in a study of the various methods of pasteurization and its effect on vitamin B state that some loss occurs in all methods of pasteurizing with a maximum destruction of 38% in some. Sherman (41) reports studies on fluid milk heated 6 hours at 100° C. showing 25% destruction of vitamin B. There was no measurable diminuation when milk powder was heated in dry form with free access to air at 100° C. for 48 hours.

Evaporated cow's milk is reported by Samuels (38) to lose about one-sixth to one-fifth of vitamin B in the evaporating process.

In baking there seems to be but little, if any, destruction if the medium of the food baked is fairly dry, even though oven temperatures are higher than the average boiling temperature. Thus Morgan (29) in studies made with bread baked at 446°F. found no destruction of vitamin B except in the crust.

The commercial canning of fruits and vegetables, which is done at high temperatures tends to the destruction of vitamin B.

Cooking at the ordinary boiling temperatures has not been regarded as causing any appreciable destruction of vitamin B. Rose (32) (1933) believed that heating caused but little destruction at boiling temperature but that the destruction increased as the heating continued. Sherman (41) was of the opinion (1932) that the destruction in cooking or canning should be regarded as relatively small unless the natural acidity of the food has been changed by the addition of alkali. Whipple (42) tested the vitamin B potency of raw and cooked oysters and reported that cooking had practically no destructive effect upon the vitamin B content. The cooking time for oysters is short, however. Munsell and Kifer (25) made a study of the vitamin B losses in cooked broccoli and found that in 15 minutes of cooking 50% of the vitamin was destroyed. Funnell (13), using fresh peas, found a 26% destruction in 15 minutes of cooking.

EXPERIMENTAL

Purpose

No reports have been found dealing with the effect of prolonged heat on a cooked product at temperatures less than 100° C. A very large proportion of our commercial eating establishments must rely on some method of keeping prepared foods hot during the serving period, which may be anywhere from one-half hour to two hours, depending upon the method of service and the number of people served. If Funnell (13) and Munsell (25) found that 15 minutes at boiling temperature was sufficient to destroy from 26% to 50% of the vitamin B content of a food, it seemed possible that further destruction might occur under conditions of prolonged heat after cooking.

For those who must depend upon food in the cafeteria or lunchroom for the vitamin B essential, any method of preparation or preservation that affects it detrimentally becomes a matter of nutritional interest and importance.

The purpose then of this study was to test the effect of prolonged moderate heat upon the vitamin B value of a cooked food under conditions of temperature and time comparable to those necessary in serving food from a cafeteria steam table.

Fresh peas were chosen for the test because they are a popular food and because they could be furnished regularly from the winter gardens of California. Being winter grown the results could be compared with those that have been reported by others on summer grown peas. Quantitative determinations were, therefore, made on cooked fresh peas held for one hour at steam table temperature. As a basis for comparison of possible vitamin B losses, quantitative determinations were also made on cooked peas and raw peas.

Animals: The rat growth method of determination was used in the investigation. White rats, bred in the laboratory of the nutrition department from stock animals that had been fed the Steenbock stock diet, were weaned when they were 24-28 days old. Their weights at this time averaged 40-55 grams. They were placed in individual cages with the wide mesh, raised screen floor to lessen the dangers from coprophagy. Distilled water from glass tube drinking bottles and the basal diet were accessible at all times.

Basal Diet: The basal diet used was essentially that of Sherman and Chase (41) consisting of:

Leached casein	18%
Cornstarch	51%
Osborne and Mendel salt mixture	4%
Agar agar	2%
Butterfat	8%
Cod liver oil	2%
Autoclaved yeast	15%

The casein was leached of vitamin B by soaking for 5 days in a dilute acetic acid solution. The water was changed twice daily, the last five washings being done with distilled water.

The butter fat was heated to about 60° C. and filtered through cotton to remove all curd and whey.

The yeast was prepared by first mixing with water to form a smooth paste and then neutralizing to litmus with sodium hydroxide. This was done to insure a more complete destruction of vitamin B during the heating process. The yeast was then autoclaved at 15 lbs. pressure for 6 hours, dried, ground, and stored for use.

Depletion Period: There was a continued gain in weight of the experimental animals for the first 10-14 days of the depletion period. The weight then became stationary and began to decline. When the weight was 1 or 2 gms. less than it had been one week before, the vitamin B stores were considered to be depleted and the rats ready for the test period proper. As nearly as possible they were divided according to sex and weight into 7 groups. Forty-two rats were used in feeding the three forms of the supplement at seven different levels. Six rats were used on each level and one from each litter was retained on the basal diet for a negative control.

Supplements--Peas: The peas to be used for testing were bought each week in the local market and stored in an electric refrigerator (at a temperature of 38° F.) until time to prepare them for the supplementary feeding when they were shelled and weighed into three 100 gram portions. The two portions for cooking were placed in enamel containers and one-half cup of boiling water added to each portion. They were covered and cooked 20 minutes, the average boiling time being 18 minutes. During the last five minutes the lid was removed to allow the water to evaporate to dryness. They were then cooled and weighed and any additional water needed to restore them to the original 100 gram weight was added. This added water had first been used to rinse the pan in which the peas were cooked. Possible losses of the vitamin by solution were avoided in this way.

One 100 gram portion of the peas was then covered and placed in a steam bath. Sufficient steam was applied to maintain a temperature of 85° C. for 1 hour. The temperature reading was taken every 20 minutes. Eighty-five degrees C. was determined as an average of steam table temperature from records taken at a cafeteria for several days. After removing from the steam bath the peas were again cooled, weighed, and water added to restore their original 100 gm. weight. By so doing the cooked peas and those cooked and held at steam table temperature could be fed on the same basis as raw peas.

All three forms of the supplement were ground in a food chopper in order to mix more thoroughly and make all parts accessible for feeding and weighing. They were then placed in half pint glass jars, covered tightly, labelled and returned to the refrigerator where the temperature was kept at 38° F. This process of preparing the peas was repeated each week during the experimental period.

Supplementary Feeding: The supplements were fed 3 times a week, calculated on the basis of daily feedings. Raw peas were fed at 0.2 gm. and 0.4 gm. levels. The cooked peas at 0.266 gm. and 0.532 gm. levels and the peas cooked and held at 85° C. for one hour, at 0.3 gm., 0.5 gm, and 0.7 gm. levels.

In calculating the levels to be used an effort was made to supply an amount large enough to produce only the desired 3 gms. gain in weight per week, which is the least amount that will maintain health in the experimental animals. The weighing of the supplement was done on an analytical balance as rapidly as possible to prevent errors from loss of moisture by evaporation. The peas were placed on glass supplement dishes and any portions that were spilled were recovered and replaced in the dish.

The rats were weighed each week for four consecutive weeks and records kept of losses and gains in weight.

RESULTS AND DISCUSSION

Negative Controls

The negative controls in this study showed signs of rapid decline as the experimental period progressed. Loss of appetite was noted, rapid loss in weight, listlessness and weakness, the characteristic humped spine and kinked neck, and general malnourished appearance were also observed. The feces became few and small, the ears, tail, and feet anemic in appearance. All the negative controls died before the end of the experimental period, with the exception of one, their average survival period being 24 days. Signs of polyneuritis did not develop in this group. This is evidence that the basal diet was free of vitamin B. Sherman (41) quotes Drummond who suggests that negative controls on a vitamin B free diet do not develop polyneuritic symptoms because some vitamin B is supplied by liberation from the rapid breakdown of body tissue.

Autopsy findings revealed a shrunken prolapsed condition of the intestinal tract with a hard mass of undigested food in the stomach and cecum. These observations were made also on the rats receiving low level supplements but not in the rats on the higher levels that had made good weight gains. Rowland (8) is quoted as believing that this prolapsed condition and stasis is due to a degeneration of the muscular coats of the bowel, the lack of muscular tone preventing normal peristalsis, so that the food does not move onward. These observations are in keeping with the generally accepted findings that vitamin B is essential to the health and integrity of the intestinal tract.

A possible explanation for the longer life of the one negative control may be that in the negative control group and the rats on the lowest levels, coprophagy was observed on several occasions. This is not an unusual observation in rats deprived of vitamin B. Guerrant and Dutcher (15) call attention to the improvement in physical condition of rats fed supplements of feces because of the presence of vitamin B in them.

<u>Low Levels</u>

The results of the experimental feeding are summarized in TableVI. From these data it will be seen that the rats on the lowest levels of all three forms of the supplement lost weight during the four weeks period. Two animals, one in the group fed 0.266 gm. cooked peas and one in the group fed 0.3 gm. cooked peas held at steam table temperature made gains of 12 gms. each. For this there was reason to suspect coprophagy as in the negative control group. The losses in weight of rats on these low levels for all three forms of the supplement are seen to vary widely.

For the animals fed 0.2 gm. raw peas, the variation is from -1 gm. to -34 gms; for those fed 0.266 gm. cooked peas, the losses vary from -1 gm. to -31 gms; for those fed the 0.3 gm. level of cooked peas held at steam table temperature the variation is from -3 gms. to -17 gms. with average weekly losses of 3.5 gms; 3.1 gms. and 1.2 gms. respectively. Variation in weight can be expected, according to Bisbey(6) when rats are fed diets very low but not entirely lacking in vitamin B.

Being definitely too low to secure unit growth it is not possible to estimate the effect of the heat treatment on vitamin B at these levels. It has been shown by McClure and co-workers (28) that in feeding less than the necessary amount of vitamin B for unit growth we are not dealing alone with the nutritional effect of a lack of vitamin B but with the effects of inanition also. Symptoms of polyneuritis developed in the animals on all three levels, but was more pronounced in the rats fed 0.2 gm. of raw peas. Loss of muscular control, paralysis of the hind legs and cart wheel turnings were observed. Autopsy findings were similar to those found in the negative controls.

Raw Peas Supplement

In the group fed 0.4 gm. of raw peas per day an average gain of only 1.5 gms. per week was made. Evidently this level was still too low to secure the desired 3 gms. gain per week. There were definite symptoms of vitamin B deficiency though not so pronounced as in the lower levels. Stunted growth, kinked neck and variable gains in weight were noted. Three rats on this level made 10 gms., 12 gms., and 13 gms. gain respectively, while three others made gains of 1 gm., 3 gms., and -3 gms. This still shows the inconsistency in growth found in feeding the vitamin at levels that are too low. These results were unlooked for since the calculated 0.4 gm. level was within 0.1 gm. of the amount fed by Funnell (13) with which she obtained an average weekly gain of 7.9 gms. with fresh peas. Comparing results in terms of units per gm., Funnell obtained 5 units per gm. with 0.5 gm. fresh peas as compared with 1.2 units per gm. with .4 gm. fresh peas as found in the present study. In considering the possible causes for this difference in results it is to be noted that Funnell worked with summer grown peas, while those used in this study were winter peas. Differences of season, climate, soil, variety, and degree of maturity should be taken into consideration in evaluating the results. Previous investigations have shown that such conditions are factors affecting the vitamin B activity of food. Bell and Mendell (7) found that the vitamin B complex was two to three times as rich in spring wheat as in winter wheat. Hunt (18) found a wide difference in the vitamin B content of wheat grown in different years, which he considered to be due to variation in climate; also Funnell (13) found a variation in the vitamin B content of fresh peas grown during different seasons.

Maturity: Hunt and Krauss ([18]) report a higher percent of vitamin B in milk from cows fed grass grown during the months when conditions of heat and moisture produced rapid growth than in milk from cows fed grass produced during the colder part of the growing season. They observed that the less mature tender grass contained a higher percent of the vitamin than the over mature grass.

In a later study made on alfalfa and timothy hay, Hunt and Bell ([17]) report that as the hay matured, the protein and vitamin B and G values decreased markedly. Timothy cut June 12, 25, and July 3, yielded 0.77 units, 0.66 units, and 0.5 units per gm. respectively. These findings have a special bearing upon the interpretation of the results obtained in this study in which the maturity of the peas varied greatly. Some of these were very immature but a larger part was over mature, sprouts having formed in many cases. Twenty minutes instead of the usual 15 were necessary to cook the peas sufficiently.

Homogeneity: A factor which may have influenced the amount of vitamin B in the raw supplement was the uneven distribution of the embryo and skin of the pea in the weighed supplement. These parts did not mix well with the less vitamin B rich endosperm possibly interfering with the accuracy of the determination.

Cooked Peas

In studying the results obtained with cooked peas fed at the 0.532 gm. level it was observed that the animals made consistent gains averaging 4 gms. per week. This is more than the necessary 3 gms. gain per week needed to measure a unit of vitamin B; cooked peas in this study are found to contain, therefore, 2.4 units of vitamin B per gram.

Unfortunately no comparison of the losses in cooking peas can be made here since the supplement of 0.4 gm. of raw peas per day failed to produce the unit growth necessary for a basis of comparison.

As has already been shown, however, vitamin B is sensitive to moist heat at temperatures above 100° C. Increasing alkalinity and decreasing acidity hasten its destruction. The work done by Keenon and co-workers (22) on autoclaved yeast and liver and that done by Sherman (41) on tomato juice demonstrate the susceptibility of vitamin B to heat. The loss of 50% of the vitamin in cooking of broccoli as shown by Munsell (25) and of 26% in the cooking of peas as shown by Funnell (13) indicate the losses that may be expected by the ordinary cooking process. Comparing the results obtained in this study with those obtained by Funnell we find a vitamin B value of 2.4 units per gram for cooked winter peas as compared with 3.9 units per gram for cooked summer peas. This variation is one that might be accounted for as due to difference in season, climate, and variety of product, as shown by the reports of previous investigations.

Cooked Peas Held at Steam Table Temperature

The rats fed 0.5 gm. of cooked peas maintained at steam table temperature made the average gain of only 1.3 gms. per week. There were definite symptoms of polyneuritis and the variability in growth that is found in feeding low levels of vitamin B. In terms of unit value only 0.86 units per gram were found in the peas at this level of this supplement. As compared with 2.4 units per gram for cooked peas there would seem to be a serious loss due to the steam table holding period.

With the 0.7 gm. level of the supplement, however, better results were obtained. An average weekly gain of 6.4 gms. per week was made, giving a vitamin B value of 3 units per gram for cooked peas maintained for 1 hour at 85° C. and fed at 0.7 gm. per day.

A possible explanation for the marked difference in results of these two levels of the same supplement is that the 0.5 gm. level is just under the amount needed to produce unit growth. The 0.7 gm. level, on the other hand, is just enough higher to supply the amount of vitamin B needed for more growth and appetite. A factor that might have influenced the higher vitamin B value of the peas held at

85° C. for 1 hour is the soluble quality of vitamin B. The long heating process at a comparatively low temperature may have caused a diffusion of this vitamin from skin and embryo throughout the endosperm so that more was accessible in this form than in the peas cooked for only a short time. The results obtained by Aykroyd (1) with rice that had been soaked and steamed before milling might be considered as comparable to the results obtained here with peas held for 1 hour under conditions of moisture and heat. Aykroyd found more vitamin B present in the rice soaked and steamed before milling than in the rice not soaked or steamed. He believed this was due to the diffusion of the water-soluble vitamin from the bran and embryo.

The evaporation of moisture while weighing the supplement might be considered also to have influenced the amount of both the cooked supplements actually fed. The cooked peas held at steam table temperature, however, always seemed more moist than the cooked supplement and the evaporation more rapid in weighing.

In view of the fact that several of the levels were too low to constitute a measure of the vitamin B present and that there were variations in weighing due to evaporation, also possible variations in the dispersion of the vitamin in all parts of the pea, no definite conclusions can be drawn at this time as to the effect of holding this food at steam table temperature. Further work needs to be done using higher levels if winter peas are to be tested, for the results of this study lead to the conclusion that there are many variables influencing the vitamin B content of peas.

SUMMARY

1--Raw peas and peas cooked and those cooked and held for one hour at 85° C. in a steam table have been tested for their vitamin B value.

2--The lower levels used in feeding raw peas, cooked peas, and cooked peas held at steam table temperature, were all too low to produce gains in weight in rats depleted of their stores of vitamin B.

3--No accurate determinations were obtained for the vitamin B value of fresh peas since the 0.4 gm. level used was also too low to give the necessary 3 gms. gain per week. Four tenths gm. of raw peas produced an average gain of only 1.5 gms. per week.

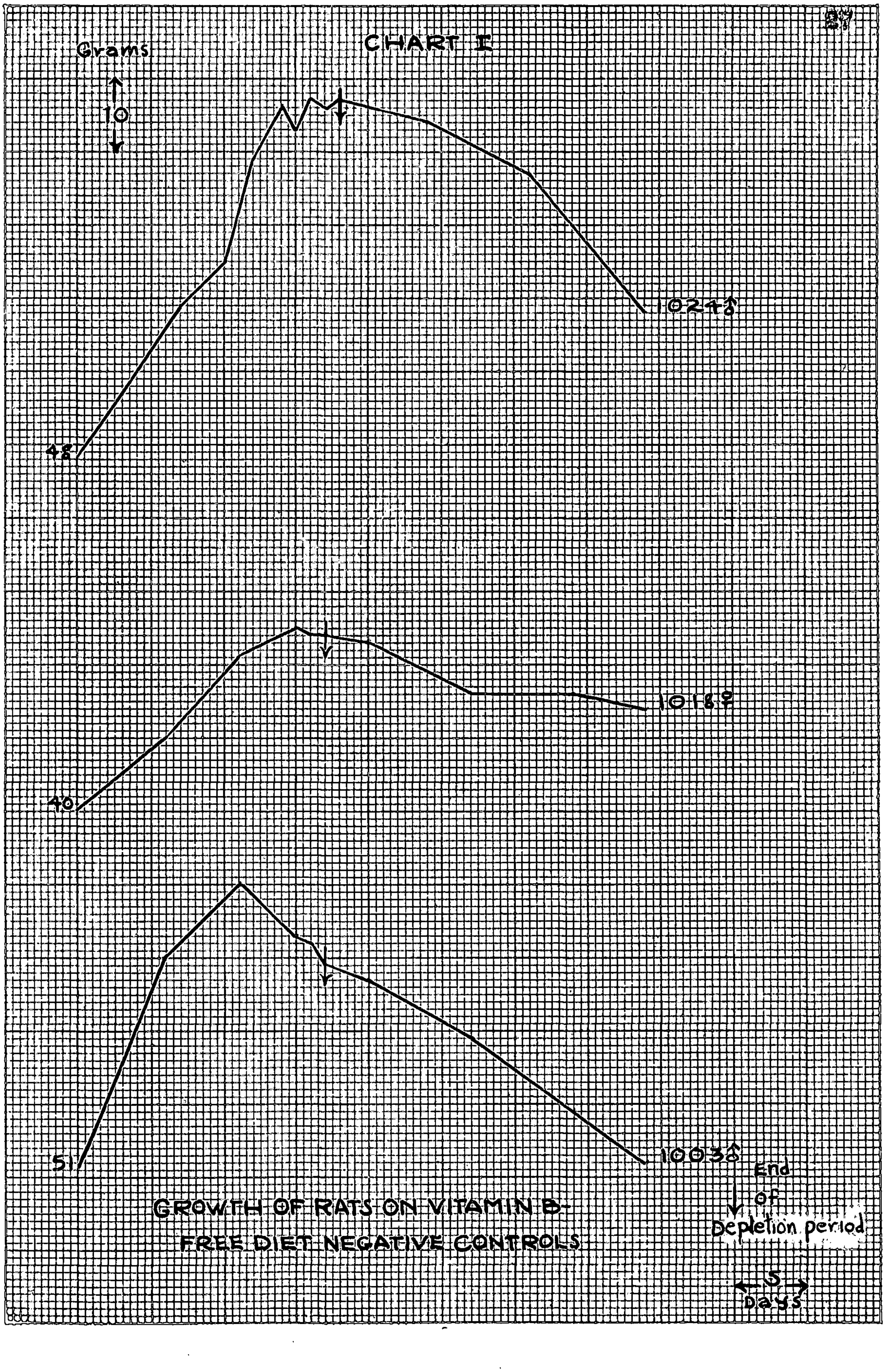
4--It is not possible to determine the losses of vitamin B in cooked peas because of the low level used in raw peas. Cooked peas fed at 0.532 gm. per day produced an average gain of 4 gms. per week. This would indicate a vitamin B value of 2.44 units per gm. for cooked peas.

5--Cooked peas held for one hour at 85° C. did not produce unit growth when fed at 0.5 gm. per day but when fed at the higher level of 0.7 gm. per day, good average gains of 6.4 gms. per week were obtained. This would indicate a vitamin B value of 3 units per gm.

6--As good results were obtained with cooked peas maintained at 85° C. for 1 hour as with peas cooked 20 minutes, therefore no losses of vitamin B can be attributed to the holding of peas at 85° C. for 1 hour.

7--The results obtained in this study are inconclusive, however, because one or more of the levels in all three forms of the supplement were too low to give unit growth.

8--The peas used in this study are shown to be lower in vitamin B than those used in tests by other investigators.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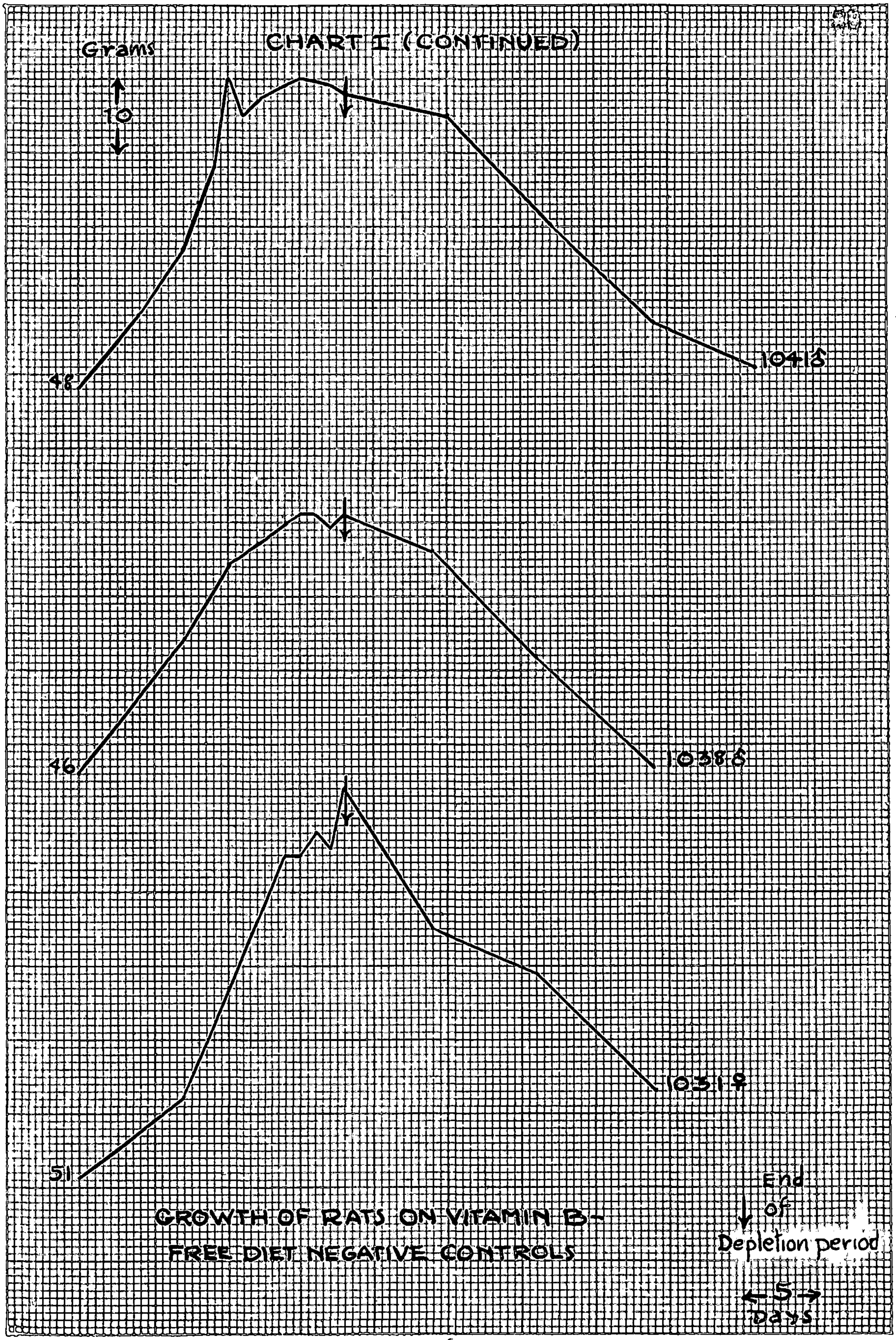
GROWTH OF RATS ON VITAMIN B-
FREE DIET NEGATIVE CONTROLS



GROWTH OF RATS ON VITAMIN B-FREE DIET NEGATIVE CONTROLS

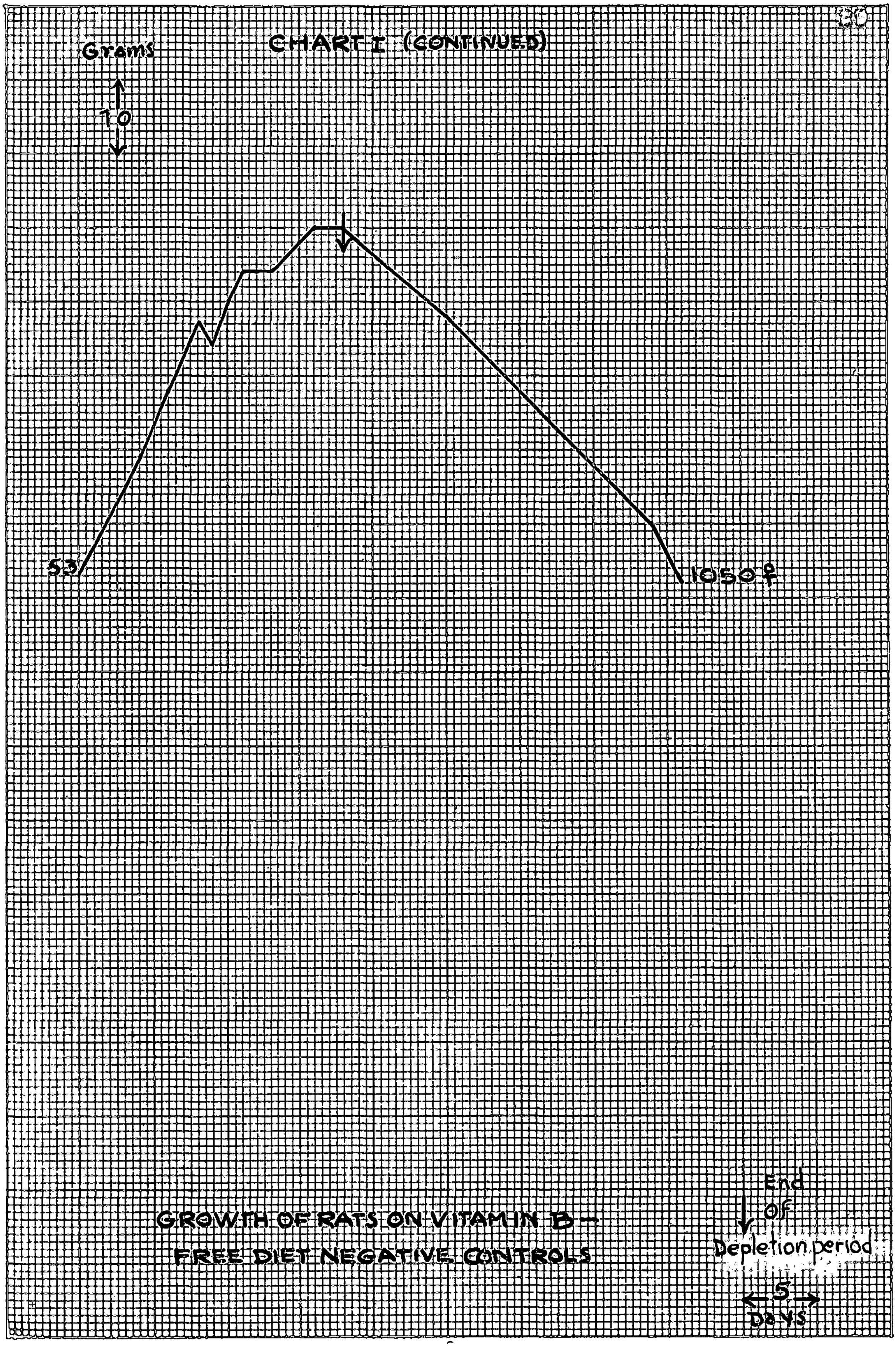
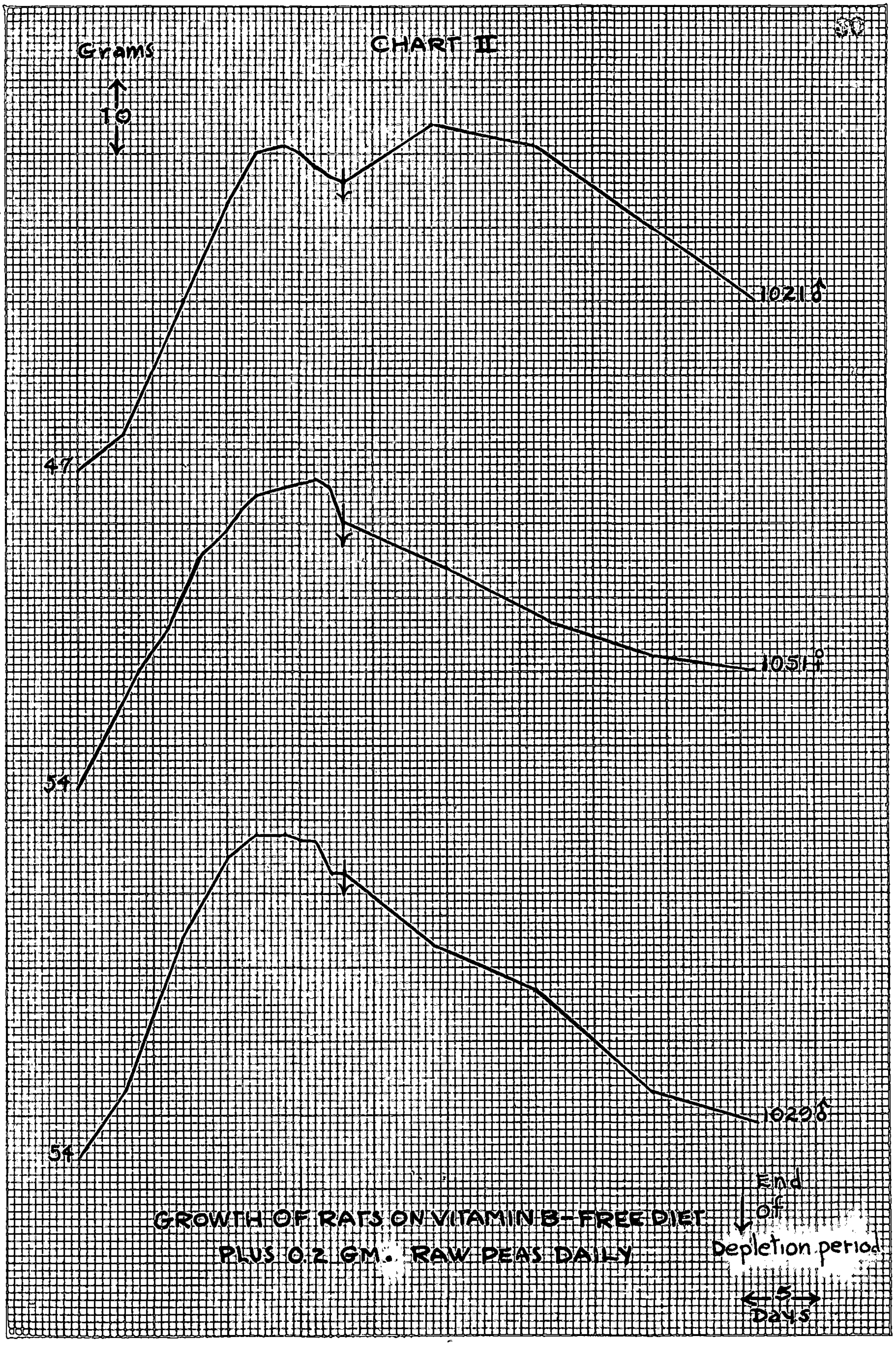
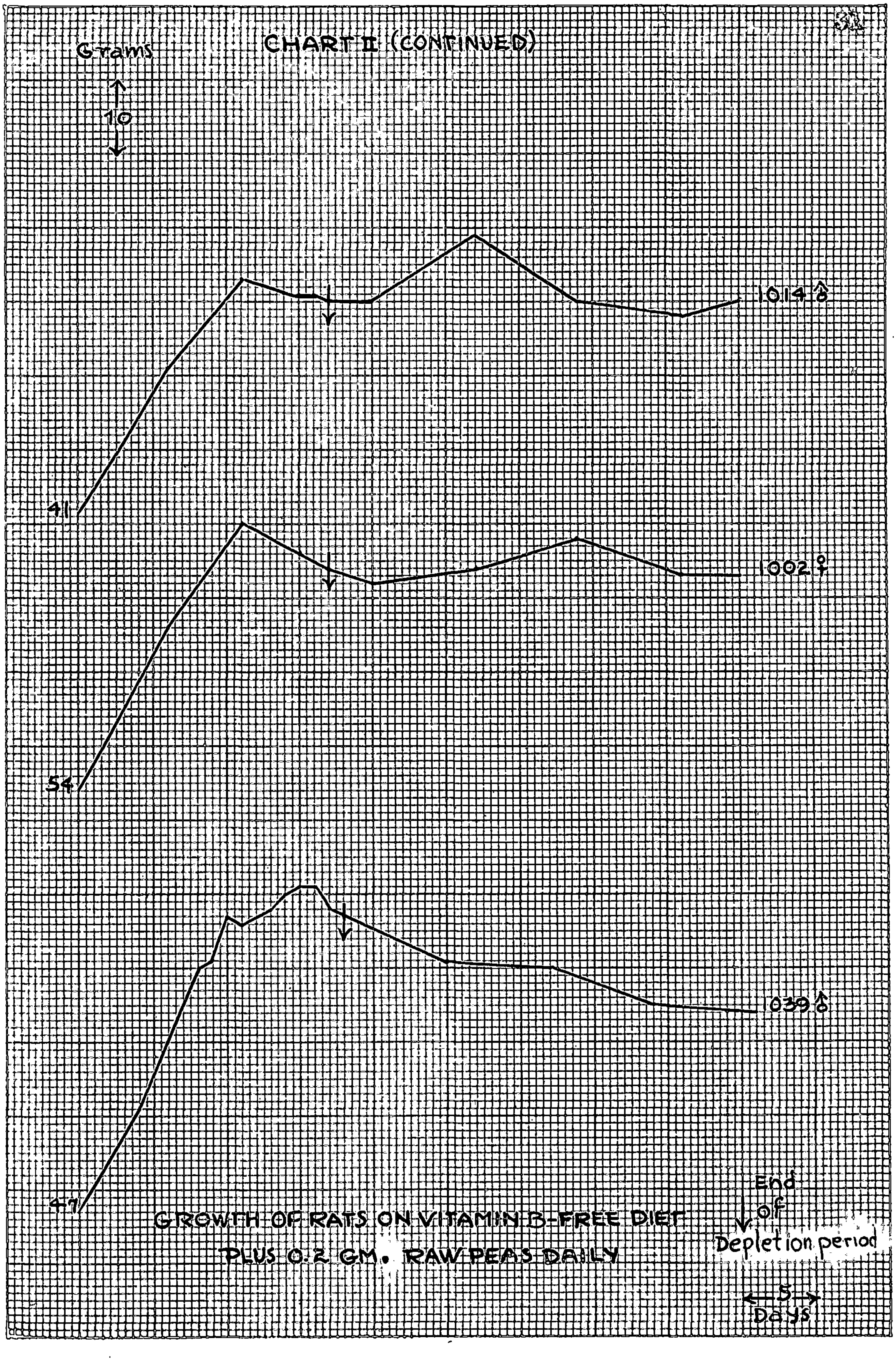


CHART I (CONTINUED)
Grams
10
53
1050 ♀
GROWTH OF RATS ON VITAMIN B -
FREE DIET NEGATIVE CONTROLS
End
of
Depletion period
5
Days



GROWTH OF RATS ON VITAMIN B-FREE DIET
PLUS 0.2 GM. RAW PEAS DAILY

CHART II (CONTINUED)



GROWTH OF RATS ON VITAMIN B-FREE DIET PLUS 0.2 GM. RAW PEAS DAILY

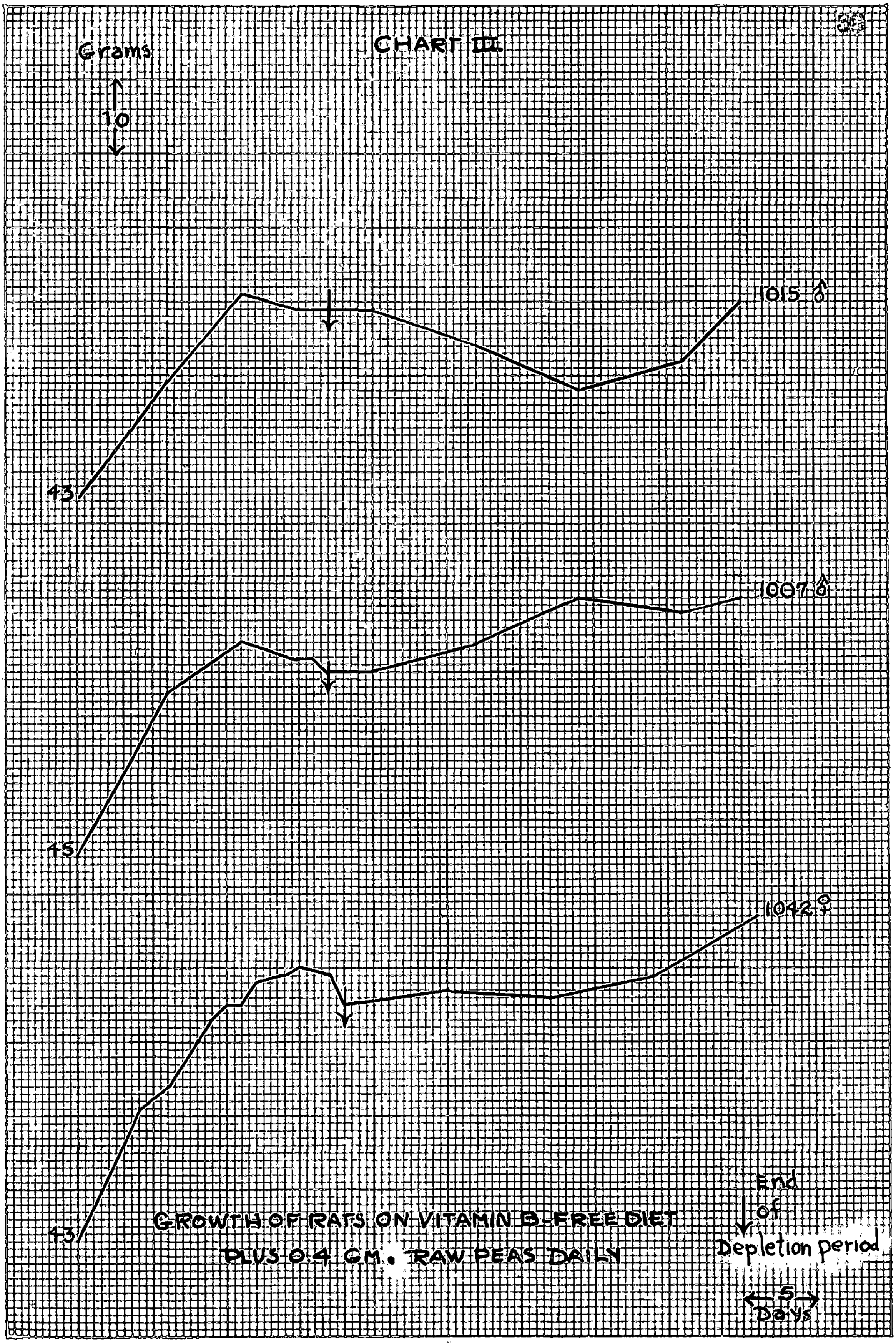


CHART III
Grams
10
1015 ♂
43
1007 ♂
45
1042 ♀
43
GROWTH OF RATS ON VITAMIN B-FREE DIET
PLUS 0.4 GM. RAW PEAS DAILY
End of Depletion period
5 Days

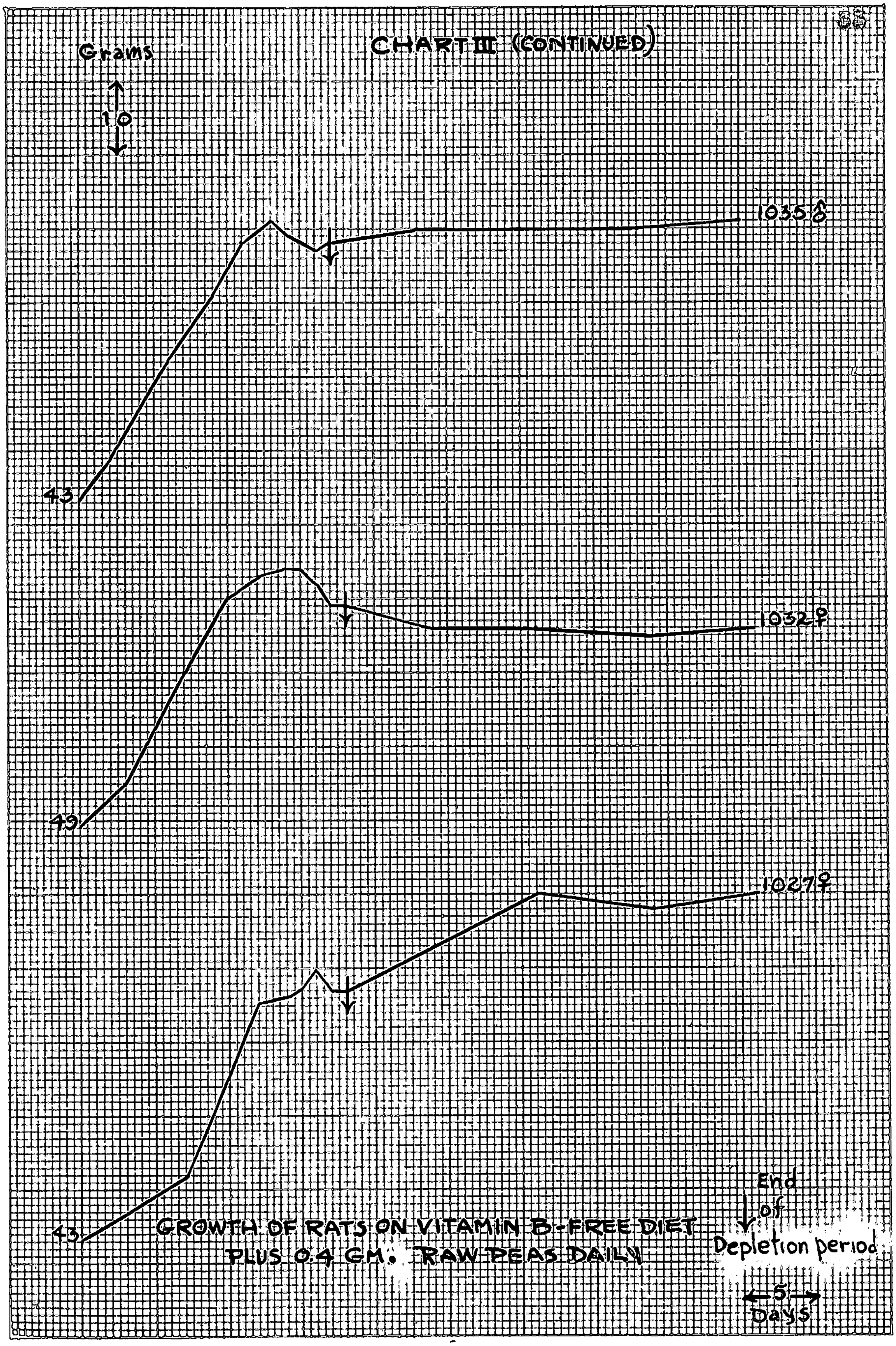
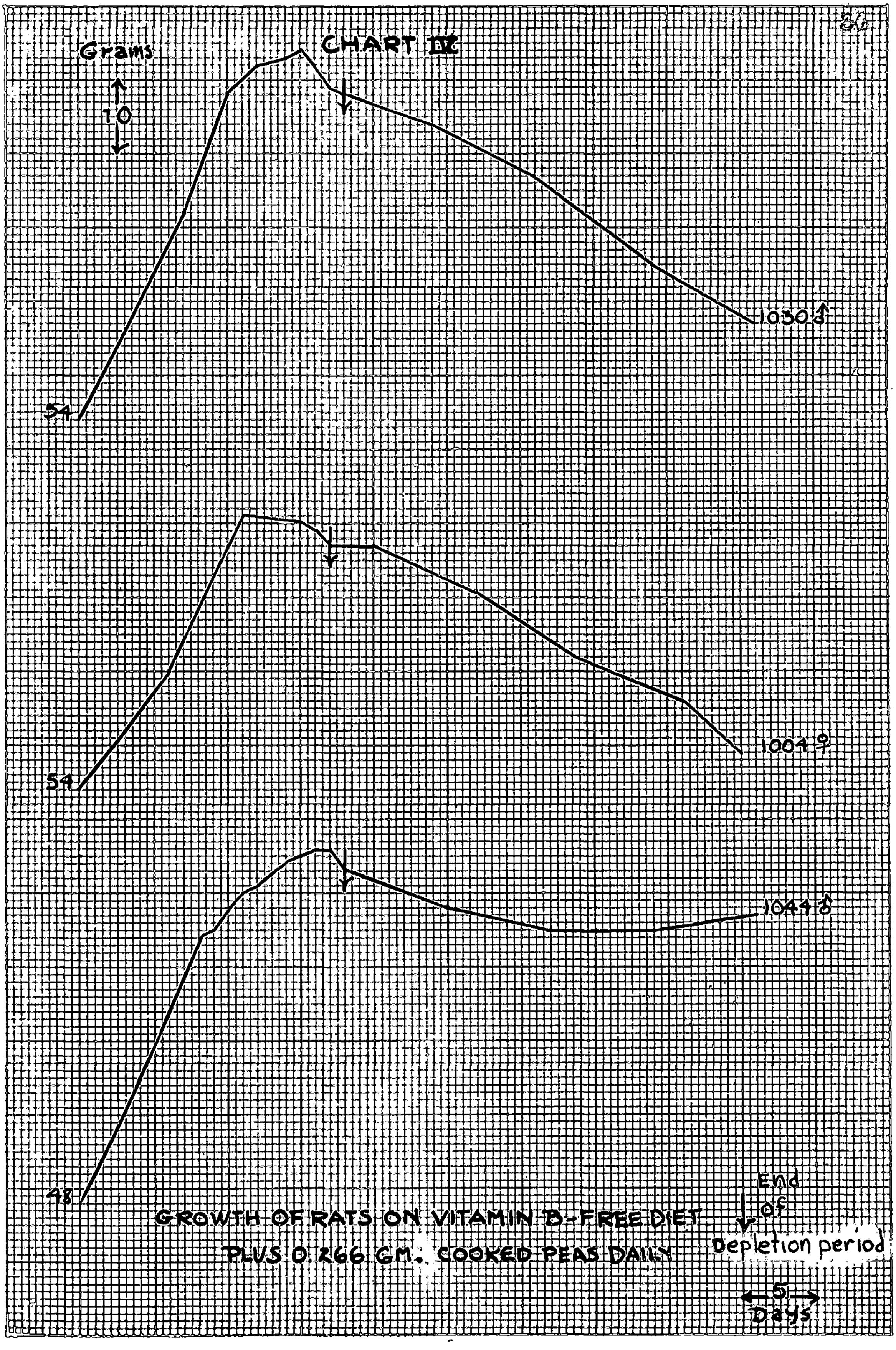


CHART III (CONTINUED)
Grams
1.0
1035♂
43
1032♀
49
1027♀
43
GROWTH OF RATS ON VITAMIN B-FREE DIET
PLUS 0.4 GM. RAW PEAS DAILY
End
of
Depletion period
5
Days

CHART IV



GROWTH OF RATS ON VITAMIN B-FREE DIET
PLUS 0.266 GM. COOKED PEAS DAILY

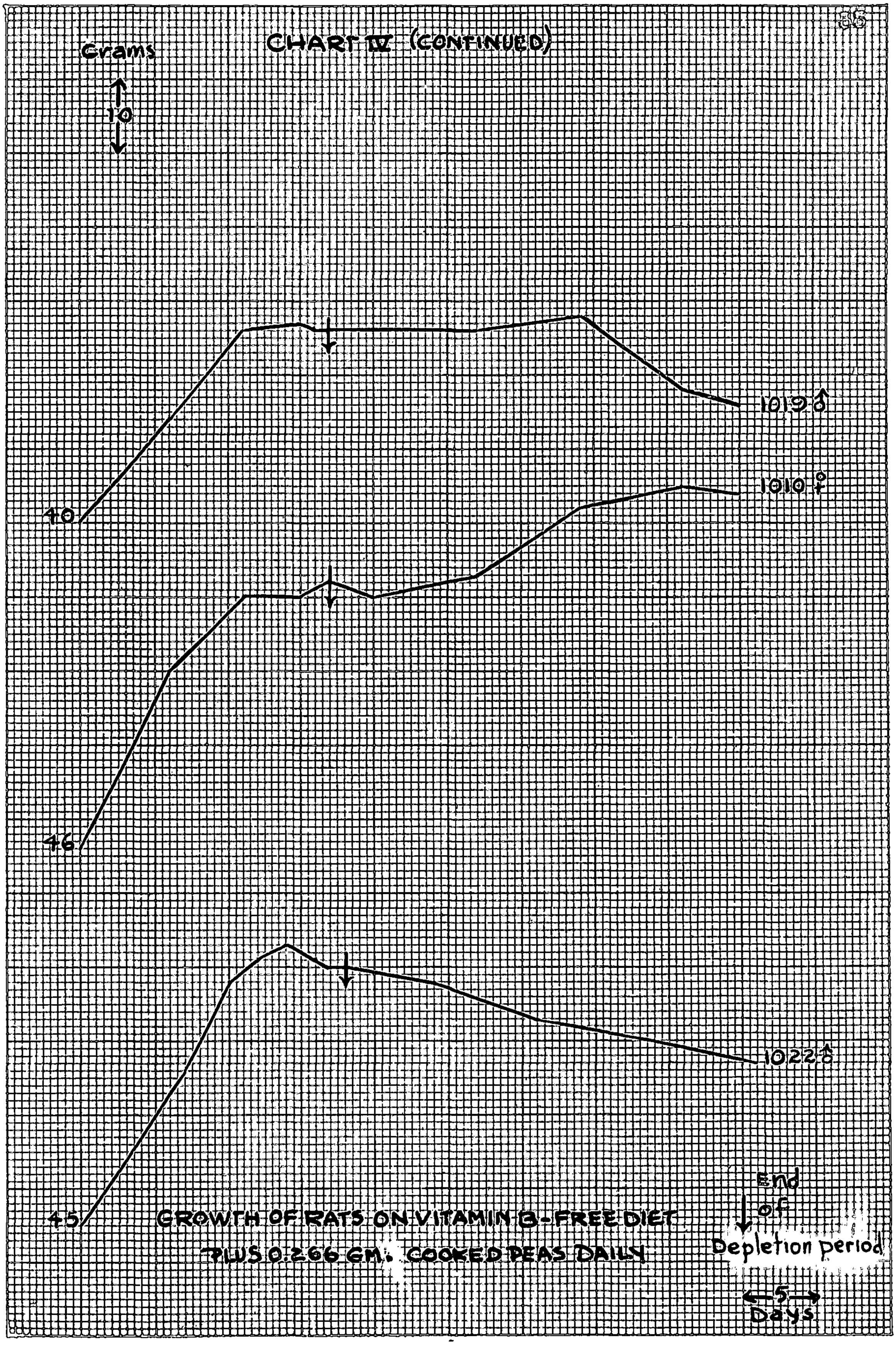


CHART IV (CONTINUED)
Grams
10
1019 ♂
1010 ♀
40
46
1022 ♂
45
GROWTH OF RATS ON VITAMIN B-FREE DIET
PLUS 0.266 GM. COOKED PEAS DAILY
End of Depletion period
5 Days

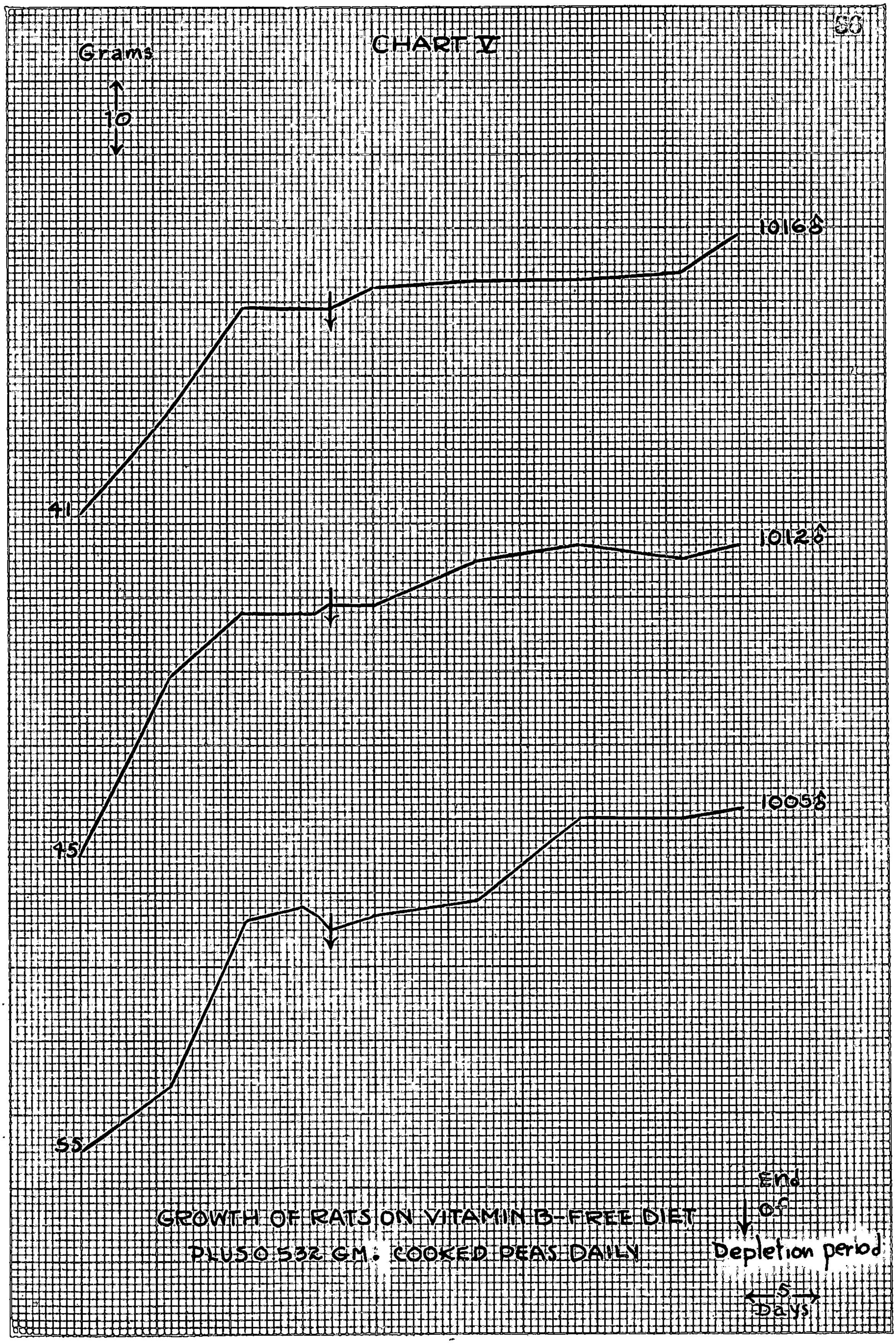


CHART V
Grams
10
41
45
55
1016♂
1012♂
1005♂
GROWTH OF RATS ON VITAMIN B-FREE DIET
PLUS 0.532 GM. COOKED PEAS DAILY
End of Depletion period
5 Days

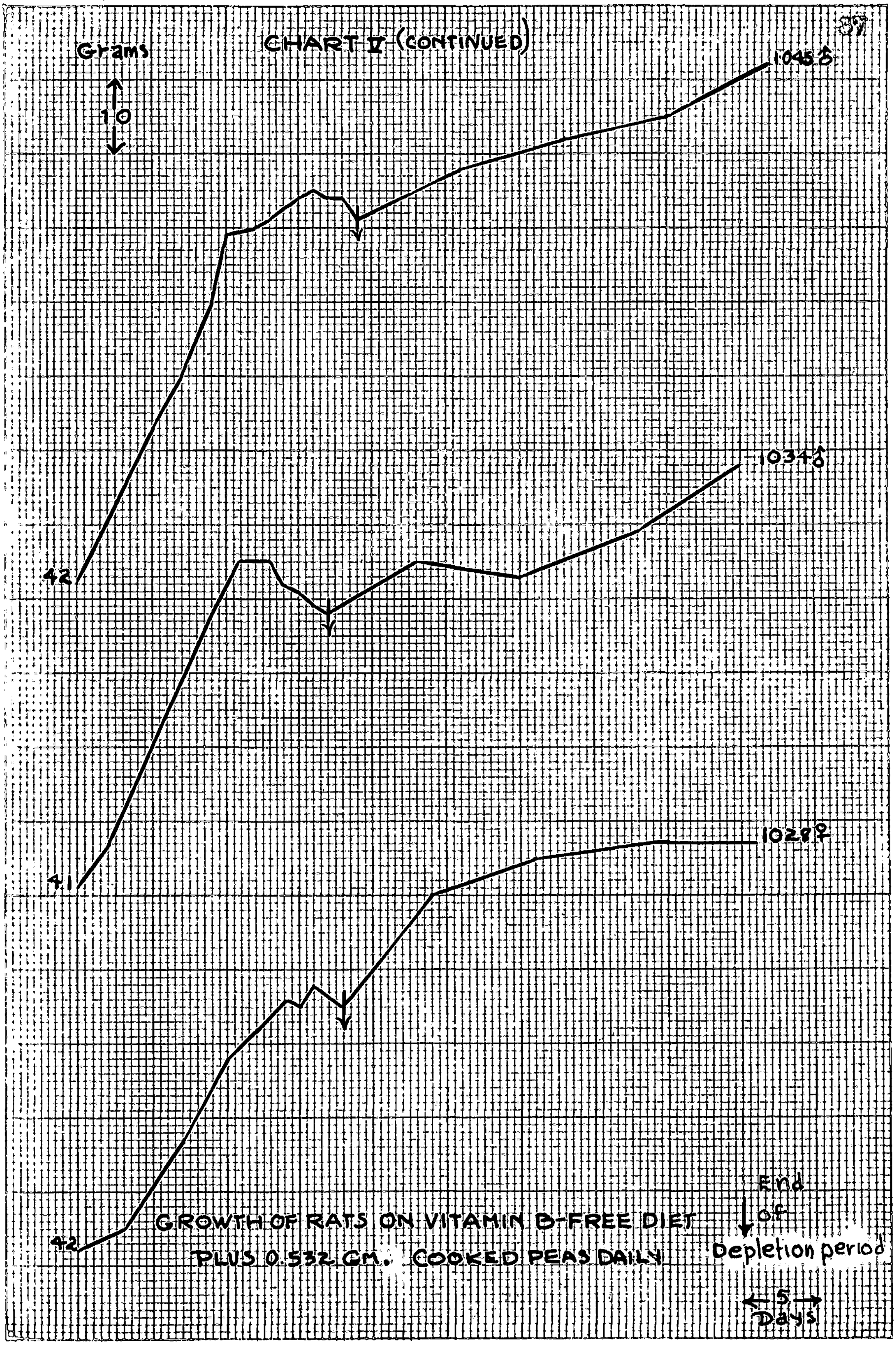


CHART V (CONTINUED)
Grams
10
1045♂
42
1034♂
41
1028♀
42
GROWTH OF RATS ON VITAMIN B-FREE DIET
PLUS 0.532 GM. COOKED PEAS DAILY
End
of
Depletion period
5
Days

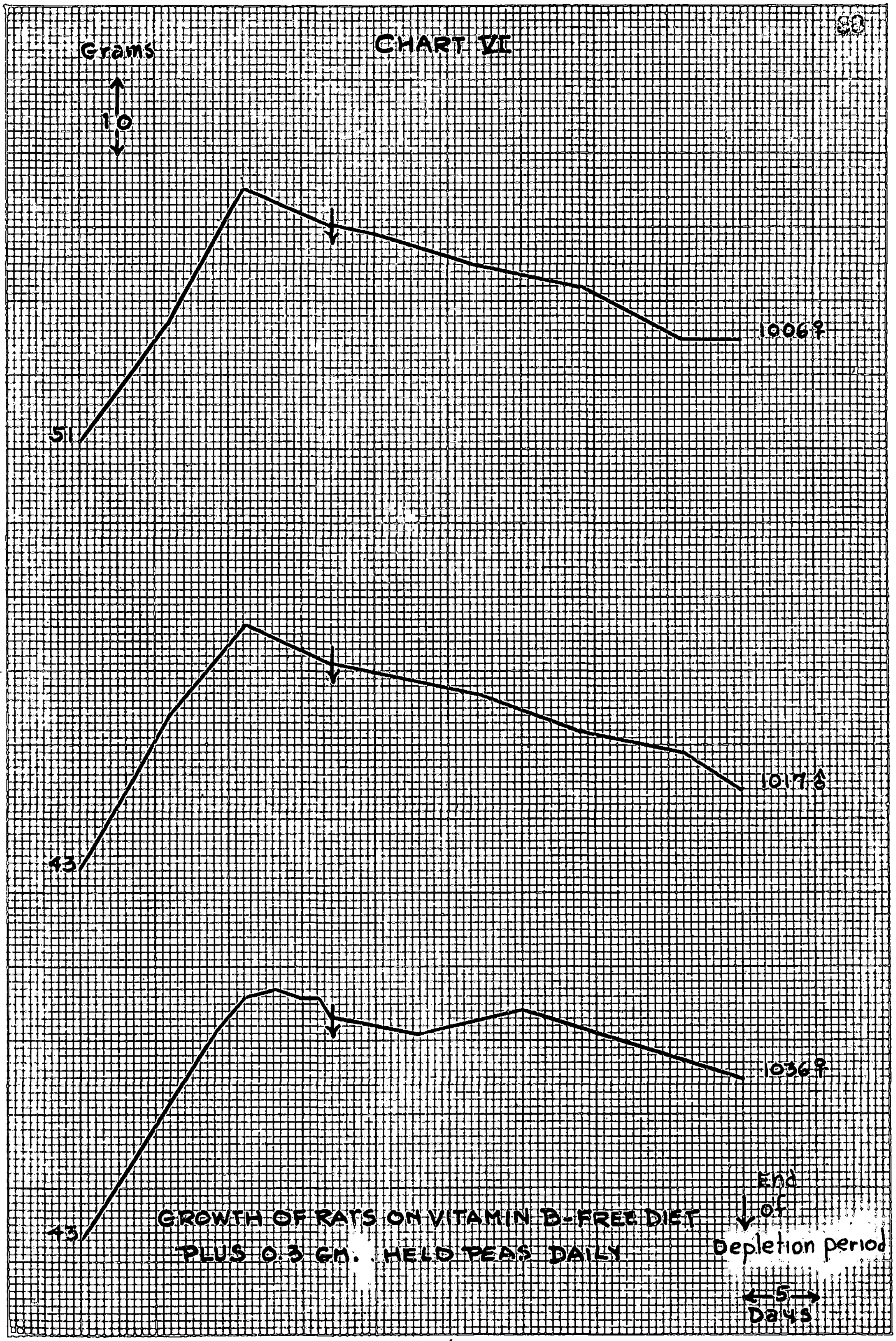


CHART VI
Grams
10
51
1006♀
43
1017♂
43
1036♀
GROWTH OF RATS ON VITAMIN B-FREE DIET
PLUS 0.3 GM. HELD PEAS DAILY
End of Depletion period
5
Days

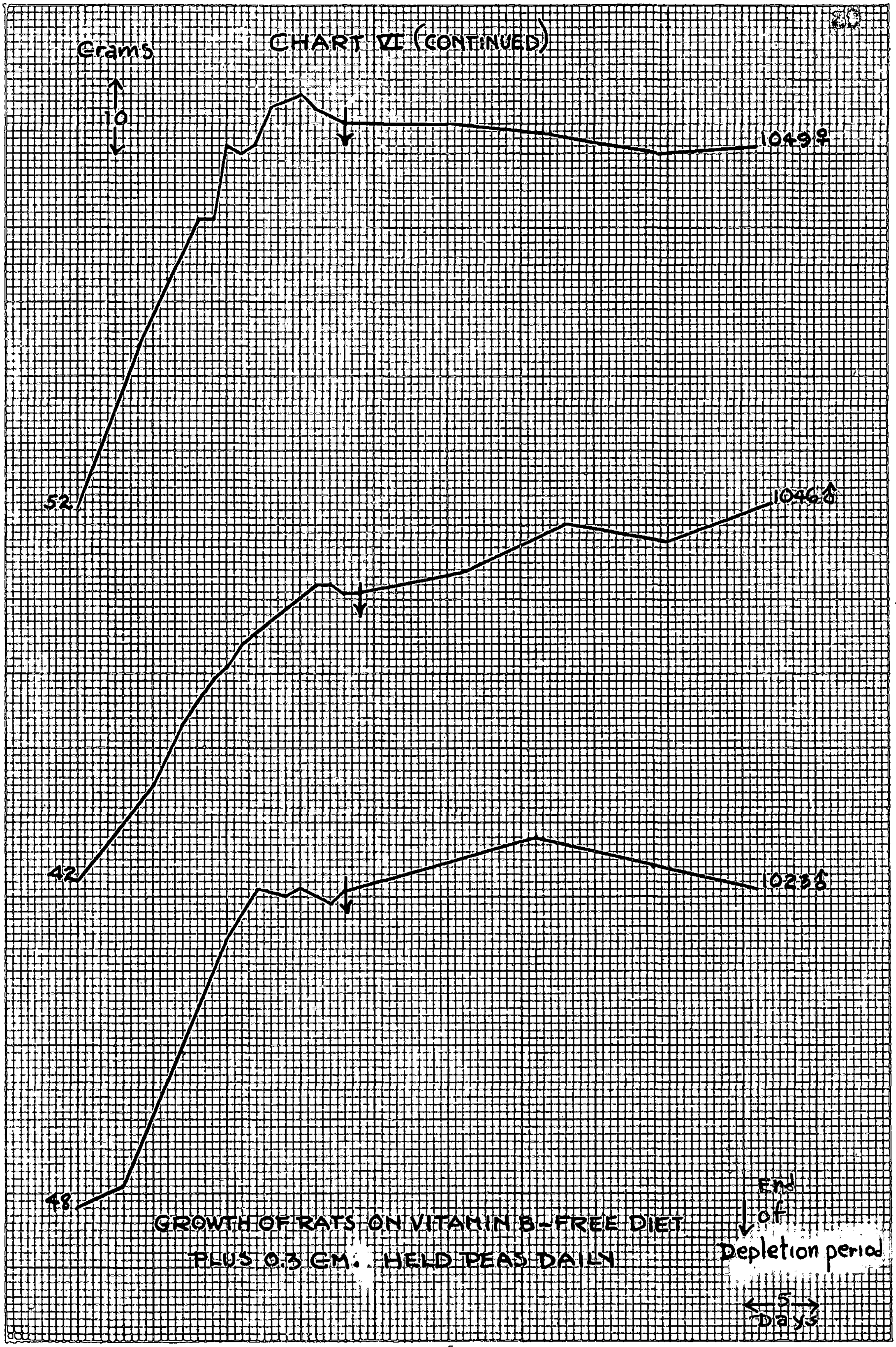
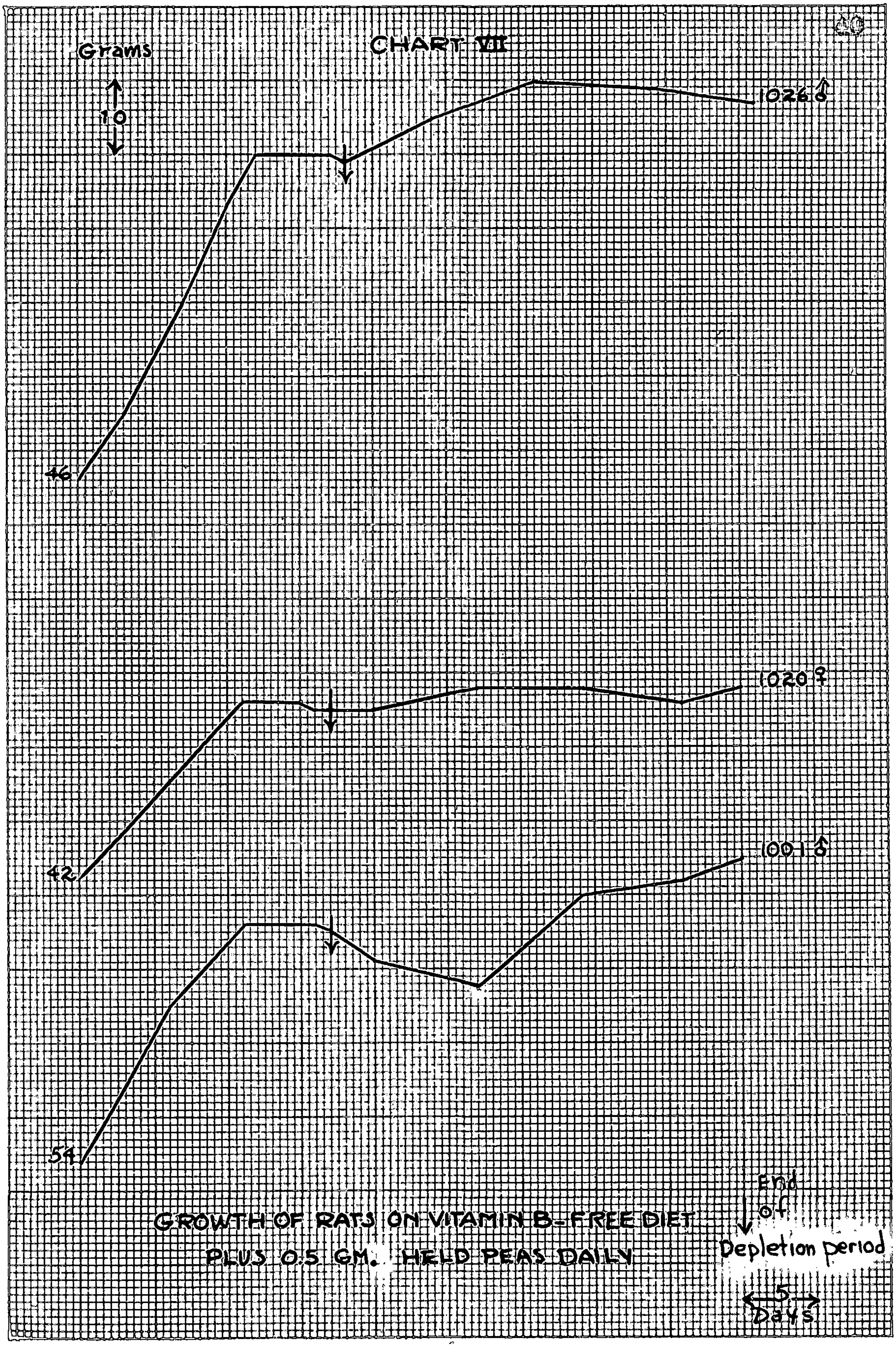


CHART VI (CONTINUED)
Grams
10
52
1049♀
42
1046♂
48
1023♂
GROWTH OF RATS ON VITAMIN B-FREE DIET
PLUS 0.3 GM. HELD PEAS DAILY
End of Depletion period
5 Days


40
Grams
10
CHART VII
1026 ♂
46
1020 ♀
42
1001 ♂
54
GROWTH OF RATS ON VITAMIN B-FREE DIET
PLUS 0.5 GM. HELD PEAS DAILY
End of Depletion period
5 Days

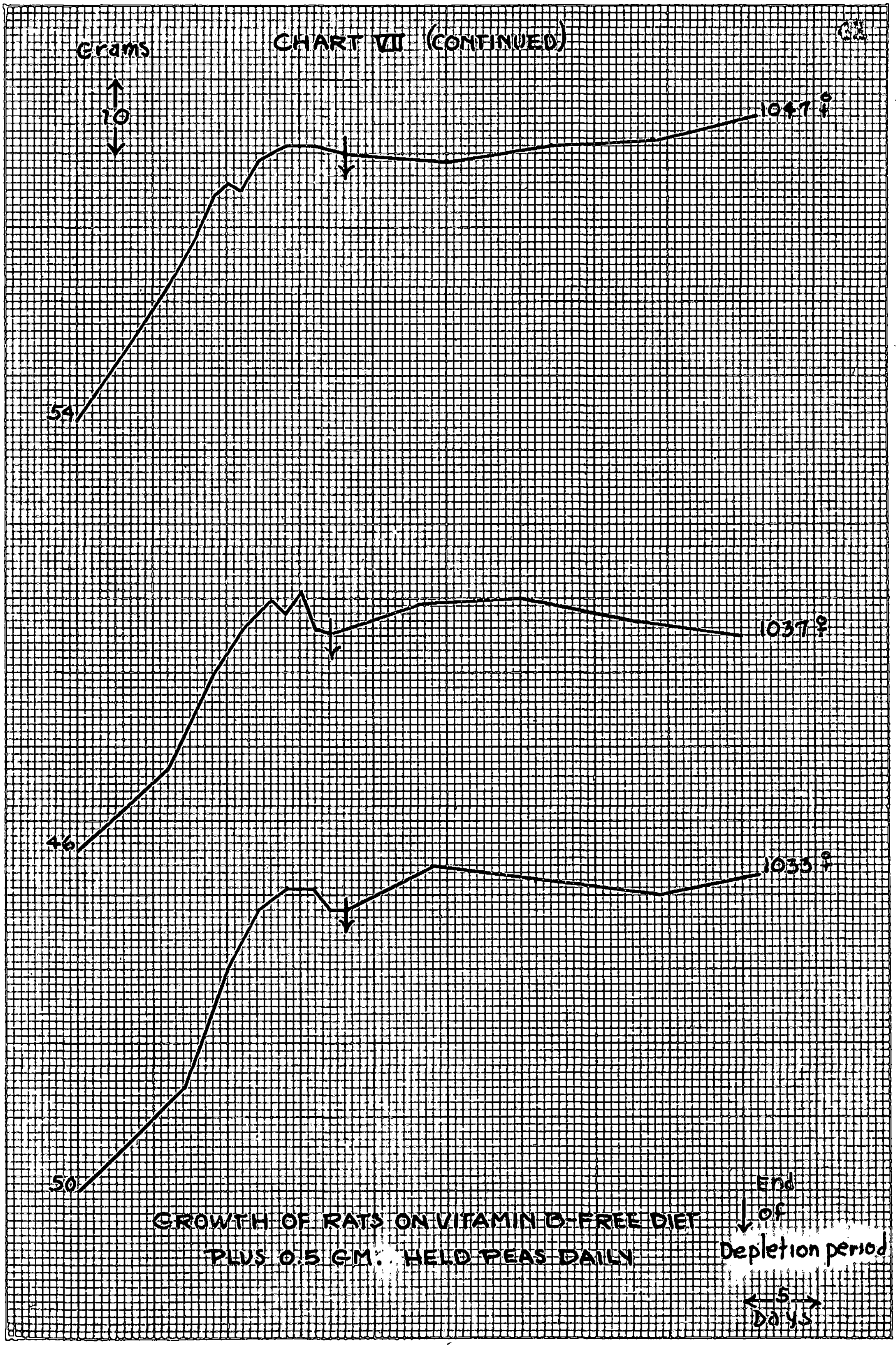


CHART VII (CONTINUED)
Grams
10
1047 ♀
54
1037 ♀
46
1033 ♀
50
GROWTH OF RATS ON VITAMIN B-FREE DIET
PLUS 0.5 GM. HELD PEAS DAILY
End of Depletion period
5 Days

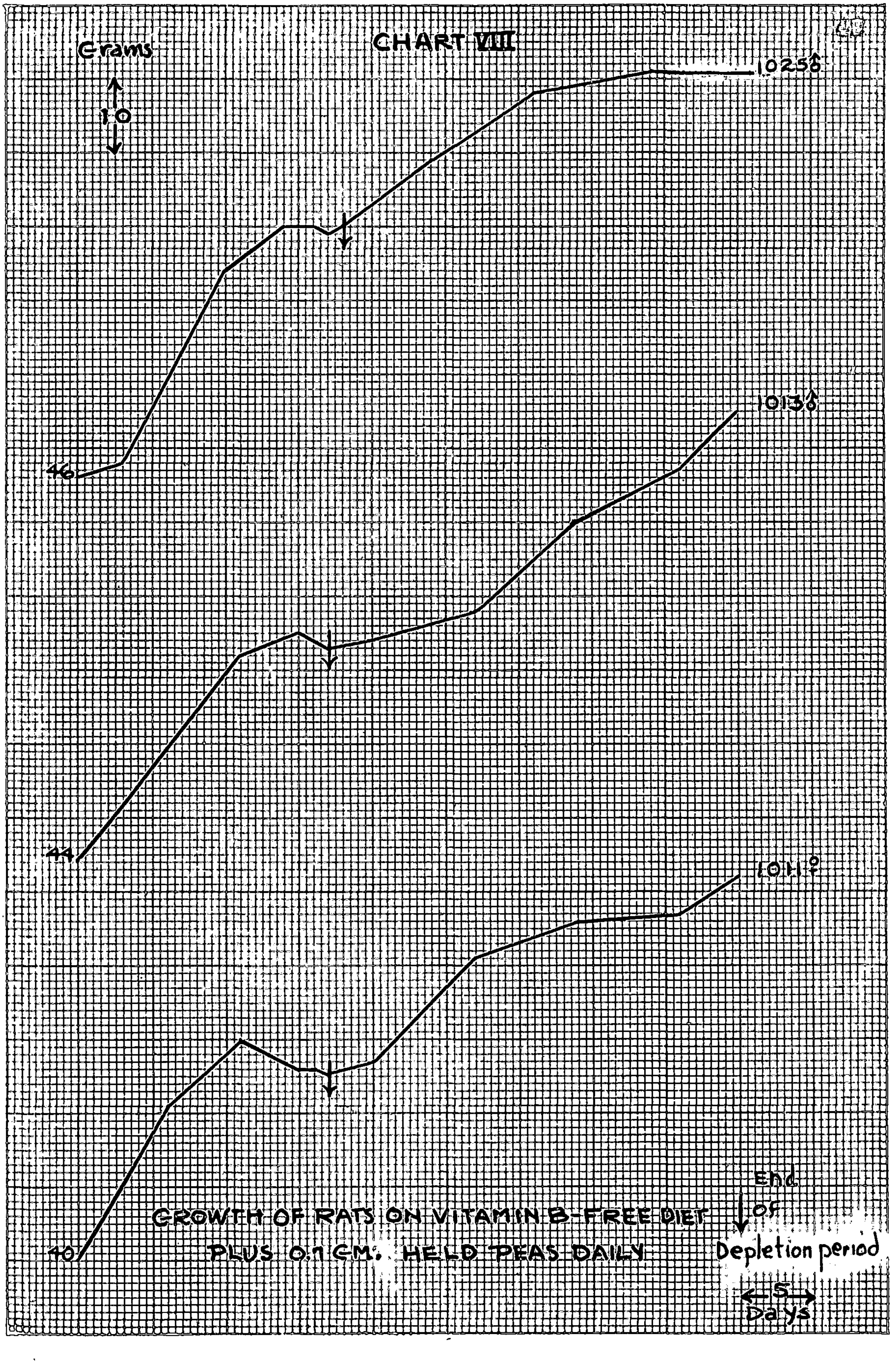
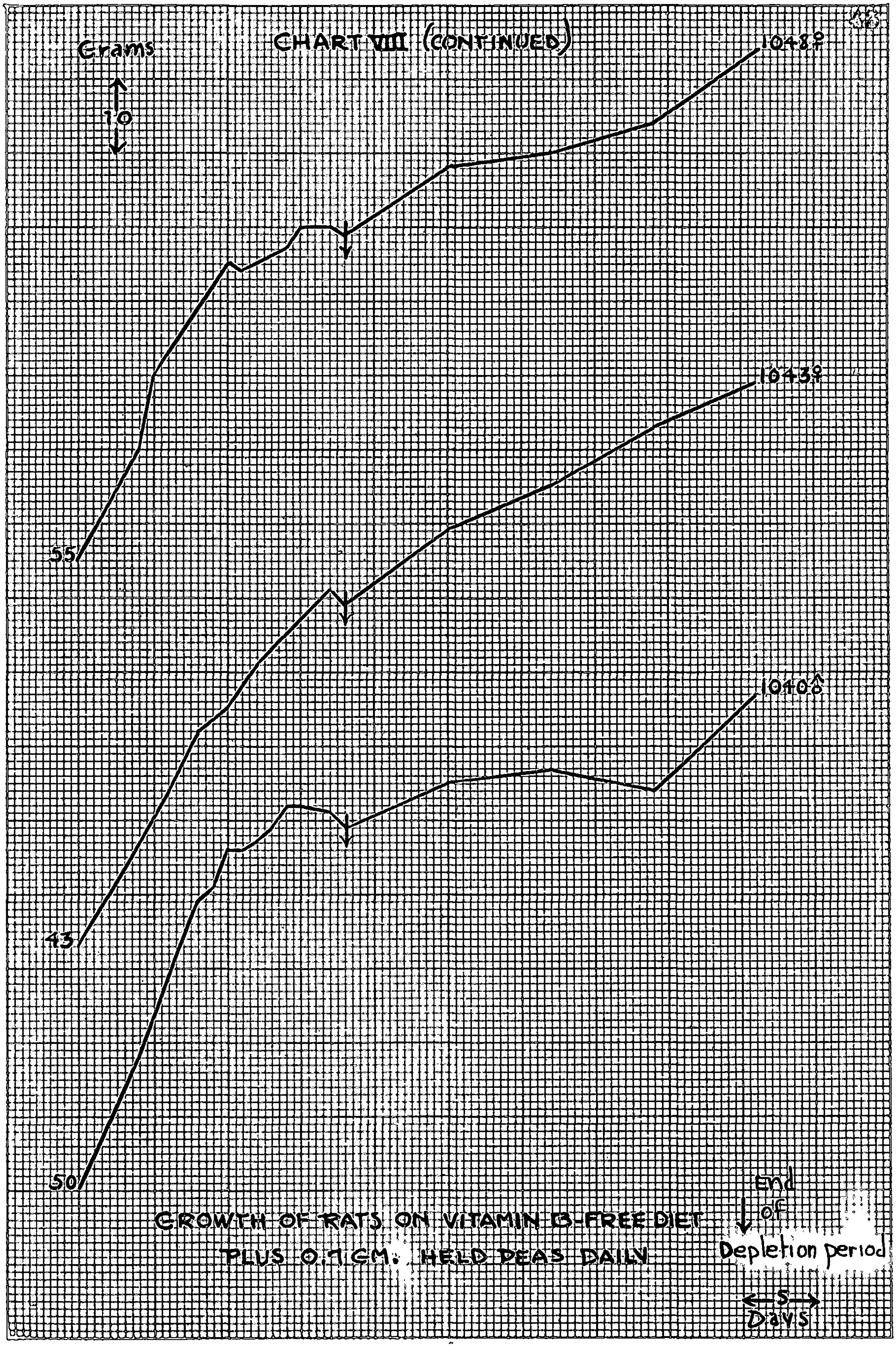


CHART VIII
Grams
10
1025♂
1013♂
1011♀
46
44
40
GROWTH OF RATS ON VITAMIN B-FREE DIET
PLUS 0.1 GM. HELD PEAS DAILY
End of Depletion period
5 Days



Grams
10
CHART VIII (CONTINUED)
1048♀
1043♀
1040♂
55
43
50
GROWTH OF RATS ON VITAMIN B-FREE DIET
PLUS 0.7 GM. HELD PEAS DAILY
End of Depletion period
5 Days

Table II

Growth of Rats Receiving a Vitamin B Free Diet

Male ♂ Female ♀	Initial Weight	Weight at end of dep. per.	Final Wt.	Total Gain
1003 ♂	51	79	52	-27
1018 ♀	40	64	54	-10
1024 ♂	48	97	68	-29
1031 ♀	51	104	63	-41
1038 ♂	46	81	47	-34
1041 ♂	48	98	51	-47
1050 ♀	53	100	52	-48
~~Average~~	~~48~~	~~89~~	~~55~~	~~-34~~

All animals except No. 1018 ♀ died before the end of the experimental period.

Table III

Growth of Rats Receiving Raw Peas As Source of Vitamin B

Rat No.		Sup.	Initial Wt.	Wt. at end of deplet. period	Final Wt.	Total gain in exp. per.	Gains per wk.
		gm.	gms.	gms.	gms.	gms.	gms.
1002	♀	0.2	64	64	63	- 1	- .3
1014	♂	0.2	41	71	70	- 1	- .3
1021	♂	0.2	47	80	70	-10	-4.
1029	♂	0.2	54	93	59	-34	-8.5
1030	♂	0.2	47	87	74	-13	-3.3
1051	♀	0.2	64	90	70	-20	-5.
Average		0.2	50	80	71	-14	-3.5
		gm.	gms.	gms.	gms.	gms.	gms.
1007	♂	0.4	45	70	80	+10	+2.5
1015	♂	0.4	43	69	70	+ 1	+ .3
1027	♀	0.4	45	77	90	+13	+3.3
1032	♀	0.4	49	79	76	- 3	- .8
1035	♂	0.4	43	78	81	+ 3	+ .8
1042	♀	0.4	43	75	87	+12	+3.
Average		0.4	44	75	81	+ 6	+1.5

Table IV

Growth of Animals Receiving Cooked Peas As Source of Vitamin B

Rat No.	Sup.	Initial Wt.	Wt. at end of deplet. per.	Final Wt.	Total gain in exp. per.	Gains per wk.
	gm.	gms.	gms.	gms.	gms.	gms.
1004 ♀	0.266	54	87	59	-28	- 7
1010 ♀	0.266	46	66	56	-10	- 2.5
1019 ♂	0.266	40	82	94	+12	+ 3
1022 ♂	0.266	45	80	67	-13	- 3.3
1030 ♂	0.266	54	98	67	-31	- 7.8
1044 ♂	0.266	48	93	87	-6	-1.5
Average	0.266	48	85	71.6	-13	-3.2
	gm.	gms.	gms.	gms.	gms.	gms.
1005 ♂	0.532	53	85	101	+16	+ 4
1012 ♂	0.532	45	79	87	+ 8	+ 2
1016 ♂	0.532	41	69	79	+10	+ 2.5
1028 ♀	0.532	42	75	97	+22	+ 5.5
1034 ♂	0.532	41	78	98	+20	+ 5
1045 ♂	0.532	42	91	112	+21	+ 5.3
Average	0.532	44	80	96	+16	+ 4

Table V

Growth of Animals Receiving Cooked Peas Held At Steam Table Temperature

Rat No.	Sup.	Initial Wt.	Wt. at end of deplet. period	Final Wt.	Total gain in exp. per.	Gains per wk.
	gm.	gms.	gms.	gms.	gms.	gms.
1006 ♀	0.3	51	80	65	-15	-3.8
1017 ♂	0.3	43	71	54	-17	-4.3
1023 ♂	0.3	48	91	91	0	0.
1036 ♀	0.3	43	73	65	- 8	-2.
1046 ♂	0.3	42	81	93	+12	+3.
1049 ♀	0.3	52	104	101	- 3	- .8
Average	0.3	47	83	78	5.1	-1.3
	gm.	gms.	gms.	gms.	gms.	gms.
1001 ♂	0.5	54	85	95	+10	+2.5
1020 ♀	0.5	42	65	68	+ 3	+ .8
1026 ♂	0.5	46	89	97	+ 8	+2.
1033 ♀	0.5	50	88	93	+ 5	+1.3
1037 ♀	0.5	46	75	75	0	0.
1047 ♀	0.5	54	90	95	+ 5	+1.3
Average	0.5	49	82	87	+ 5	1.3
	gm.	gms.	gms.	gms.	gms.	gms.
1011 ♀	0.7	40	65	92	+27	+6.8
1013 ♂	0.7	44	73	105	+32	+8
1025 ♂	0.7	46	80	101	+21	+5.3
1040 ♂	0.7	50	99	117	+18	+4.5
1043 ♀	0.7	43	89	119	+30	+7.5
1048 ♀	0.7	55	99	125	+25	6.3
Average	0.7	46	84	110	+25	+6.4

Table VI

Summary of Growth of Rats Receiving Raw and Cooked Peas and Peas Cooked and Held at Steam Table Temperature As a Source of Vitamin B

Supplement	Amt. fed daily	No. of rats	Av. Initial Weight	Av. Wt. at end dep. per.	Av. Final Wt.	Tot. gain Av.	Av. gain per week
	gm.		gms.	gms.	gms.	gms.	gms.
1-Negative controls	--	7	43	89	55	-34 *	--
2-Peas, raw	.2	6	50	85	71	-14	-3.5
Peas, raw	.4	6	44	75	81	+ 6	+1.5
3-Peas, cooked	.266	6	48	85	72	-13	-3.2
Peas, cooked	.532	6	44	80	96	+16	+4
4-Peas, held	.5	6	47	83	78	- 5	-1.3
Peas, held	.6	6	49	82	87	+ 5	+1.3
Peas, held	.7	6	46	84	110	+26	+6.4

* All except one died before end of experimental period.

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