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Change in Body-Weight and Food Consumption of Rats on Repeated Feeding of a Deficiency Diet.

By

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In his study on the variations in reaction of rats to different diets Bloomfield (1937) observed that when a series of rats of the same breed and of approximately the same age was placed on a defective diet, there were great individual variations in weight loss. Repetitions of the experiments after weight loss had been restored by a normal diet showed that, on the whole, the animals which lost most weight in the first instance did so again and *vice versa*. In a further study French and Bloomfield (1937) stated that " rats which have lost weight as the result of a defective diet and have then been restored to ' normal ' by stock ration show a more rapid weight loss if now placed for a second time on the same defective diet. This ' secondary rapid weight loss ' may occur after as long an interval as 80 days between the first and second periods on defective diet ". The authors, therefore, believe that they have established what may perhaps be called a state of " latent deficiency ". Unfortunately, French and Bloomfield did not measure the food intake and they did not state whether their animals were kept on screens or whether they were allowed access to their excreta.

Inasmuch as South Africa is known for its periodical droughts and adverse seasons, a large percentage of the livestock in this country must sometimes exist for prolonged periods on food probably very deficient in one or more respects. If such periods follow one another in close succession, as is sometimes the case, and if the observation of French and Bloomfield also holds true for farm animals, it is obvious that this phenomenon should be of great importance to the livestock industry in this country. The following experiments were planned, therefore, with the object of further investigating this problem.

Experimental.

Young mature rats of the same breed and of approximately the same age were used in these experiments. They were raised on the colony stock ration used in this laboratory. Before being put on the defective diets, they were fed for one week on the synthetic

(experimental) stock ration used in these experiments. The rats were then fed, in addition to distilled water, diets * that were defective in various respects. The number of rats on each diet varied from 12 to 24 with an even number of males and females in each group. Each rat was housed in a separate cage and, with the exception of experiment IV, kept on a wire screen. The animals were weighed every other day but were fed daily and the total individual food consumption for every two days recorded. The composition of the stock and defective diets is given in Table I.

TABLE I.

Composition of Rations in Percentage by Weight.

	Colony Stock Diet.*	Experimental Stock Diet.†	Diet low in Vitamins and Minerals.	Diet low in Vitamins, Minerals and Bulk.	Diet low in Proteins.
Yellow maize meal	60	—	—	—	—
Linseed oil meal	12	—	—	—	—
Crude casein	10	20	20	20	—
Dried browers' yeast	5	8	—	—	4
Lucerne meal	3	7	—	—	2
Butter fat	5	—	—	—	—
Beef liver (dried at 70° C.)	2	—	—	—	—
Bone ash	1	—	—	—	—
Cod liver oil	1	5	—	—	5
$CaCO_3$	0·5	1	—	—	1
NaCl	0·5	—	—	—	—
Dextrinized starch	—	45	62·5	65	72
Lard	—	10	15	15	10
Salt 40‡	—	4	—	—	4
Agar	—	—	2·5	—	2

* Plus tap water and fresh, whole milk *ad libitum*.

† The experimental stock ration used by French and Bloomfield to restore their depleted animals to normal weight was the same as that of Addis and co-workers (1926). The ration consists of maize starch 44, casein 16, lard 14, cod liver oil 10, salt mixture (Osborne and Mendel) 4, yeast 10, and lucerne meal 2 parts by weight. This ration seems to be complete in every respect and no doubt not inferior to the experimental stock ration used in this laboratory. Therefore, it is improbable that the difference in weight lost by rats during the first and second trials on the defective diet was due to the intermediate feeding by French and Bloomfield of a stock ration which was in itself not optimum in every respect.

‡ The composition of Salt 40 was similar to that of Steenbock and Nelson (1923) as modified by Keenan and others (1933).

Altogether there were six experiments. A description of these is given below and the data obtained on weight loss and food intake during these experiments are summarised in Table II. Furthermore, the average curves of each group for weight loss, food per rat per day.

* All the synthetic food mixtures were stored in a refrigerator, and, in order to prevent the development of rancidity, only enough of each ration to last for about three to four days was mixed at a time.

and food per 100 gm. rat per day, are given in figures I to VI. The solid lines are curves during the first trial on defective diet, the broken lines represent the second trial. In all the experiments the initial body weight is taken as 100 and the changes are expressed in actual grams lost per day.

Experiment I.

The 12 animals in this group were fed the vitamin and mineral low diet (but containing 2·5 per cent. agar) for 45 days when they had lost on the average about 21 per cent. of their body weight. They were then returned to the synthetic stock diet until they had regained their former weight and were then again fed the deficient diet for another 38 days. It is of interest to point out that seven days after the animals had been removed from the defective diet (after first trial with weight loss of 21 per cent.) and placed on the experimental stock diet, they weighed on the average 23 grams more than when they were first started on the deficient diet. In other words, the rats made an increase of 41·4 per cent. in body weight whereas during the week previous to the first trial on the defective diet they only gained 10·7 per cent. in body weight on the same diet. The indication of a stimulating after-effect of partial inanition on growth therefore supports the results of Kopec and Latyszewski (1932) obtained with mice. The remarkably quick recovery is also reflected by the food intake. During the seven days between the first and second trials on defective diet the animals consumed on the average 15·3 grams of the stock ration per rat per day or 7·5 grams per 100 gram rat per day whereas during the week previous to the first trial on defective diet they consumed 12·9 gm. of the stock ration per rat per day or 6·1 gm. per 100 gm. rat per day.

The curves in Fig. 1 show that the males lost less weight during the second trial on defective diet than during the first but also consumed slightly more food during the second trial than during the first. For the first 11 days the females also lost less in weight and consumed more food per rat per day during the second trial than during the first. After that time the curves crossed and the general picture was just the reverse. Because the difference in weight lost during first and second trials on defective diet seems to be a true reflection of the difference in food intake, it is difficult to resist the conclusion that, under the experimental conditions, the change in weight on defective diet was due primarily to the change in food intake.

Experiment II.

As the results obtained in experiment I do not support those of French and Bloomfield (1937), the experiment was repeated with 12 male and 12 female rats. These animals were fed the same deficient diet used in experiment I for 25 days each during the first and second trials.

From the curves given in Fig. 2, it is clear that the males again reacted as in the first experiment. The change in weight curve of the females is in agreement with those found by French and

Bloomfield in so far that the females lost appreciably more in weight during the first 12 days of the second trial than during the same period of the first. For 8 out of these 12 days the animals even consumed more food per rat daily during the second trial than during the first but, when expressed on the basis of a unit body weight (100 gm.), they actually consumed less during the second than during the first trial which may again help to account for the difference in weight lost.

Experiment III.

The deficient ration used in the two previous experiments differed from the ration used by French and Bloomfield only in so far as it also contained 2·5 per cent. of agar. Because of the difference between the results of these investigators and those of the writer, it was decided to omit the agar from the diet in order to see to what extent the agar was responsible for the discrepancy in results. The results obtained with 6 male and 6 female rats are depicted graphically in Fig. 3. The males again lost less weight during the second trial than during the first whereas there was hardly any difference between the weights lost by the females during the first and second periods on defective diet; and it is evident, therefore, that the agar was not the cause of the difference in results obtained in the two laboratories..

Experiment IV.

French and Bloomfield did not state whether their animals were kept on screens or not and it is possible, therefore, that their animals had access to their own excreta and that coprophagy took place. In order, therefore, to study the effects of a free access to excreta on the food intake and weight lost on a defective diet, 12 animals were kept on wood shavings in individual cages and fed the deficient diet used in experiment III. The curves given in Fig. 4 show again that the change in weight and food intake of the animals did not differ much during the first and second trials on the same diet.

Experiment V.

In view of the fact that, during the dry seasons the pasture in South Africa is of such a poor quality, the livestock, under ranch conditions, may not only suffer from a periodical vitamin (especially vitamin A) and a widespread mineral (Theiler and others, 1920, 1924, and du Toit and co-workers, 1932 and 1935) but also from a protein (Henrici, 1932a; 1932b, Henrici and Potter, 1934, and Smuts and others, 1939) shortage, a fourth group of 6 male and 6 female rats was included on a protein deficient ration. The ration was complete in every respect except that it was very low in proteins. It only contained about 0·34 per cent. nitrogen as supplied by the yeast and lucerne meal supplements. The first and second periods on this ration occupied 44 and 35 days respectively. The curves given in Fig. 5 show that, on the whole, there are no appreciable differences in the performance of the animals during the first and second trials on the low protein diet.

TABLE

SUMMARY OF DATA ON WEIGHT LOSS AND FOOD INTAKE OF GROUPS OF RATS DURING

Number of Experiment.	Number of Animals.	Sex.	Dietary Deficiencies.	Trial.
I	6	Males	Vitamins and minerals	First
			Vitamins and minerals	Second
	6	Females	Vitamins and minerals	First
			Vitamins and minerals	Second
II	12	Males	Vitamins and minerals	First
			Vitamins and minerals	Second
	12	Females	Vitamins and minerals	First
			Vitamins and minerals	Second
III	6	Males	Vitamins, minerals and bulk	First
			Vitamins, minerals and bulk	Second
	6	Females	Vitamins, minerals and bulk	First
			Vitamins, minerals and bulk	Second
IV	6	Males	Vitamins, minerals and bulk	First
			Vitamins, minerals and bulk	Second
	6	Females	Vitamins, minerals and bulk	First
			Vitamins, minerals and bulk	Second
V	6	Males	Proteins	First
			Proteins	Second
	6	Females	Proteins	First
			Proteins	Second
VI	6	Males	Starvation but water allowed	First fast
			Starvation but water allowed	Second fast
	6	Females	Starvation but water allowed	First fast
			Starvation but water allowed	Second fast

* The signs — and + signify respectively

p205-206

p205-206 (cont.) ⟶

II.

First and Second Trials on Various Defective Diets and Starvaton.

Weight Grams.	Average change in body weight.*				Grand average food consumption.			
	For first 12 days.		For first 24 days.		For first 12 days.		For first 24 days.	
	Grams.	Per cent.	Grams.	Per cent.	Per Rat per day Grams.	Per 100 gm. Rat per day Grams.	Per Rat per day Grams.	Per 100 gm. Rat per day Grams.
237·7	−14·4	− 6·1	−31·0	−13·0	8·6	3·7	7·4	3·3
251·8	+ 3·5	+ 1·4	− 5·3	− 2·1	11·8	4·6	10·3	4·1
178·4	− 6·4	− 3·6	−19·0	−10·6	7·3	4·2	6·4	3·8
211·0	− 9·4	− 4·4	−39·4	−18·7	8·9	4·2	6·4	3·2
282·4	−15·0	− 5·3	−29·2	−10·3	9·4	3·4	8·1	3·0
295·5	− 4·0	− 1·3	−20·7	− 7·0	10·6	3·6	9·0	3·1
205·7	− 7·7	− 3·7	−23·4	−11·4	7·3	3·6	6·2	3·1
207·7	−12·2	− 5·9	−26·2	−12·6	6·3	3·2	5·5	2·8
256·7	− 2·5	− 1·0	−10·9	− 4·2	10·7	4·2	9·9	3·9
256·8	+ 7·9	+ 3·1	+ 1·1	+ 0·4	11·6	4·4	10·6	4·0
172·8	− 2·5	− 1·5	− 5·3	− 3·1	7·6	4·5	7·5	4·4
179·5	− 0·5	− 0·2	− 9·3	− 5·2	8·1	4·5	7·0	4·0
273·0	− 8·5	− 3·1	−10·3	− 3·8	9·5	3·6	9·2	3·5
282·8	+ 4·4	+ 1·6	− 0·5	− 0·2	10·6	3·7	9·6	3·4
211·5	− 5·5	− 2·6	−12·4	− 5·9	8·8	4·2	8·0	3·9
212·5	− 1·5	− 0·7	− 9·0	− 4·2	8·6	4·1	7·9	3·7
232·8	−38·1	−16·4	−52·8	−22·7	9·3	4·3	9·1	4·6
236·0	−33·1	−14·0	−50·6	−21·4	8·7	3·9	8·6	4·2
198·9	−28·2	−14·2	−41·9	−21·1	7·9	4·2	7·6	4·4
199·3	−25·9	−13·0	−39·2	−19·7	7·8	4·2	7·5	4·3
	For first	8 days.	For first	16 days.				
409·4	−79·8	−19·5	−140·1	−34·2	—	—	—	—
401·6	−75·5	−18·8	−124·8	−31·1	—	—	—	—
298·9	−57·7	−19·2	−99·3	−33·2	—	—	—	—
290·3	−57·1	−19·7	−92·7	−31·9	—	—	—	—

loss and gain in body weight.

p205-206 (cont.)

Experiment VI.

In order to make the experimental conditions as drastic as possible, a group of 12 (6 males and 6 females) adult rats were starved, except for distilled water, for 16 days each during the first and second trials. The curves given in Fig. 6 show that the animals lost weight at an equal rate during the first and second fasts.

Summary.

(1) Data are presented on the change in body weight and food intake of young mature rats during the first and second trials on diets deficient in minerals and vitamins; minerals, vitamins and bulk; and proteins. Data are also given on the loss in body weight of rats during first and second fasts.

(2) The results show that, under the experimental conditions, rats which have lost weight as the result of a defective diet, and have then been restored to normal weight by stock ration did not show, as was found by French and Bloomfield, a more rapid weight loss, if now placed for a second time on the same defective diet. As a matter of fact in the majority of cases the animals lost slightly less weight during the second than during the first trial on defective diet. This was true no matter whether the rats had free access to their own excreta or not.

(3) Similarly, the food intake of the rats did not differ appreciably during successive periods on the same defective diet.

Conclusion.

There seems to be a positive relationship between the change in daily food consumption and the change in body weight. It is probable, therefore, that the reason why the animals of French and Bloomfield lost more rapidly in weight during the second than during the first trial on defective diet, was not because of a "latent deficiency" but because their animals consumed, on the whole, less food during the second than during the first trial on defective diet. Why that should have been so, is difficult to say, but it is possible that the palatability of their ration was not as good during the second as during the first trial.

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EXPERIMENT I.

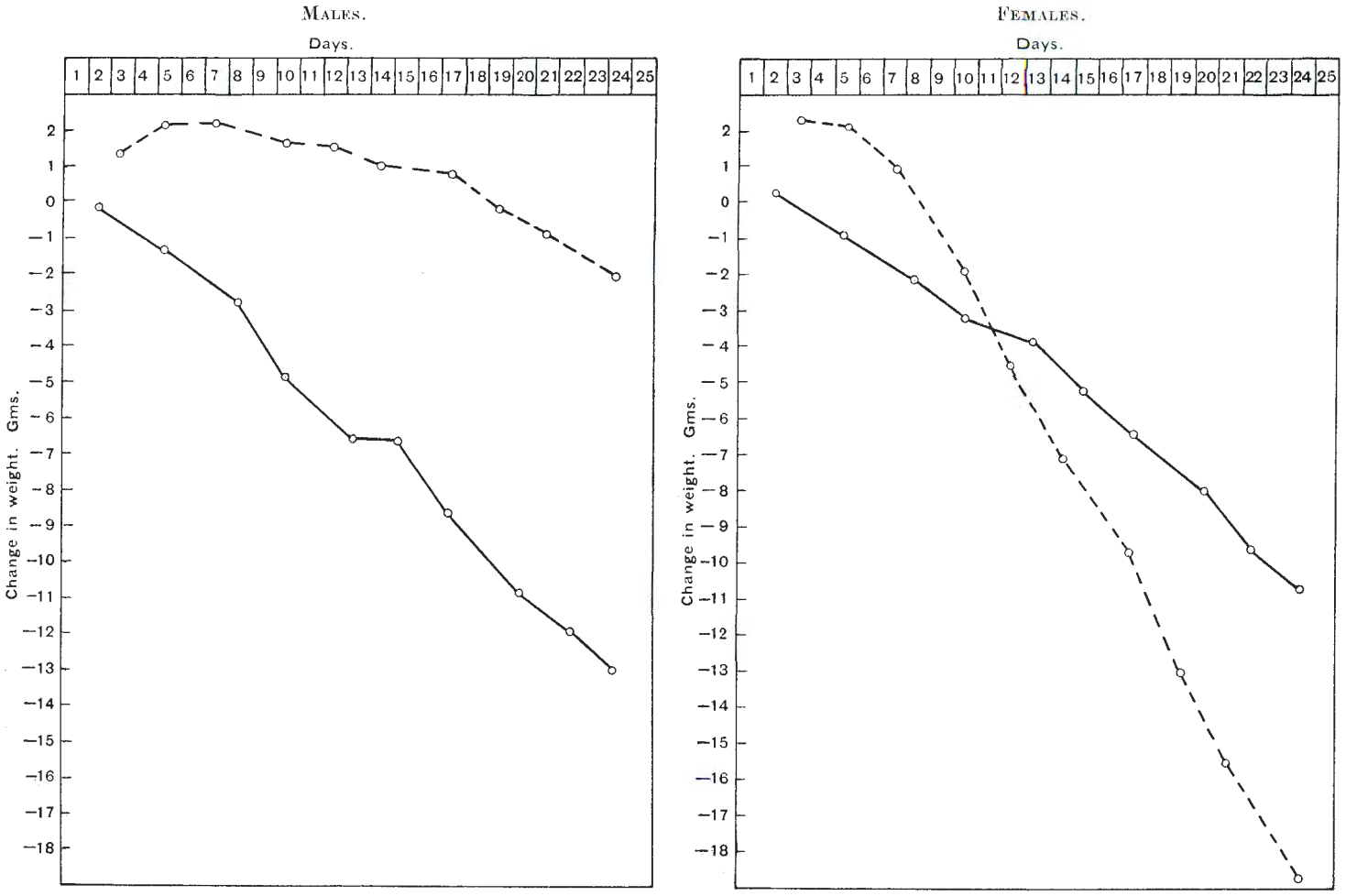
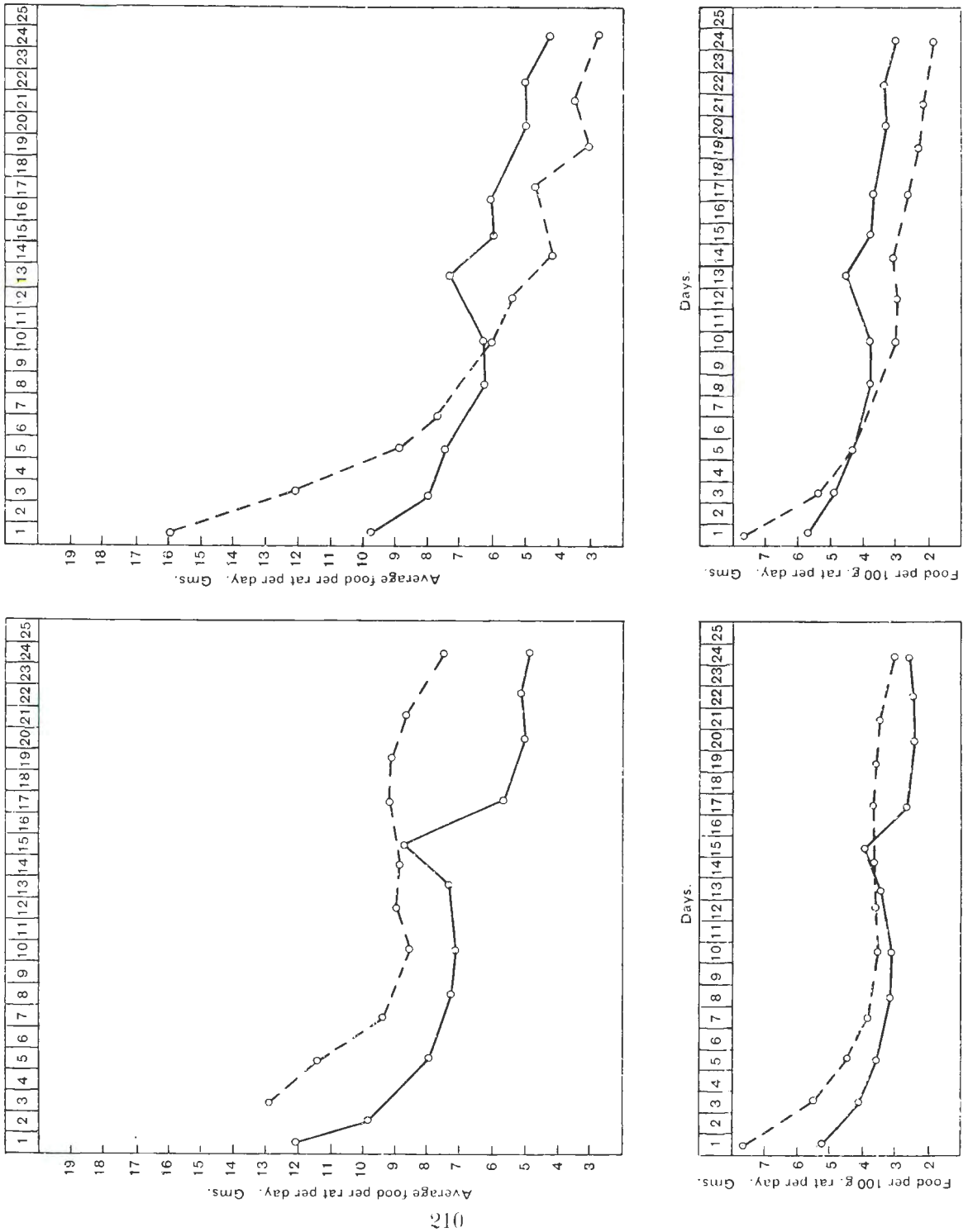


Fig. 1.—Graph of data from Experiment I (see text). The solid lines are curves during first trial on defective diet, the broken lines represent the second trial.

EXPERIMENT 1 (*continued*).

Fig. 1 (*continued*).



EXPERIMENT II.

MALES. FEMALES.

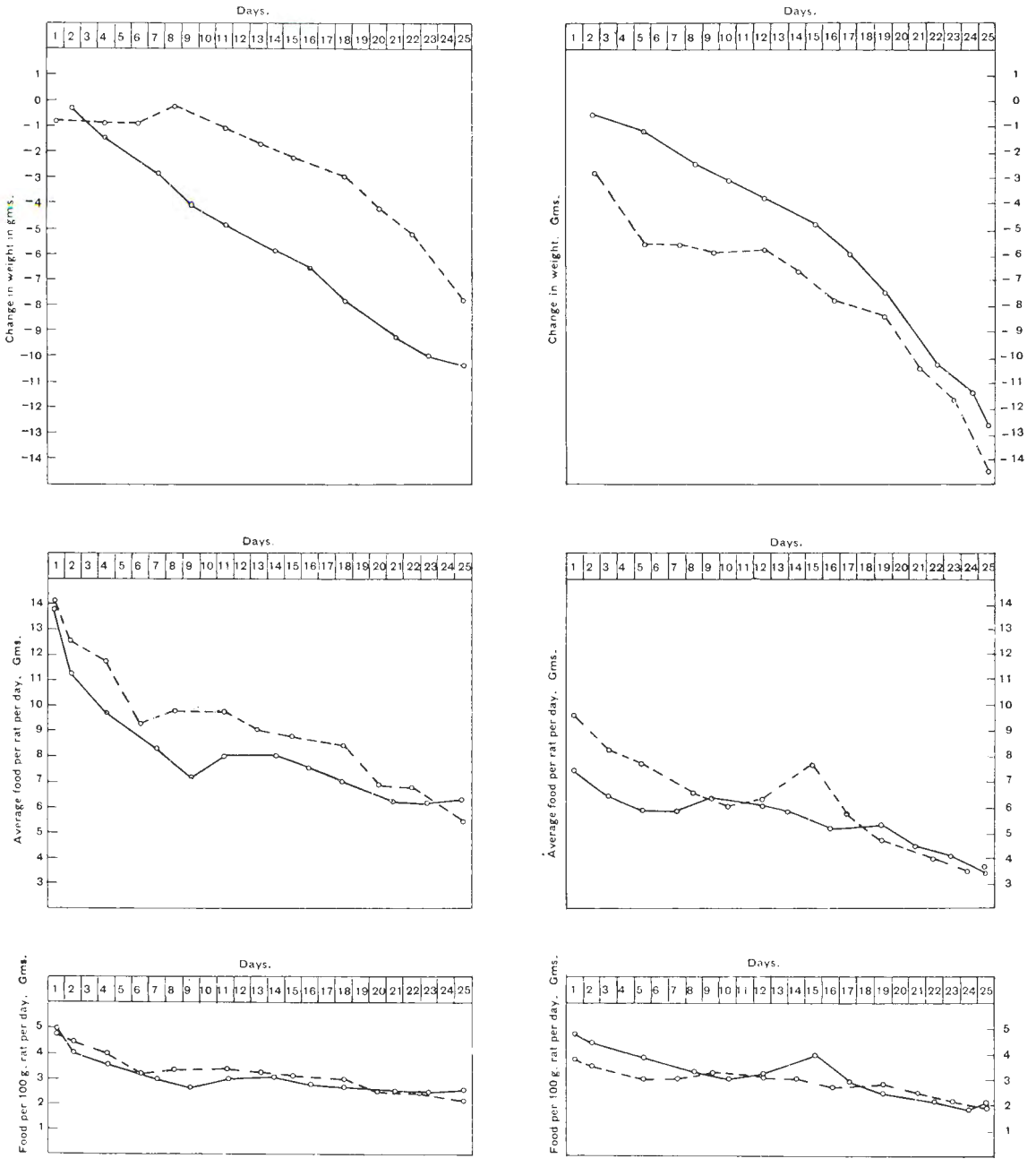


Fig. 2.—Graph of data from Experiment II (see text). The solid lines are curves during first trial on defective diet, the broken lines represent the second trial.

EXPERIMENT III.

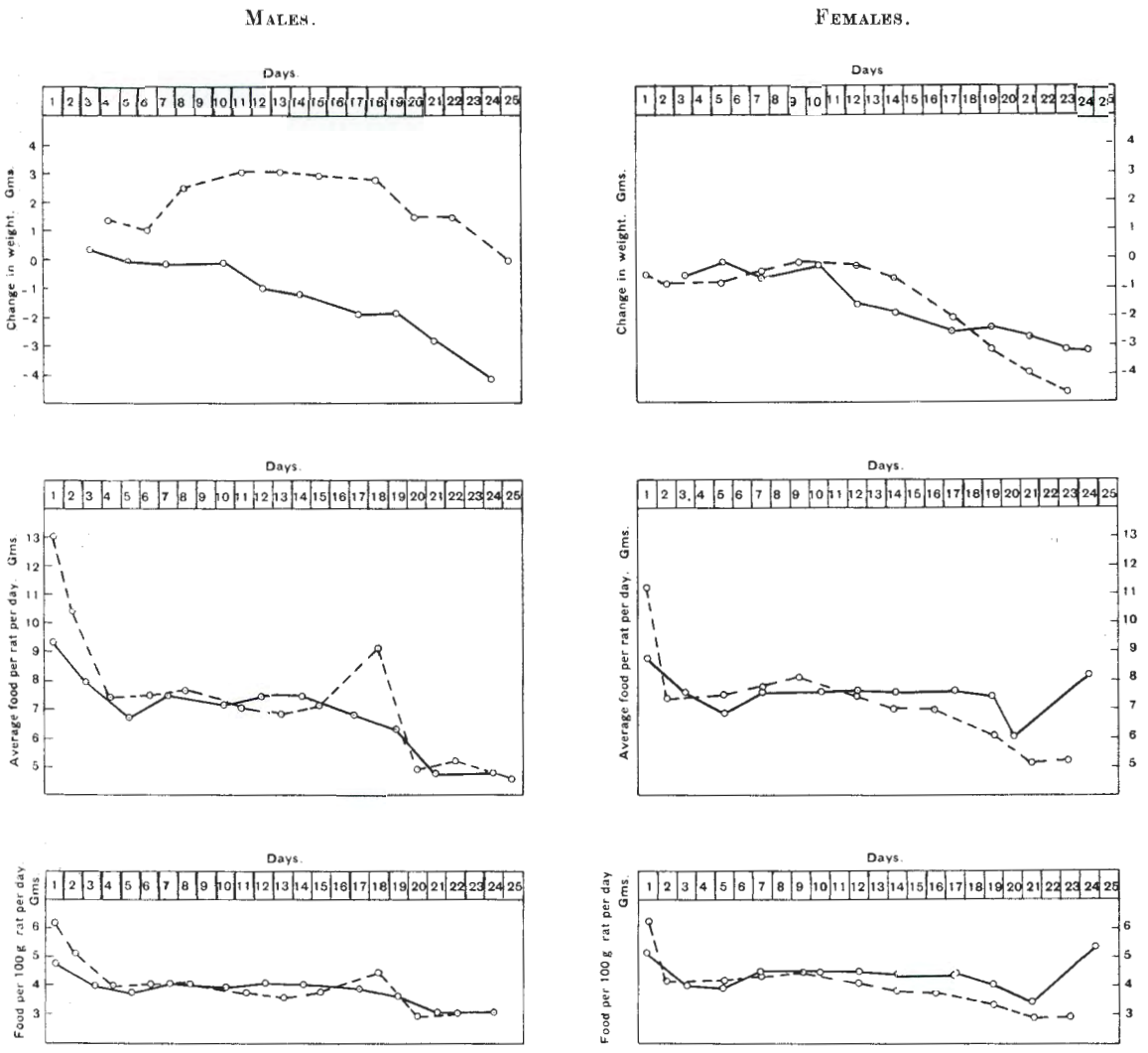


Fig. 3.—Graph of data from Experiment III (see text). The solid lines are curves during first trial on defective diet, the broken lines represent the second trial.

EXPERIMENT IV.

MALES. FEMALES.

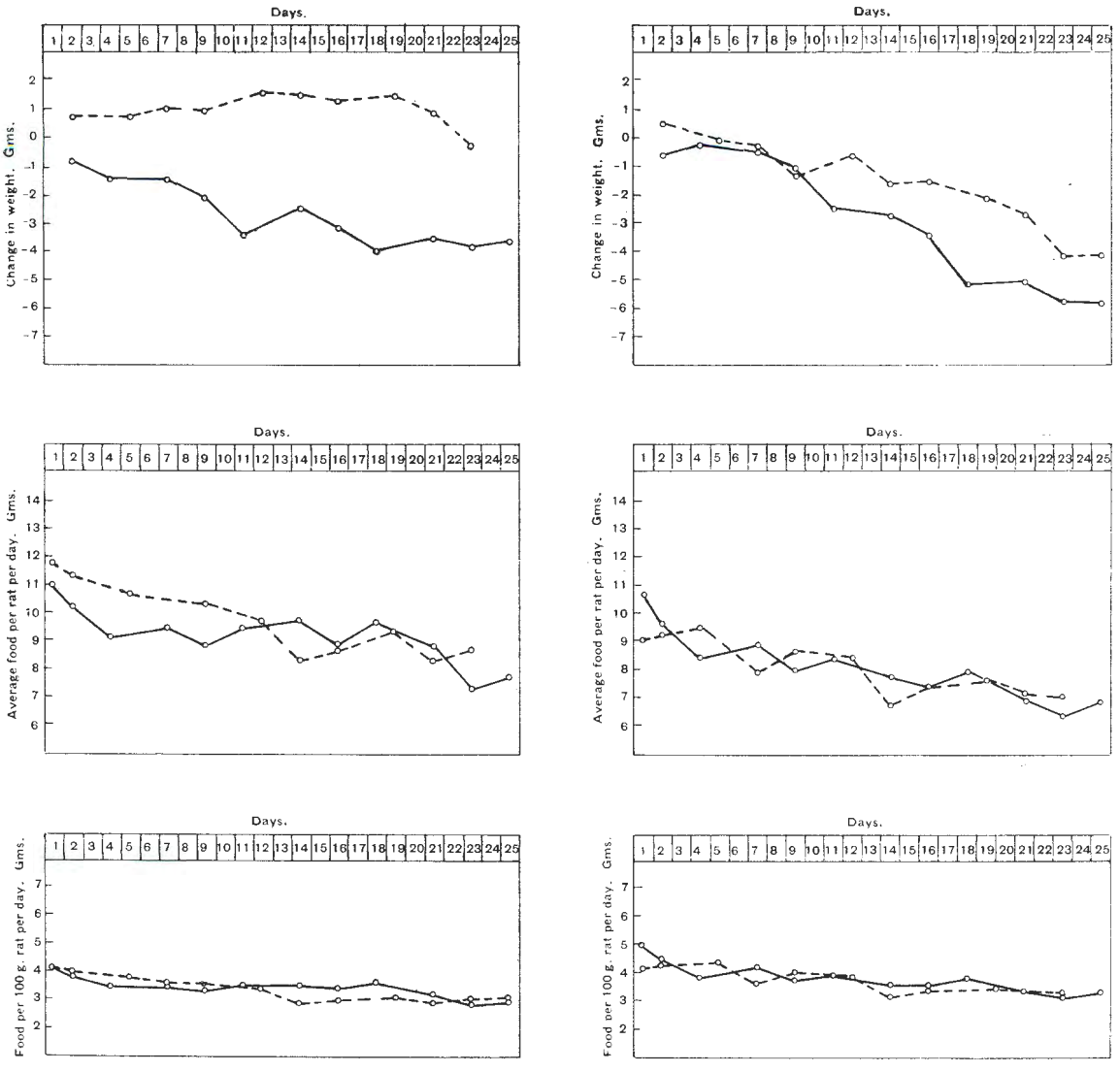


Fig. 4.—Graph of data from Experiment IV (see text). The solid lines are curves during first trial on defective diet, the broken lines represent the second trial.

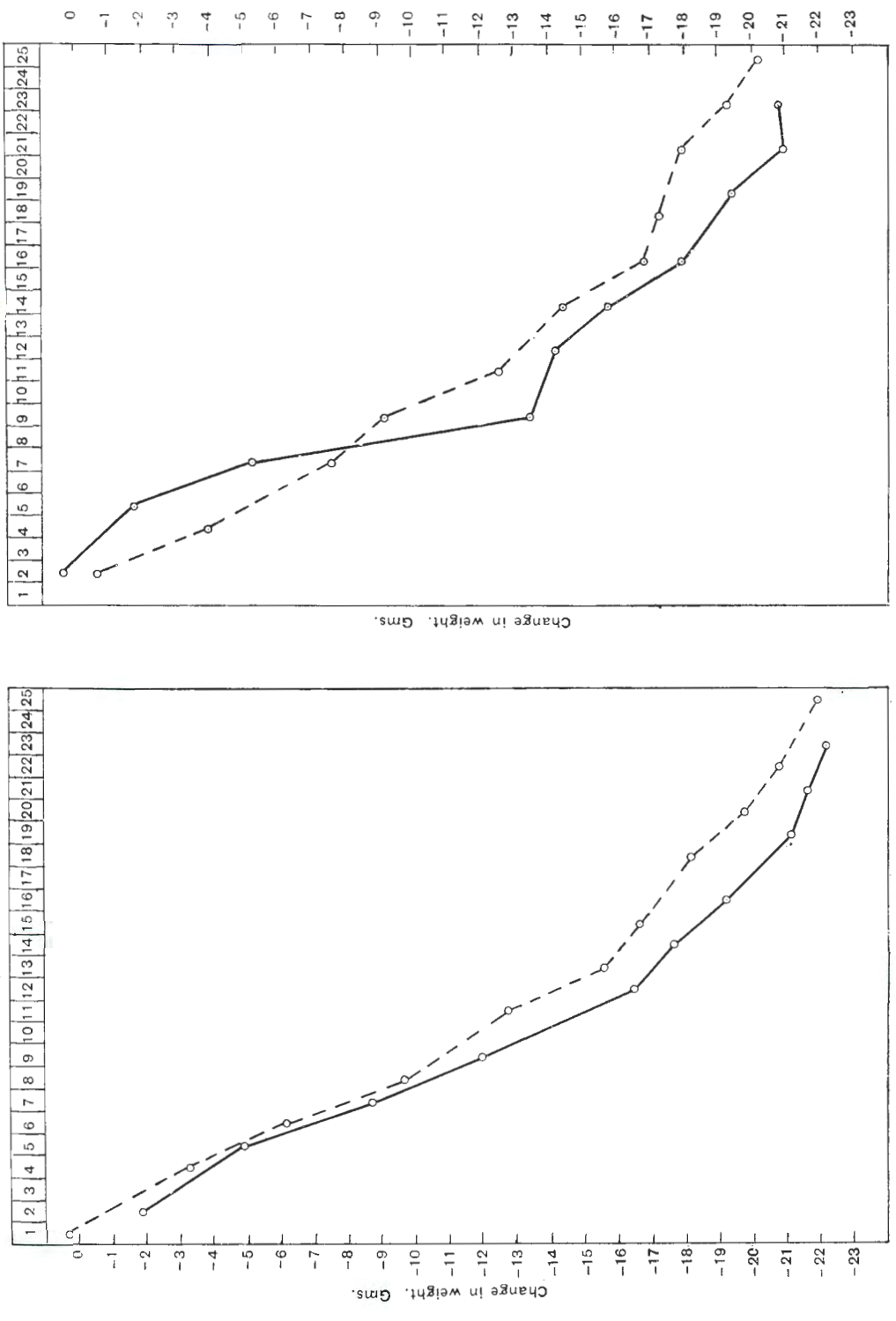
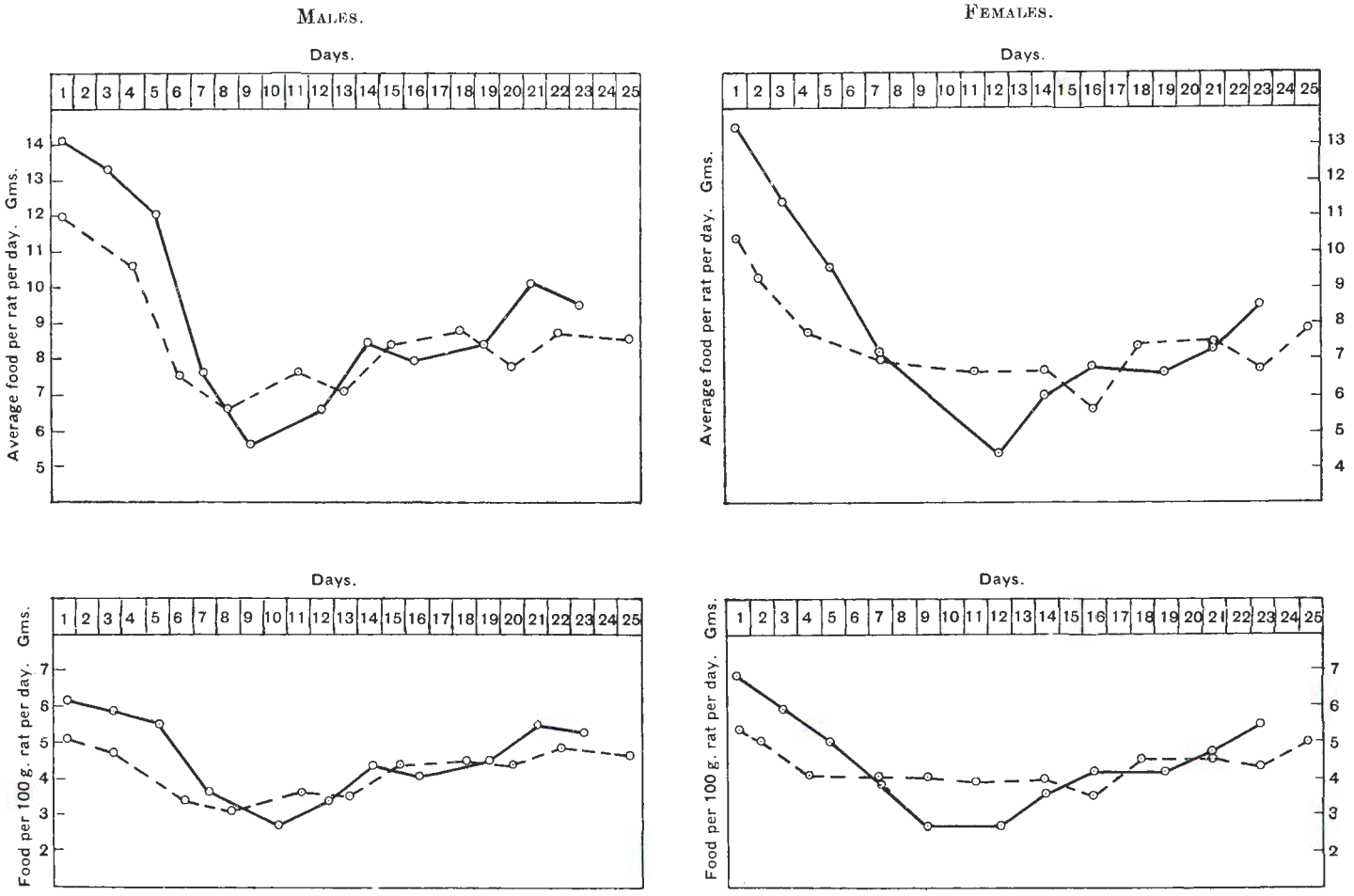


Fig. 5.—Graph of data from Experiment V (see text). The solid lines are curves during first trial on defective diet, the broken lines represent the second trial.

EXPERIMENT V (*continued*).

Fig. 5 (*continued*).



EXPERIMENT VI.

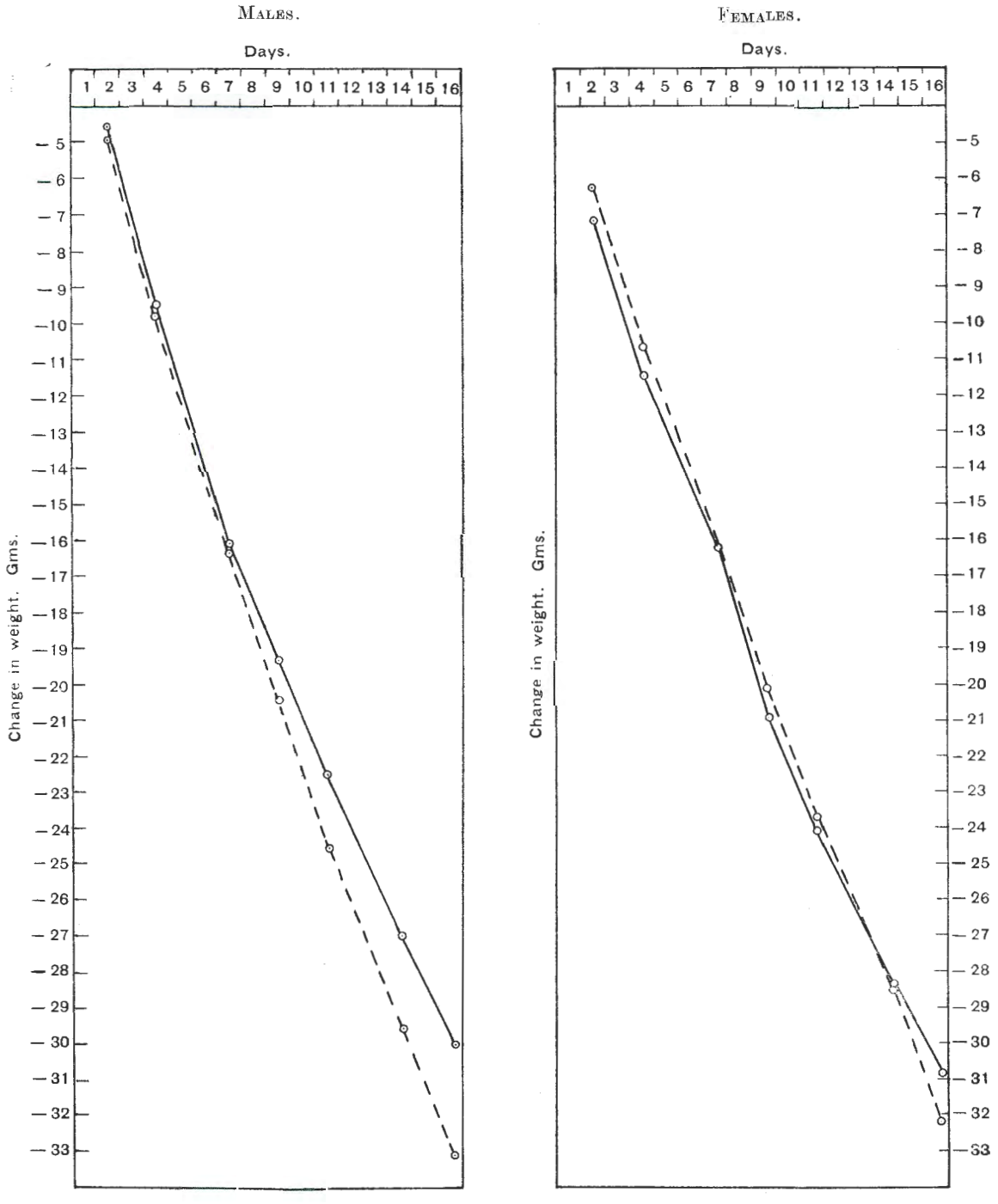


Fig. 6.—Graph of data from Experiment VI (see text). The solid lines are weight curves during the first fast, the broken lines represent the second fast.