that the month in which the rats were born was of the greatest importance in determining whether the animals would be light or heavy at the different ages.

These results also show that the influence at birth and shortly after was manifested until the animals were mature.

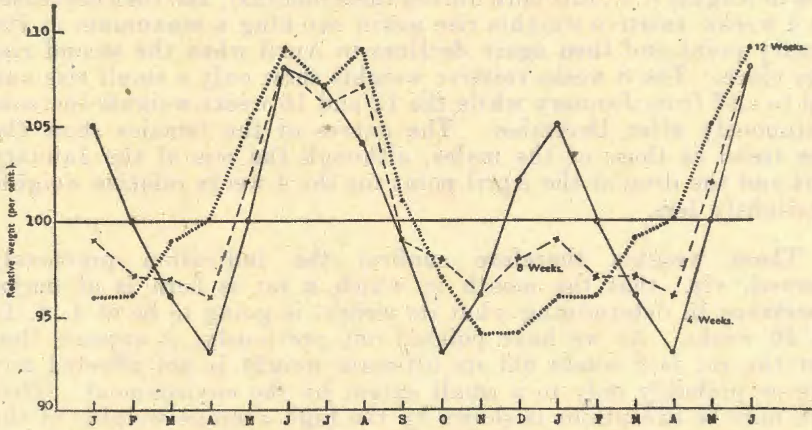

Fig. 54.—Influence of time of year on relative live weights of rats born during different months—males of different ages.

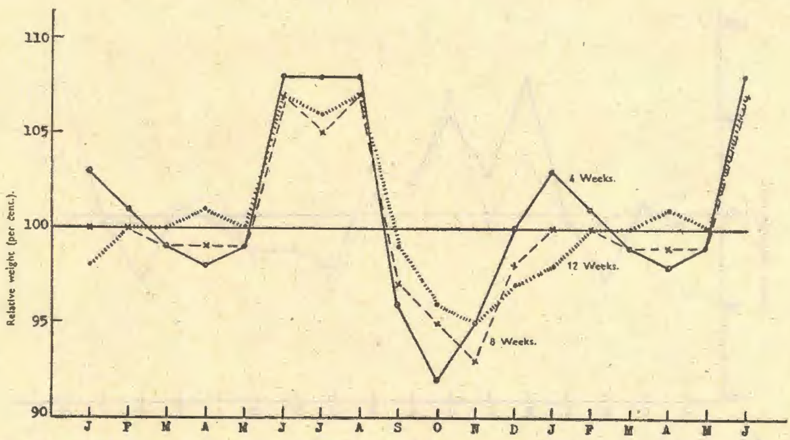

Fig. 55.—Influence of time of year on relative live weights of rats born during different months—females of different ages.

To investigate the influence of the month in which the rats were born, the average weights at 4, 8, 12, and 16 weeks of rats born during different months are given in Table 55. The average weights have been smoothed by means of the moving average, three months being taken to get one average, and these smoothed averages expressed as percentages of the standard weights at the respective ages. The relative weights of the males and females have been plotted in Figs. 54 and 55.

The curves in Fig. 54 are about the same as those in Fig. 53, only the high and the low points do not coincide with regard to the time of the year. The high and the low points of rats at 4 weeks in Fig. 54 are a month earlier than those in Fig. 53. The relative weights of rats at 4, 8, 12 and 16 weeks are all at their maximum at the point June to August (i.e., rats born during these months), and then decrease. The 4 weeks' relative weights rise again reaching a maxumum at the January point and then again declines to April when the second rise takes place. The 8 weeks relative weights show only a small rise and drop to and from January while the 12 and 16 weeks weights increase continuously after December. The curves of the females show the same trend as those of the males, although the rise at the January point and the drop at the April point for the 4 weeks relative weights are slightly less.

These weights therefore confirm the indication previously observed, viz., that the month in which a rat is born is of major importance in determining what its weight is going to be at 4, 8, 12 and 16 weeks. As we have pointed out previously, it appears that after the rat is 8 weeks old its ultimate weight is not affected any more or probably only to a small extent by the environment. That there may be exceptions is shown by the high average weights of the rats of 4 weeks during January and the low average weights of rats of 12 and 16 weeks, and the reverse during April.

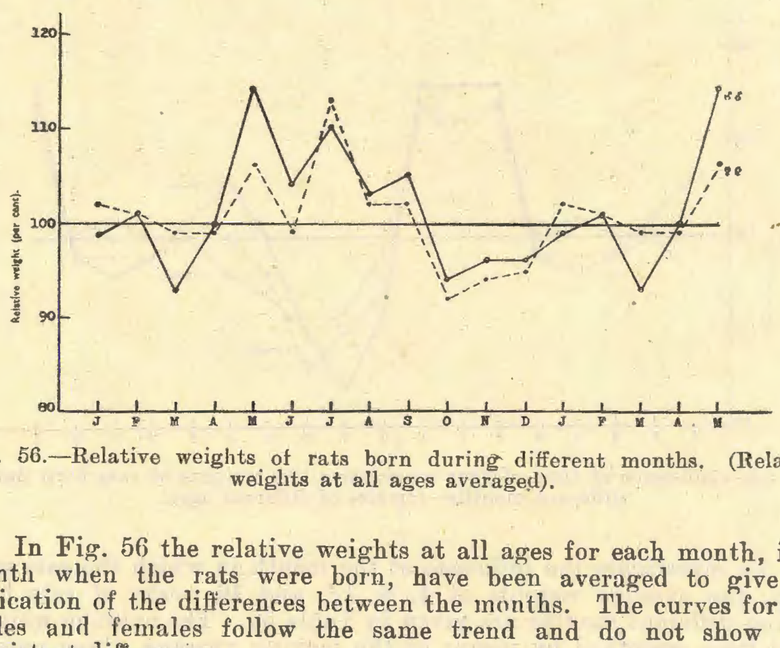

Fig. 56.—Relative weights of rats born during different months. (Relative weights at all ages averaged).

In Fig. 56 the relative weights at all ages for each month, i.e., month when the rats were born, have been averaged to give an indication of the differences between the months. The curves for the males and females follow the same trend and do not show any consistent differences.

In the following table the average gains made by the males during the first, second, third and fourth months in the different months are given, also the total growth value for each month.

Gains made by Males at Different Ages during Different Months.

Gain (g.) made in	Gain (g.) made in											
	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1st month	55	54	46	48	59	57	55	55	48	48	47	56
2nd month	96	101	108	98	107	128	108	119	109	121	101	112
3rd month	58	51	61	65	73	85	70	70	84	73	82	71
4th month	35	41	39	39	46	46	45	34	49	45	49	48
TOTAL	244	247	254	250	285	316	278	278	290	287	279	287
Growth Value for each Month	61	62	64	63	71	79	70	70	73	72	70	72

The biggest differences in gain per month are shown during the second and third months after birth, so that the largest differences were not due to differences in milk production. Below, the actual gains during each month have also been expressed as percentages of the average actual gains. They show the influence of the month when rats are born on the subsequent growth and also the influence of each month on the gains of rats of different ages.

	Influence of Month of Birth on Gains.	Influence of Month on Gains at Different Ages.
January	94	90
February	101	91
March	97	91
April	102	92
May	102	106
June	106	114
July	108	101
August	106	99
September	108	107
October	92	101
November	93	104
December	90	106

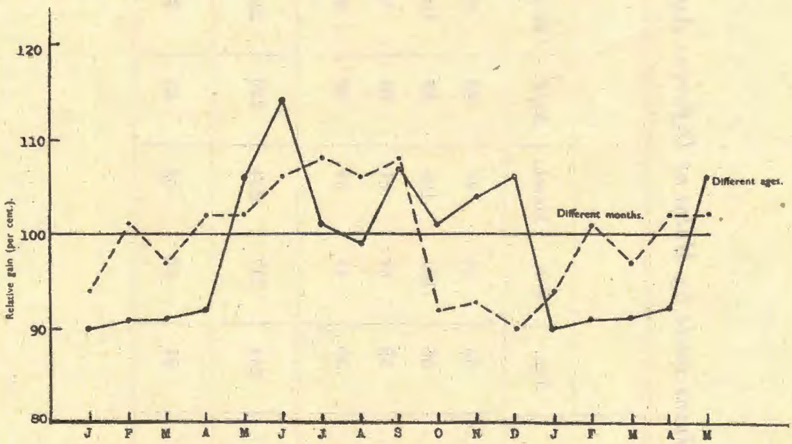

Fig. 57.—Relative monthly gains of male rats during different months. [Showing influence of month of birth on gain and the actual gains during different months (rats of different ages).]

These figures are illustrated in Figure 57. The curve illustrating the effect of the month, when rats are born on their gains, is very much the same as those in Figue 56. The curve illustrating the gains at different ages during the different months shows a lag of three months due to the fact pointed out earlier, that the month of birth is of greater importance than the month in which a rat happens to be, but born during another month. Since the males and females show the same trend, we have only determined the gains of the males.

On account of the influence of the month in which a rat is born on its growth, the distribution of the males born during the different months during the four years are given in the following table:—

	Growth Value of Each Month.	Distribution during the Four Years.			
		1933–34.	1934–35.	1935–36.	1936–37.
		%	%	%	%
January	94	14·1	9·6	6·3	3·7
February	101	—	10·6	7·0	—
March	97	12·5	10·6	—	12·3
April	102	7·8	10·6	—	13·1
May	102	11·5	—	—	3·7
June	106	13·0	16·3	35·2	—
July	108	9·9	20·2	16·9	9·4
August	106	8·3	—	—	27·0
September	108	6·8	13·5	19·0	6·6
October	92	2·6	—	5·6	—
November	93	5·7	8·7	—	6·6
December	90	7·8	—	9·9	17·6
Average for Year		87	103	103	100

These figures show that differences between years in the growth of the rats can be caused through a difference in the numbers born during the different months. This factor may have been the main reason why the rats of the different years showed the differences in rate of growth. On monthly distribution alone 1933-34 was the worst year and the second and third the best and the fourth not quite so good.

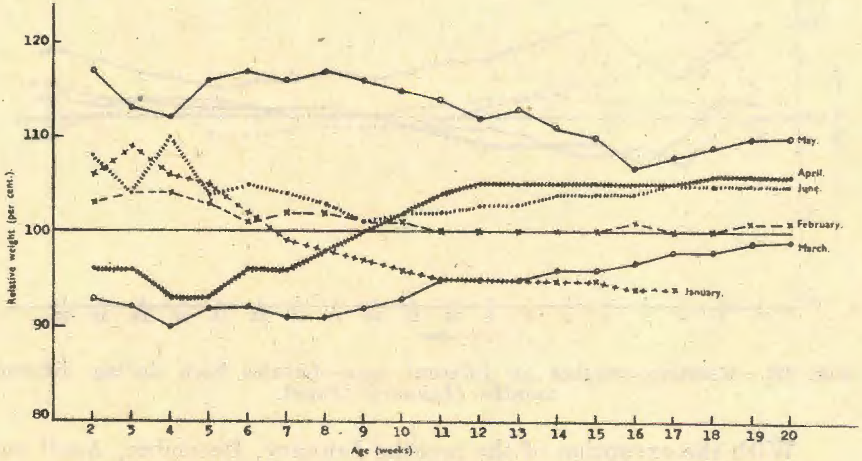

Fig. 58.—Relative weights at different ages—males born during different months (January—June).

To obtain an idea of the trend of the weights from the youngest to the oldest for each month, the average weights of the rats born during the different months are given in Table 56. For better comparison the average weights at each age have been expressed as percentages of the standard weights. The relative weights have been plotted in Figs. 58 to 61. The average weights of the females showed less deviation from the standard than those of the males, but otherwise the trends for all the months were about the same for the males and females. We will therefore only discuss the weights of the males as plotted in Figs. 58 and 59.

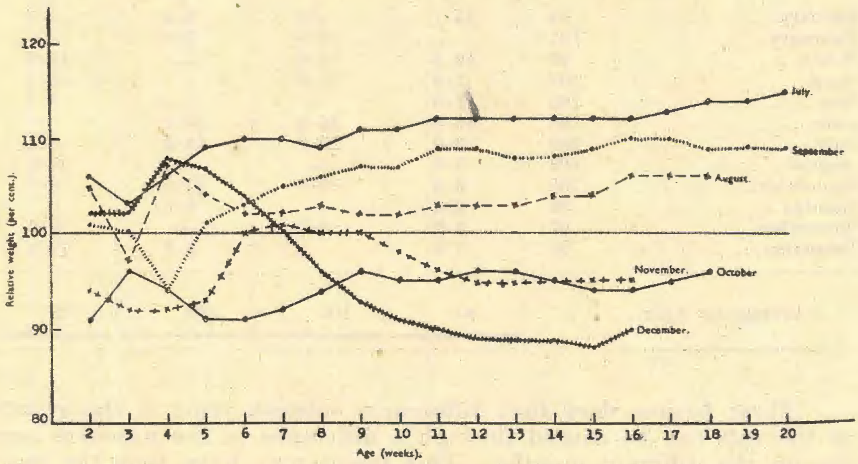

Fig. 59.—Relative weights at different ages—males born during different months (July—December).

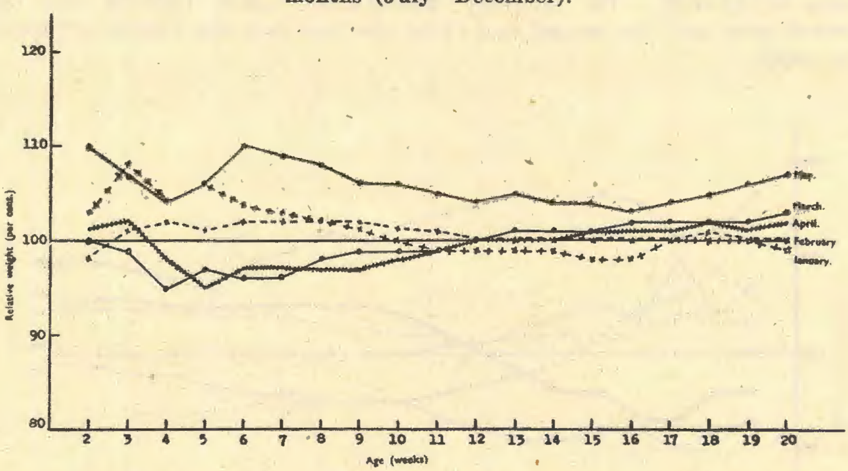

Fig. 60.—Relative weights at different ages—females born during different months (January—June).

With the exception of the months January, December, April and probably September, the trends for each month ran more or less parallel with the standard curve as the rats grew older. The rats born during January and December were at first above the standard weights but their weights decreased continuously so that they were below the standard after they were 6 or 7 weeks old. The weights of the rats born during April and probably September showed the opposite trend.

They were at first below the standard but showed a continuous rise till the rats were about 11 weeks old after which the weights ran parallel above the standard. These trends, therefore, show what one could already surmise from the positions of the relative weights in Fig. 54 at the different months.

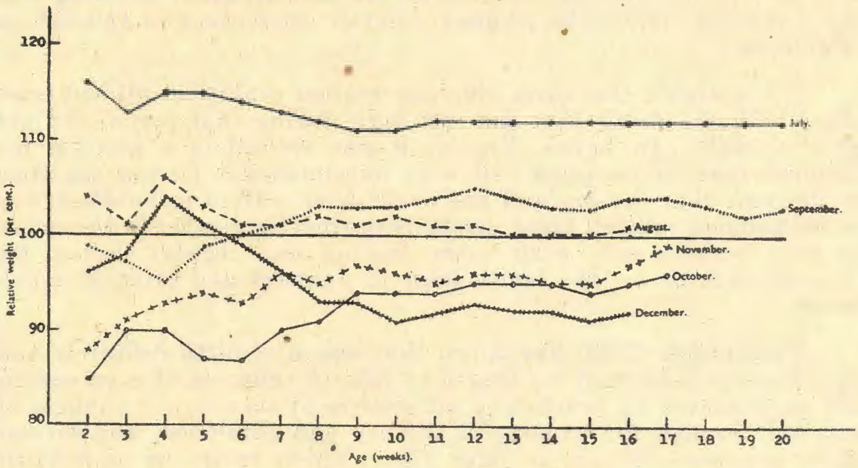

Fig. 61.—Relative weights at different ages—females born during different months (July—December).

With regard to the weights of the rats born during the different months we can offer suggestions and may come to a few tentative conclusions. As we have pointed out at the start, definite conclusions can only be drawn after such work had been carried out under controlled conditions with regard to temperature, humidity, light and pressure.

The average weights of the rats of different ages born from May to August (inclusive) were above the standard weights. From between September and October to February the average weights at all ages, except the 4 weeks old rats, were below the standard weights. The four weeks old rats born during December and January were above the average while all the others were below. The 16 weeks old rats born during March and April were just above the standard, with those at 12 weeks slightly lower, while the 8 and 4 weeks rats were much lower.

From these trends it does not appear likely that temperature alone could have been the only determining factor although it may have played an appreciable rôle. The rat is only poorly equipped with a heat regulating mechanism and suffers easily from too low or too high temperatures. The optimum temperature for rats is from 70° to 75° F. It is, however, unlikely that the low temperatures could have had any deleterious effect since the room was heated during the winter. Rats are also most active during the night so that even if the temperature did not fall too much below the optimum it may not affect them adversely. The room had fans which ran day and night during the hot period of the year. The temperature nevertheless occasionally rose above 85° to 90° F. The coldest time of the year is from May to August and the hottest from October to February. The rats born during the cold months were therefore above the average weights while those born during the warm months were again below the average, except the youngest rats born during December and January. During September and October the humidity is at its lowest. The disagreeable dust storms are most frequent in spring and early summer before the summer rainfall commences in October or November.

It is probable that these different weather conditions all had some effect with the result that the rats born during that period did not grow so well. In Lyons, France, it was noticed in a hospital for children that babies cried and were uncomfortable during the time of the year that the dry and hot winds blew. Here in South Africa in the summer rainfall areas, lambs born from September to December do very poorly, even with extra feeding and regular dosing for internal parasites. The lambs born in January and later do much better.

Huntington (1938) has shown that season of birth definitely and significantly influenced (*a*) length of life, (*b*) chances of a successful life as measured by practically all criteria of success, (*c*) chances of survival through the dangers of infancy and childhood, and several other existence factors of later life. There exists an undoubted seasonal vitality tide for man which directly influenced parental vitality as well as that of the offspring. The tide varies in its timing in different climatic regions and seems to depend more on the effective temperature level than on any other single factor. In middle temperate regions those individuals conceived at the time of the late spring peak in general vitality exhibited an average life span almost four years longer than do those conceived at the end of the summer's heat. A preponderance of great and illustrious personages over the world were conceived at this season which offers a longer life span.

Just what stimulated the growth of the 4 weeks old rats born during January is difficult to explain. The high weights were, however, not maintained, probably as a result of the depressing influence during March and April on the rats born in January. The low relative weights of the young rats but heavier relative weights of the older rats born in March and April, is probably due to the fact that there is some depressing effect which is not so marked on the older rats since they had a chance of experiencing the stimulating effect of June, July, and August.

At present we cannot say for certain what caused the depressing effect during March and April. A possible explanation, however, is that the shortening of the days may have influenced the activity of the pituitary of the growing rats and so slowed down the growth rate. The 12 and 16 weeks old rats born during January were above the average at 4 weeks but below from 8 weeks onward. That the mature rats may also have been affected is indicated by the observations that the females do not breed readily during April. There is also a possibility that the milk secretion may have been affected as well in the case of those that suckled young during March and April, so that the weights of the 4 weeks old rats may have been influenced by the effect on the pituitary and by the milk supply.

In this connection it may be of interest to mention the experience of dairymen in the summer rainfall area. During March and April there is a decrease in milk production with the best feeding. Most of the calves are born during January and February, but even this can not prevent the decrease during March and April.

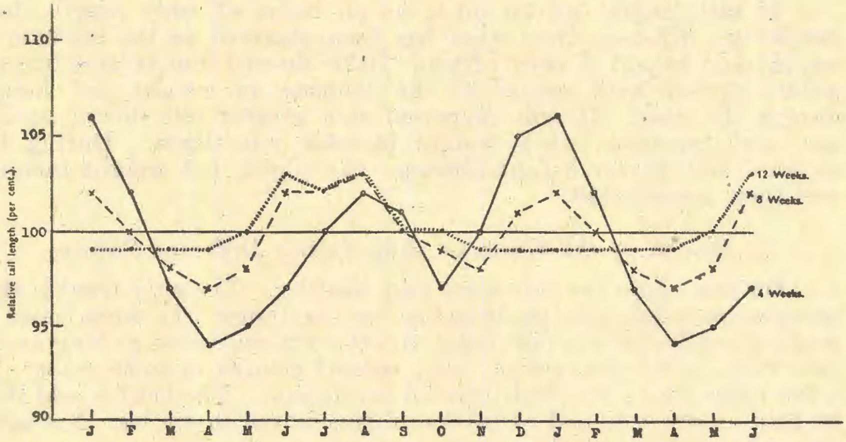

Fig. 62.—Influence of time of year on relative tail length of rats born during different months— males of different ages.

Tail length.—The average tail lengths of the rats of 4, 8, 12 and 16 weeks of age born during the different months are given in Table 57. The average tail lengths have been smoothed and expressed as percentages of the standard tail lengths. The smoothed and relative lengths are also given in Table 58 and the relative tail lengths illustrated in Fig. 62. The rats in the youngest age class showed the greatest fluctuation during the year, the 8 weeks old rats less and the 12 and 16 weeks old rats still less. The relative weights (Fig. 54), however, of the rats in the different age classes were much closer together during the different months, except perhaps December and January, than the tail lengths were.

The 4 weeks old rats showed a continuous decrease in tail length from January until April. After this there was a slow increase until August when the average tail length of rats born during that month was slightly higher than the average. The tail length reached another minimum during October when it started rising again, reaching its highest level in January. The 8 weeks old rats also showed two high and two low levels which were, however, closer to the average than the tail lengths of the 4 weeks old rats. The 12 and 16 weeks old rats had average tail lengths slightly above the standard from June to August. For the rest of the year they ran parallel with the average, but only slightly below.

As we have mentioned, the tail lengths of rats of different ages showed less fluctuations during the year than the weights did. The fluctuations that did occur, coincided more or less with the trends of the weights. The fluctuations of the tail lengths of the 4 weeks old rats differed from the weights in so far that the maximum tail length of the rats born during January was greater than the maximum of those born during August, while the opposite was the case for the weights of 4 weeks old rats.

The lesser fluctuation of tail length during the year than of weight, would be expected since the former is earlier maturing than weight and is consequently less affected by environment.

If tail length can be taken as an index of body length these results are different from what has been observed on the increase in weight and height of man. Nylin (1929) showed that several investigators agreed with regard to the increase in weight and height during the year. Height increased at a greater rate during spring and early summer, while weight increase was slight. During the autumn and winter height increase was slight, but weight increase was then accentuated.

5. *Health of the Growing Rats during Different Seasons.*

On the whole the rats were very healthy. The only trouble that was encountered, was an infection of the lungs. In some cases it was noticed for only a few days; in others it continued as long as the rats were under observation, viz., several months in some cases. In a few cases young rats had internal ear disease. The head would then be held on one side and often the animal moved in circles. Not more than half a dozen of these cases occurred.

With regard to the infection of the lungs, detailed observations were made only on the growing rats before they were 20 weeks old. Of the 1389 rats that were weighed every week 131 or 9·4 per cent. had lung trouble for a few days or longer. Of the 131 sick rats 83 or 63·4 per cent. were males and 48 or 36·6 per cent females. Or put differently, 12·2 per cent. of all the males showed some lung trouble as contrasted to 6·8 per cent. of the females. Taken as a percentage either of all the sick rats or of all the males, there were nearly twice as many males that showed the lung trouble as females.

How the sick cases were distributed over the different age classes is of interest as shown by the following figures:—

		Age in Weeks.				
		7 and below.	8–11.	12–15.	16–20.	Total.
Males............	Number	9	22	19	33	83
	Per cent.	10·8	26·5	22·9	39·8	
Females..........	Number	8	8	12	20	48
	Per cent.	16·7	16·7	25·0	41·7	
All Rats..........	Number	17	30	31	53	131
	Per cent.	13·0	22·9	23·7	40·5	

There appears to be no significant difference between the sexes with regard to the distribution over the different ages. Both show a much higher incidence of disease from 16 to 20 weeks of age than during any other period of equal length. During that time 40·5 per cent of the cases occurred. It should be mentioned that when a rat had lung trouble which disappeared and recurred again before it was 20 weeks old, only the first occurrence was taken into consideration so that the 131 rats are all separate animals. Of the 17 cases below 7 weeks of age only 5 were of rats which were 4 weeks old or younger.

When the time of year during which cases of lung trouble occurred, are grouped, there is a decided seasonal trend as shown by the following figures:—

		Winter. (May–July.)	Spring. (Aug.–Oct.)	Summer. (Nov.–Jan.)	Autumn. (Feb.–April.)	Total.
Males............	Number	30	28	12	13	83
	Per cent.	36·1	33·7	14·5	15·7	
Females..........	Number	16	12	12	8	48
	Per cent.	33·3	25·0	25·0	16·7	
All Rats..........	Number	46	40	24	21	131
	Per cent.	35·1	30·5	18·3	16·0	

The lung trouble was therefore most prevalent during the winter months. The spring months followed closely. During the summer and autumn months only about half the number of cases occurred as during the other two seasons.

C. Growth Factors Influencing Food Intake.

1. *Pregnancy.*

(*a*) Average food intake of all females.
(*b*) Influence of weight of female on food intake.
(*c*) Influence of litter size at birth on food intake.

2. *Lactation.*

(*a*) Daily weight of females.
(*b*) Daily weight of young.
(*c*) Daily food intake of females.
  (i) All females.
  (ii) Effect of litter size.

3. *Young growing rats (males and females)—food utilization.*

The energy, protein, mineral and vitamin requirements of the rat during growth and reproduction have all been studied in detail by a large number of investigators. It is, however, not our intention to cover the same field again in this section, but rather to utilise the food intake as a measure in obtaining more information on how the rat adjusts itself with regard to its food intake during pregnancy, lactation and growth.

In these experiments we intended to use a ration fairly similar to the stock ration. The milk intake could not be regulated properly since it became sour during the summer months and the composition varied from day to day. It was, therefore, decided to use rats receiving only a meal mixture and water. Some were given the meal and milk for the sake of comparison. Slonaker's (1931, a, b, c, d, e, f) studies on the protein requirements of different classes of rats have indicated that the optimum is close to 18 per cent. protein in the ration. The following meal mixture, which has been adopted as the stock ration after the completion of our observations, was, therefore, used:—

Yellow maize meal	65 per cent.
Linseed meal	15 per cent.
Crude casein	7 per cent.
Yeast	3 per cent.
Lucerne meal	2 per cent.
Bone meal	2 per cent.
Cod liver oil	2 per cent.
$CaCO_3$	0·5 per cent.
NaCl	0·5 per cent.

The crude protein of the above mixture is 18·5 per cent. and the crude fibre 3·0 per cent.

Pregnant and lactating females and young growing rats were fed individually on the above mixture, some received milk, which was not controlled, and others water. A small number of males and females were also kept and fed in groups to compare their rate of growth with those fed individually. The rats fed individually could eat as much of the meal as they desired. The meal fed was weighed every day and the amount not consumed weighed back the day after.

1. *Pregnancy.*

Three trials were conducted in which pregnant females were fed individually. The females were first fed in individual cages for about a week before they were put with the males. Every morning all the females were inspected for vaginal plugs. Those that were served were removed, each one being put back in her cage. Each rat then received a weighed amount of the meal mixture. The meal that was left over the following morning was weighed back and a fresh amount weighed out. This was done daily up to the birth of each litter and after that, for 28 days, when the young were weaned. In the three trials, 28 females received the meal mixture and water. In the third trial another six females were given milk instead of water.

In Table 59 are given the daily weights of the rats and the daily amounts of food consumed. The weights of all the rats that received water have been averaged. The average weights of the rats in the third trial that received milk and those that received water are also given. The rats that received milk ate only 9·2 g. daily of the meal mixture while those that received water ate daily 16·7 g. of the meal. The rats that had milk showed no increase in the amount of meal consumed as pregnancy advanced. During the first week after service they consumed daily 9 g., 9·5 g. during the second week and 9·1 g. during the third week. The females that received water in the third trial, consumed daily 15·5 g. the week after they were served, 17·2 g. the second and 17·4 g. the third week. When all the females (28) that received water are grouped then the daily food consumptions during the first, second and third weeks after service are 13·4, 15·5 and 16·9 respectively, and an average of 15·3 g. daily for the whole period. After the first week the consumption had increased by 16 per cent. and 26 per cent. after the second week, or an increase of 9 per cent. from the second to the third week.

The rats receiving milk ate a total of 193 g. of meal per rat during 21 days after service, which was divided evenly over the three weeks—33 per cent. of the total being consumed during the first week, 34 during the second week and 33 during the third week. The other rats consumed 320 g. per rat during 21 days after service. During the first week of pregnancy 29 per cent. of the total amount was consumed, 34 per cent. during the second week and 37 per cent. during the third week.

All these figures show that when milk is fed, the rats do not eat more of the meal as pregnancy advances, while those receiving water instead of milk, show an increase of 26 per cent. from the first to the third week after service. It would, therefore, appear that those receiving milk, rather drink more milk than eat more of the meal mixture to supply in the increasing demands of pregnancy.

Slonaker (1927), however, found that during pregnancy the daily food intake increased only by 2 g. His non-pregnant females, however, ate about 19 g. daily while those in our experiment only ate an average of 12·5 g. when no milk was given. He had his rats in revolving cages so that this may have caused some of the difference between his and our results.

In a previous section (prenatal growth) the weight changes of different classes of rats during pregnancy have been shown. With the exception of the very young females there is only a small increase (about 15 per cent.) in weight during the first two weeks. After the second week of pregnancy there is a sudden increase in weight. The increase in food consumption does not show the same sudden rise. The daily amount of food consumed reaches its maximum three days before the birth of the litter. After that there is a sudden decrease. This, therefore, corresponds to the daily increase in weight of the pregnant female which reaches its maximum four days before the birth of the litter. Slonaker (1925) also found that about four days before the birth of the litter there is a decrease in the daily food intake, which is very low on the day that the litter is born.

Only in the first and third trials were the daily amounts of food weighed during the week before the females were put with the males. The average amount consumed daily per rat was 9·9 g. The average for the first trial was 7·3 and 12·5 g. for the third. The average weights of the rats were 223 and 225 g. respectively. When the average of the two trials is taken, then there is an increase of 35 per cent. in the amount of meal mixture consumed from the week before service to the week after service. The increase is 70 per cent. from the week before service to the third week after service.

Our results agree with those of Cole and Hart (1938) with regard to the increase in the food consumption of pregnant *versus* non-pregnant rats. They state that an increased appetite is manifested 48 hours after copulation and that the average consumption during pregnancy is 30 per cent. greater than in the non-pregnant controls. Their results, however, do not agree with ours with regard to the increased consumption during the gestation period for they found that the food consumption remained relatively constant throughout the period of pregnancy, while our results show an increase of 26 per cent. from the first to the third week of pregnancy. Slonaker's (1927) results again showed only an increase of 2 g. in the daily consumption of rats after they became pregnant. It was, however, pointed out that his rats were in revolving cages and consumed a rather high amount of food daily before they were served.

Slonaker (1927) estimated that the energy required for the prenatal development of each young was approximately 80 calories and for the postnatal growth to the weaning age 300 calories. We have arranged the food consumption of the females during the three weeks of pregnancy according to litter size at birth in Table 60. It will be seen that there are some fluctuations but no trend is manifested.

To see whether the weight of the female at service did not perhaps have some influence on the food consumption, the food consumed was arranged according to body weight at service. It will be seen in Table 61 that the weight of the female had no influence on the amount of food consumed.

2. *Lactation.*

(*a*) *Daily weights of mothers.*

The daily weights of the females from the birth of the litters to weaning (28 days) are given in Table 62 and illustrated in Figures 63 and 64. The weights of the rats receiving milk with the meal mixture and those receiving water with the meal mixture, have been kept separately. On account of the smaller number of observations, the former shows some fluctuations, otherwise the curves are more or less the same. After birth there is a tendency for the weight of the mother to remain constant or to increase slightly up to 19 days after the birth of the litter for those receiving water, and 20 days for those receiving milk, after which there is a gradual decrease up to the time that the litter is weaned.

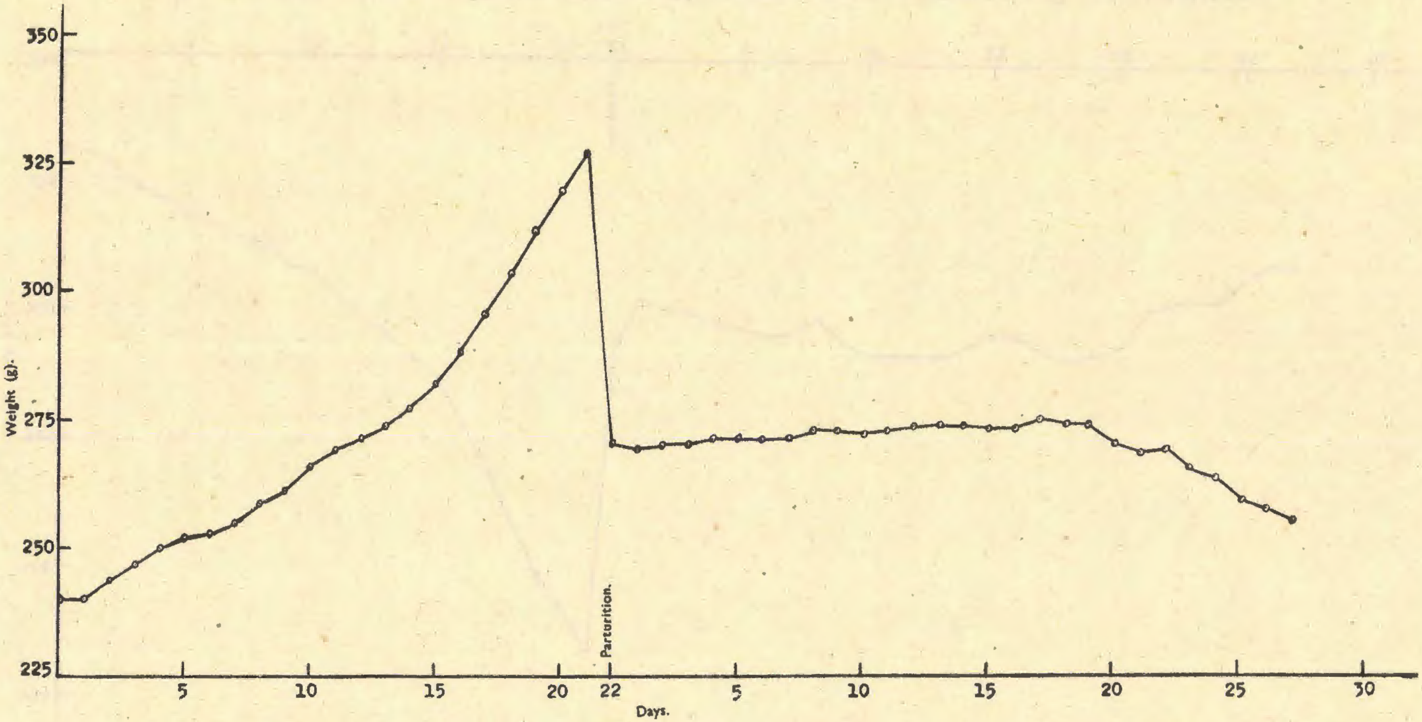

Fig. 63.—Daily weights of females during gestation and lactation—group on water and meal mixture.

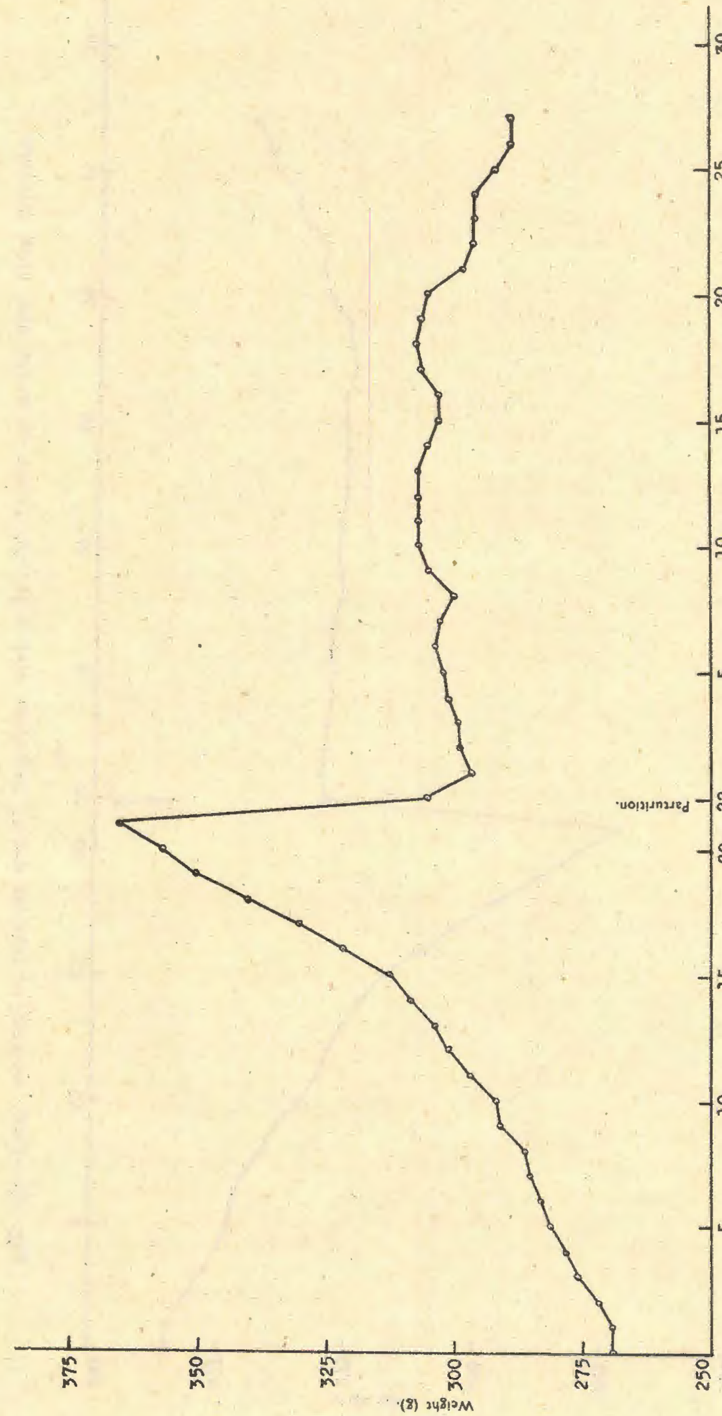

Fig. 64.—Daily weights of females during gestation and lactation—group on milk and meal mixture.

In a former section (weights of mothers while suckling pups) the weights of females at 2, 3, and 4 weeks after the birth of litters have been given. There the weights at 2 and 3 weeks were above the birth weights and at 4 weeks had again decreased to the same as the birth weights. The present data only show a slight increase up to about 3 weeks and then a continuous decrease up to 4 weeks. The weights at 4 weeks are therefore lower than the weights at the birth of the litters.

In the previous section the results were obtained from 123 rats, the litters of which were born throughout the year. The data under consideration were obtained from October to December. There were also indications that there may be some seasonal influence on the weights of the mothers while they suckled their young. The weights at 4 weeks, especially during the three months October, November and December, are below the average of all the litters.

It does not appear, however, as if the seasonal influence explains all the difference found in the trends of the weights taken only at birth, 2, 3, and 4 weeks and those taken daily. In all cases the rats had access to as much food as they would eat. It seems doubtful whether daily handling could have had an influence since all the rats were very tame. The most likely explanation appears to be the absence of milk in the ration.

Cole and Hart (1938) also observed a fairly rapid weight increase of the females during the first 14 days of lactation. They did not mention what the trend of the weights of the females was up to weaning.

All our data, however, agree in that the weight decrease only begins to take place near three weeks after the birth of the litters. In taking daily weights of the mothers after the birth of the litters, it appears that the decrease commences at about the 19th or 20th day after the birth of the young. This more or less coincides with the period when the young start to eat solid food. Moore and his co-workers (1932) found that the weight of the mothers remained constant for a week after the litters were born and then decreased, while Slonaker (1931 f) found a decrease from birth, the amount of decrease depending on the amount of protein in the ration and probably also on the size of the litter. Macomber (1934) also found that the protein content in the ration had a very marked effect on the amount a female lost in weight during lactation. When lactating females received a ration with 20 per cent. protein they lost 4 g. in the one experiment and gained 6·3 g. in another. On a ration with 16·8 per cent. protein they lost 19·3 g., 40·5 g. on 10 per cent. and 74 g. on 5 per cent. protein.

Hitchcock (1927) did not give the daily weights of his rats during the lactation period but only the average weight at birth and at 30 days when the litters were weaned. In one group the females were 0·6 g. lighter and in the other 1·2 g. heavier at weaning than at the birth of the litters.

(b) Daily weights of the young.

In Table 63 and in Figures 65, 66 and 67 are given the daily weights and the daily increments in weight of the young while suckling.

When all the litters are considered, then the daily gains show a fairly rapid increase up to the 8th day after birth. From the 8th to the 12th or 13th day the increase is only gradual, and start decreasing after the 13th day up to the 16th day, and remains constant until the 18th day, after which there is a rapid increase in the daily gains.

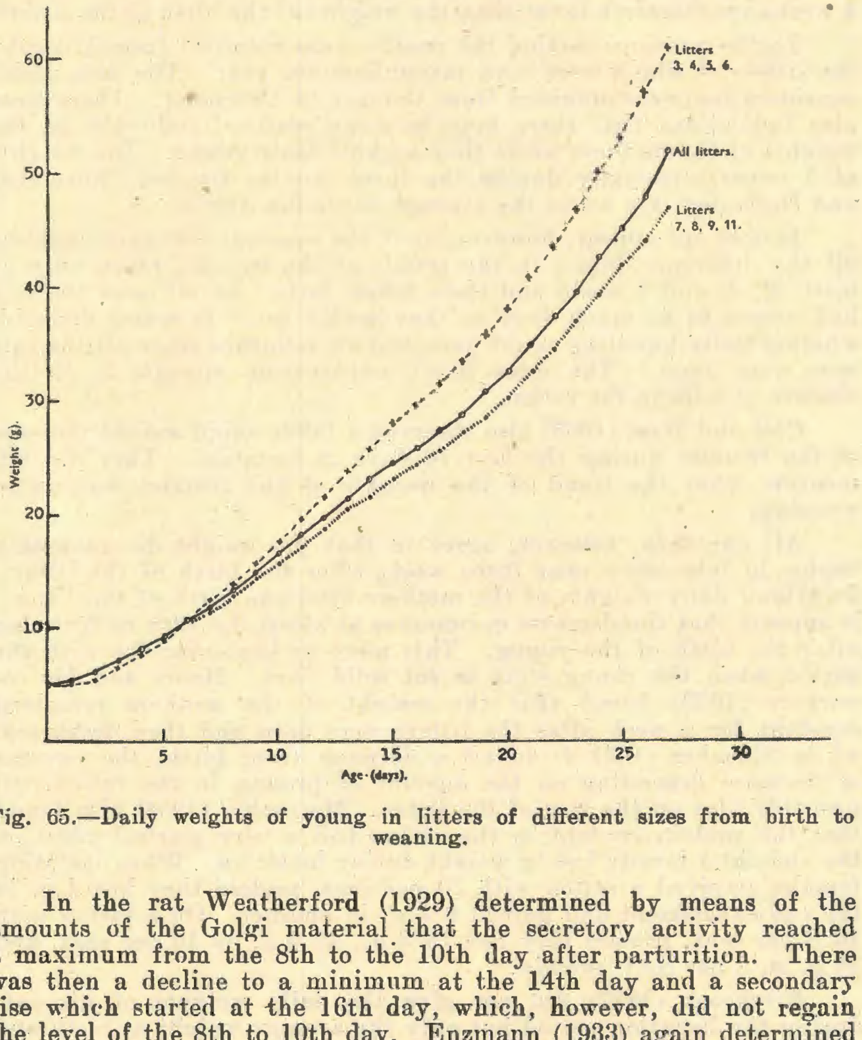

Fig. 65.—Daily weights of young in litters of different sizes from birth to weaning.

In the rat Weatherford (1929) determined by means of the amounts of the Golgi material that the secretory activity reached a maximum from the 8th to the 10th day after parturition. There was then a decline to a minimum at the 14th day and a secondary rise which started at the 16th day, which, however, did not regain the level of the 8th to 10th day. Enzmann (1933) again determined the milk production of mice, which also showed a maximum at 10 days after parturition and declined until the young were weaned. The growth curve of the young ran parallel with that of the milk production. Mothers with large litters gave more milk than mothers with small litters. The rate of growth increased again at the 15th day after the young had started to eat solid food. It was noteworthy that the decline set in before the eyes of the young opened and so before they started to eat solid food. Enzmann consequently concluded that the activity of the young was not the only factor involved in the decrease in milk flow as maintained by MacDowell and his co-workers (1930). They maintained that the eating of solid food was the cause of the decline in the growth rate and not the decline in milk production. In mice, Parkes (1926) obtained the same type of curve for the daily gains, which he divided into three phases: the first 0-9 days—a period of rapid growth; 10-15 days—a period of progressively reduced growth when the nutrition of the young become progressively inadequate; 16-21 days—when the growth again becomes rapid as the young learn to eat for themselves. With our data the growth curve during the four weeks that the young are suckling can also roughly be divided into three periods; from 0-13 days, from 14-18 days, and from 19-28 days.

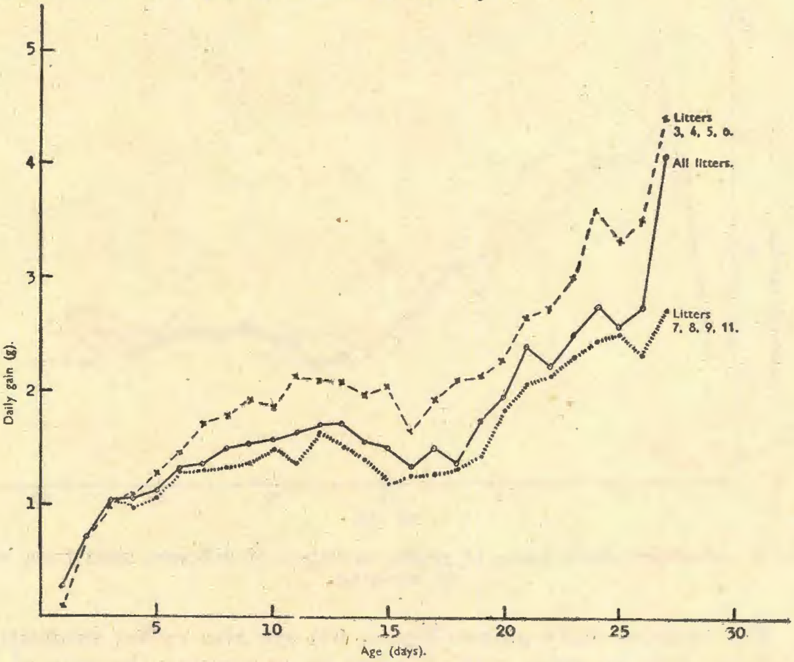

Fig. 66.—Daily gains of young in litters of different sizes from birth to weaning.

During the first period the young obtain enough nourishment from their mothers to show an increase in their daily gains. During the second period, however, the demands of the growing young have become so great that the females cannot supply enough milk with the result that the daily gains start to decrease. At 14 to 15 days the eyes of the young are open and they start to nibble the solid food with the result that the decrease in gains is arrested at 16 days. At the 19th day there is an increase again which is maintained up to weaning.

That this is the correct explanation is indicated by the curves obtained for large and for small litters. The daily weights are about the same up to 6 days after which the difference increases daily. The daily gains also show different types of curves. The rats in the small litters (3-6) show a marked increase in daily gains up to 11 days, while those in large litters (7-11) only show a marked increase up to 6 days and after that only small increases up to 12 days and then decreases to 15 days. The curve of the small litters tends to remain constant or to decrease slightly from the 11 to 15 days with a drop at 16 days. After that there is a steep increase, which only takes place after 19 days in the large litters. The earlier increase in the daily gains of the rats in the small litters is probably due to the fact that they start to eat earlier than those in the large litters which had been stunted to a certain extent and consequently do not start eating solid food so readily.

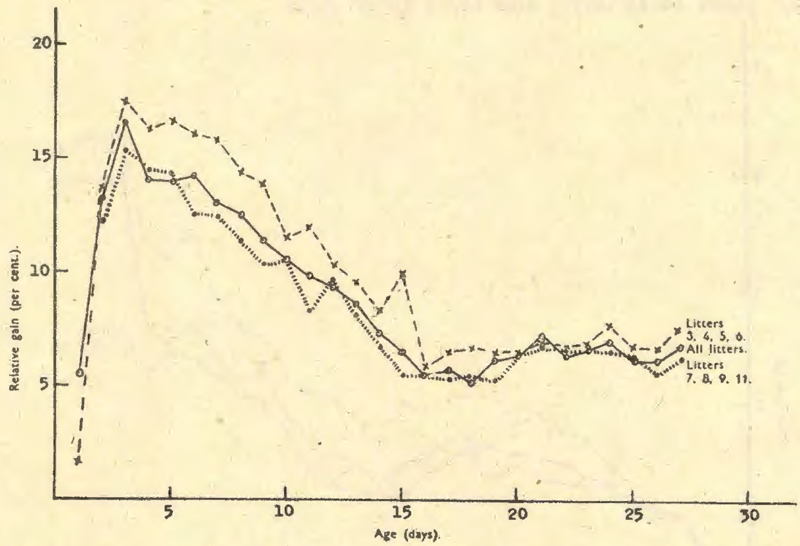

Fig. 67.—Relative daily gains of young in litters of different sizes from birth to weaning.

The relative daily gains (Figure 67) are also rather interesting. The relative daily gains were obtained by expressing the gain of one day as a percentage of the liveweight on the previous day. At 3 days after birth the maximum is reached, after which there is a gradual decrease up to 16 days, and an increase again at 19 days which is, however, not maintained after 21 days, but remains at about the same level. The relative gains of the rats in the small litters remain higher than those of the large litters up to about 20 days after which there is very little difference. At that age, the rats in the large litters are already eating well, so that the relative gains are nearly the same as those of the rats in the small litters. At that stage the effect of the difference in the amount of milk obtained per rat has been eliminated since the rats can then eat as much solid food as they desire.

The results of Hain (1935) on the growth rate of suckling rats of different sized litters agrees with our results. She found that the growth rate of rats in litters of 2-7 is more rapid than that of rats in litters of 8-13, the difference being especially marked between the 10th and 20th days. After 20 days the rate of increase was almost the same in both groups. This fact she took to indicate that the retardation of growth from the 10th to 20th days when a larger litter was suckled was due to lack of adequate nourishment.

The average daily weights of the pups of females that received milk with the meal mixture and of those that received water with the meal mixture have been included in Table 62.

The milk ration had no influence on the birth weights of the pups. It, however, appears that it had a beneficial effect on the milk production of the females for although the birth weights of the pups in the milk ration were lower they had the same average weight at 3 days. At 4 days they were higher, the difference increasing up to 27 days when they were 63·3 g. and those on the water and meal ration 48·7 g.

In mice MacDowell, Gates and MacDowell (1930) found at 15 days after birth a break in the growth curve of the young. They attribute it to the change in behaviour of the young. Up to this time the large, well fed young are markedly inactive,—the eyes have opened the day before; in another 24 hours they begin to run around, pick up solid food and begin to nibble. They are indiscriminate in what they eat—even faeces of their mothers. Intestinal looseness develops. They can eat solid food, but are still dependent upon their mothers, since removal of mothers at this time will result in a continued and rapid loss of weight for 4 to 6 days. They maintain that there can be no question but that a new phase of life is inaugurated at the end of the second week by the eating of the first solid food. The transition is not as rapid as that affected by parturition, nor is the change so great as that from uterine to free existence, but none the less comparable—a change from one source of nutrition to another.

(*c*) *Daily food intake of females.*

The daily food intake of females while suckling young is given in Table 62 and Fig 68. The food consumption of the rats that received milk is also included for the sake of comparison. The two groups of rats show different trends in their consumption of the meal mixture. Those that received milk, only at 7·8 g. daily during the first week after the birth of the young. This is even below the amount taken during pregnancy. During the second week the daily increase had doubled. It increased continuously until the females ate 4½ times as much during the fourth week than during the first week. The rats that received water on the other hand, ate more during the first week after the birth of the young, than during the last week of pregnancy. During the second week the consumption had increased by 51 per cent. The increase from the second to the third week was only 28 per cent., but from the third to the fourth week 50 per cent. It would appear that during the third week the females more or less approach their limit, but at 19 days the food consumption shows a sudden increase indicating that the young have commenced

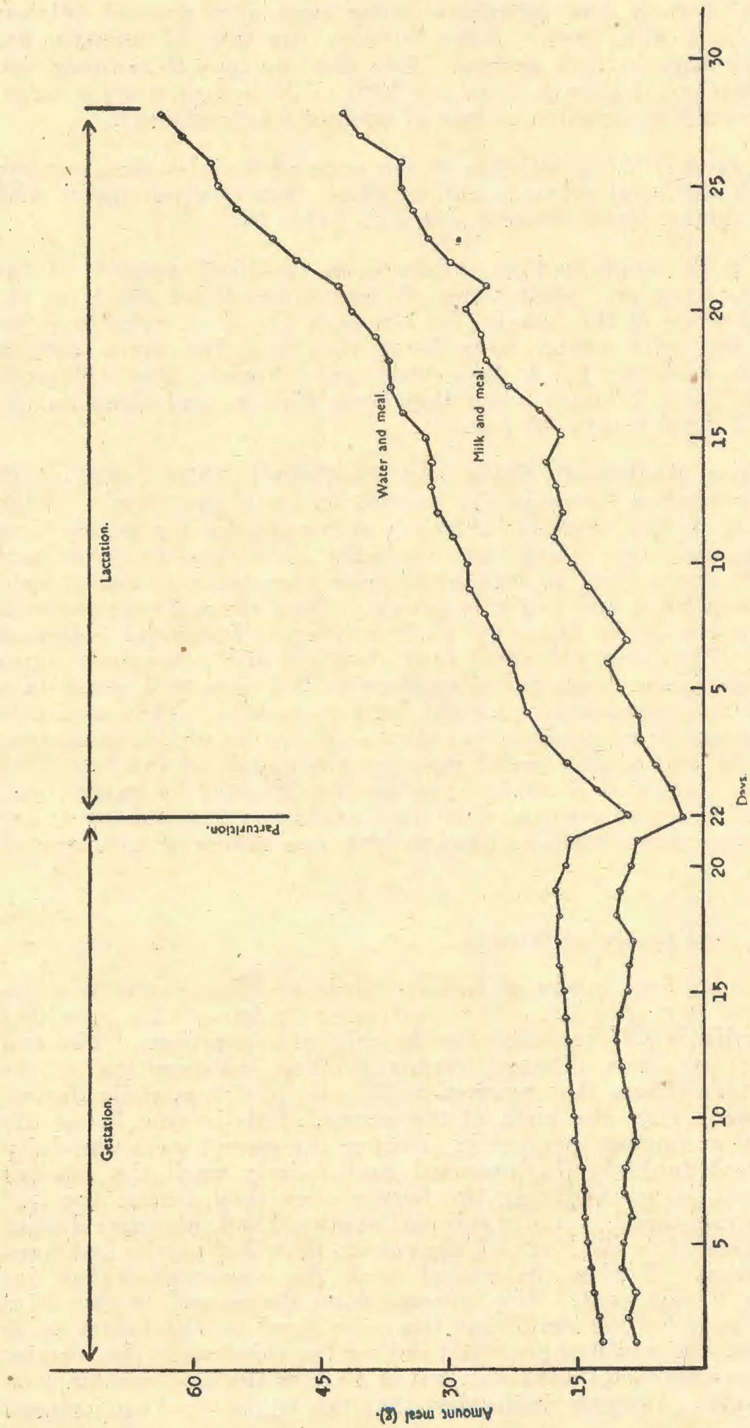

Fig. 68.—Daily food consumption of females during gestation and lactation.

taking an appreciable amount of solid food. The rats receiving milk did not show the same percentage increase from the third to the fourth week, indicating that the young made good use of the milk that was fed.

Hitchcock (1927) fed rats with litters on a balanced ration and others on the same ration plus meat. Those on the meat ration consumed daily 37 g. of food during the lactation period, of this amount he estimated that 10 g. was required for maintenance. The other rats ate daily 29 g. of which 9·4 g. was for maintenance. The average daily food intake for the rats in our experiment that received water was 36 g. during the lactation period, a figure which is, therefore, very close to what Hitchcock obtained for his one group.

Litter size and amount of food consumed.—The females that reared all their young, were grouped according to litter size to get an indication of the influence of litter size on food intake of the mothers. The result is given in Table 64. The weekly amounts of food consumed are given along with the totals for the four weeks. The relative amounts have also been determined, the food intake of the smallest litter size being taken as 100.

The figures indicate that during the first week after the birth of the young, females with litter sizes of 4 to 7 (inclusive) take the same amount of food. With larger litters, however, the food intake increases. During the second and third weeks there is only a small increase for litters up to 7, and only during the fourth week are there any appreciable increases. When the whole lactation period (4 weeks) is taken, then females with 5 and 7 young only eat 9 and 14 per cent. respectively more than those with 4 young. Larger litters show much larger differences in food intake.

Although the number of observations is rather limited, these results indicate that females with 7 young and less require more or less the same amount of food while the young are suckling. Only when the pups start eating is there an appreciable increase in the food intake. With larger litters, however, there appears to be an increase in food intake with each increase in litter size. During the lactation period of 28 days the average daily food consumption of females with litters of 7 and smaller was 31 g. and of females with litters of 8 and above 42 g. Slonaker (1925) found that females with litters of 6 and below consumed an average of 27·3 g. of food daily during 25 days of lactation. Those with litters of 7 and above consumed 38·6 g. daily. The females with small litters were also less active than those with large litters. The former averaged 1456 revolutions and the later 1858 revolutions in their revolving cages. This difference in activity was not due to individuality for when the same female had a large litter her activity was greater than when she had a small litter. Slanoker is inclined to believe that a difference in vitality is the cause and the vitality of individuals may change at various times. With a low vitality smaller litters are produced and the female has less inclination to run.

Slonaker (1927) estimated that a female suckling a litter required 300 calories per young during the lactation period. In the ration he used, one gramme of meal mixture had 3·82 calories, so that 79 g. of food was required per young. When all the litters of different sizes are taken in our observations, then the amount of food required during the lactation period for an increase of every pup from 4 to 11 is 72 g. When the litter increases from 4 to 7, then the average increase in food intake per unit increase in litter size is only 40 g., while with an increase in litter size of 7 to 11 the average increase in food consumption is 98 g. per unit increase in litter size during the lactation period of 28 days.

Slonaker (1931 c) found with his old females that they wasted 26 per cent of the meal mixture that was fed. The wastage in our experiments was not determined, but from observations it appeared to be much less than the figure found by Slonaker. The shape of the containers prevented the rats from scratching out the meal. A small wastage may occur when the rats scoop up meal in their front paws and then drop some outside the containers.

3. *Young rats after weaning.*

In this part our main object was to obtain data on the differences in food intake of males and females during the period that the greatest daily gains are made. In a previous section we have shown that shortly after weaning the difference in the weights of males and females increases rapidly.

Young rats from five litters were used in this experiment. The youngest litter was just weaned and the oldest litter 12 days earlier. The rats were divided into 4 groups according to weight and age. In each group there were 4 males and 4 females. The first group received milk with the meal mixture, each rat being put by itself in a cylindrical cage of wire mesh which measured 9 in. in diameter and 15 in. high. The rats in the second group were also placed in these individual cages, but received water instead of milk with the meal mixture. Every rat was fed as much as it would eat, the food being weighed out every morning, after the food that was left over from the previous day had been weighed back. The rats in group three also received milk with the meal mixture, the 4 males and the 4 females being fed in 2 cages. Those in group four were also fed in 2 cages, but received water with the meal mixture. These rats were fed as much as they would eat. The food given was not weighed. All the rats were weighed daily.

On account of the difficulty in feeding liquid milk, as explained earlier, we used the water and meal ration but included a milk group to get a comparison of the growth rates. The two groups in which the rats were fed in lots were again included so that we could have a control for the treatment the rats had in the colony.

Individual vs. *group feeding.*

The males and the females in the four groups had the same average weights when the experiment commenced. The rats in the individual cages were fed and weighed for 60 days and those in groups for 50 days. To eliminate the daily variations 5 days were taken as a period. The weights and average daily gains at the end of each 5-day period are given in Table 65. The males that were kept in the individual cages and received milk were 29, 27 and 26 g. heavier than the other three groups of males respectively. There is no significant difference between the other three groups of males. The females on the other hand show no difference between the groups fed individually and in groups so that the method of feeding had no influence on their gains.

It was noticed that the rats, kept in groups in the larger cages, played and ran about a great deal. Those in the individual cages could not run about on account of the small size of the cages. This does not appear to have affected the gains of the rats, unless this may have caused the difference in weight of the males fed milk in individual cages. No explanation can, however, be given why the males fed water individually and in groups did not show a similar difference in favour of those fed individually. It appears, however, that taken generally there has been no detrimental effect in confining the rats to the small cages. The results obtained with individual feeding can, therefore, be taken as comparable to what one will expect from similar rats kept under conditions of the rats in the colony.

Milk vs. *water.*

Only those males and females that were fed in individual cages will be considered here. The final weights at the end of 60 days, or period 12, are given in Table 65. The males that received milk were 11 per cent. heavier than those that received water while the females that received milk were 8 per cnt. heavier than the females that received water. The average daily gains given in Table 66 also show larger differences between the two groups of males (4·32 and 3·8 g.) than between the two groups of females (2·26 and 2·04 g.). The average daily food intake shows the reverse. The males that received water ate 42 per cent. more of the meal mixture than those that received milk, while in the case of the females the difference is 73 per cent. These results, therefore, indicate that even after rats have been weaned they still grow better when milk is added to a balanced meal ration.

Food utilisation by growing males and females.

Palmer and Kennedy (1931) have shown when studying the effect of diet on growth that it is not enough to give the amount of food consumed per unit of gain since this method does not allow for the food cost of maintenance, which increases as growth proceeds. They then recommended the use of a figure, which they termed the "efficiency quotient", which represents the digestible dry matter consumed in grs. per gr. of gain in weight of 100 g. of body weight.

The calculation is made as follows:—

$$\text{Efficiency quotient} = [\text{digestible dry matter consumed} \div \text{gain in live weight}) \div \text{mean weight during the experiment}] \times 100.$$

In this experiment we did not determine the digestibility of the dry matter in the ration. Since the ration was the same throughout we used the actual amount of food consumed to determine the efficiency index. The efficiency indices for the four groups of rats during the different periods are given in Table 66 along with the average daily food consumptions.

The daily amount of food intake of the males increases up to about the sixth or seventh period(30-35 days), which is equivalent to an age of 65 to 70 days (Fig. 69). After that the consumption remains more or less constant, although the average daily gain starts to decrease. The daily food intakes of the females only increase up to the fourth period (20 days), i.e., when they are about 55 days old, and then remains constant (Fig. 70). Their daily gains also show a decline.

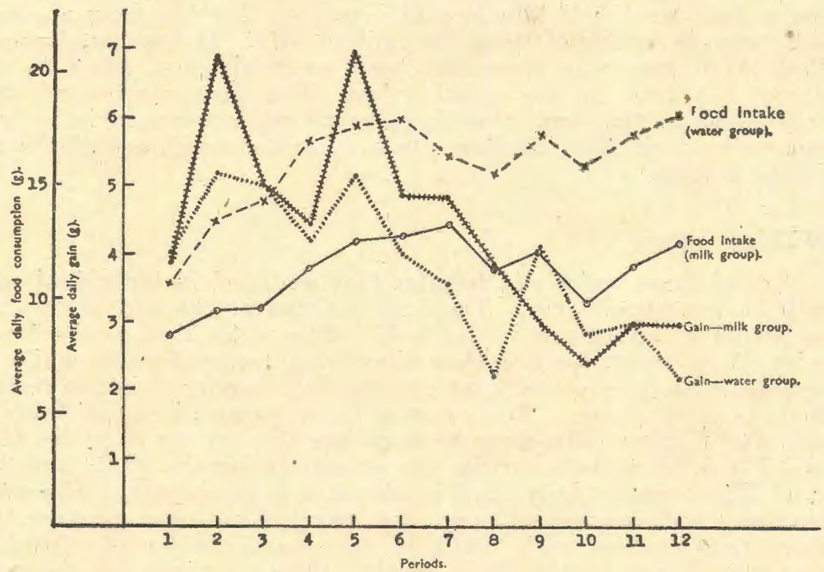

Fig. 69.—Gains and meal consumed per rat per day—males.

The efficiency indices of the males receiving water shows greater variation than those receiving milk. The females receiving water also show more variation than those receiving milk. This appears to be due to less variation in the daily gains of the rats receiving milk. The efficiency index of the males receiving water is 71 per cent higher than those receiving milk and of the females receiving water 121 per cent. higher than those receiving milk. These efficiency indices are just used to indicate to what extent use was made of the milk, since to obtain the true efficiency index the digestible dry matter of the milk should also be considered.

The efficiency index of the males on milk is lower than that of the females on milk, the two average figures being 1·36 and 2·34 respectively, while that of males on water is lower than that of females on water, 2·33 and 5·17 respectively. The efficiency index of females on milk is, therefore, 72 per cent. higher than that of males on milk, while that of females on water is 122 per cent. higher than that of males on water. The food utilisation of the females is, therefore, much lower than that of the males. They also show a greater variability. The same thing was found by Palmer and Kennedy (1931) and by Morris, Palmer and Kennedy (1933) when they worked with the digestible dry matter.

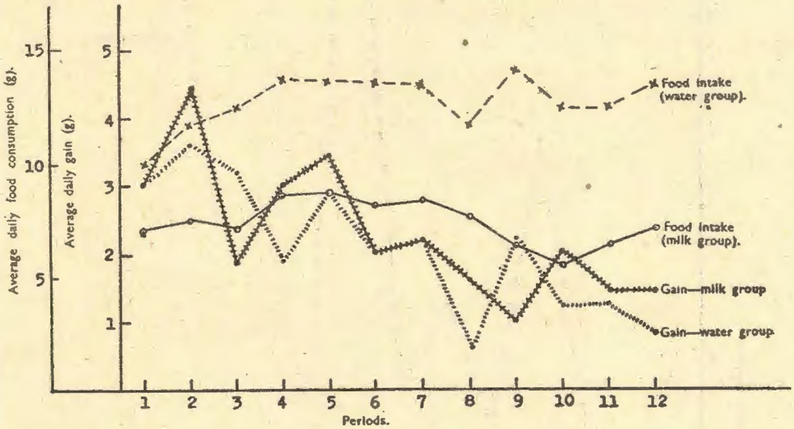

Fig. 70.—Gains and meal consumed per rat per day—females.

The effiiciency indices have been plotted in Fig. 71. There is just an indication that the efficiency indices of the males and of the females on water show a tendency to increase toward the end. The efficiency indices of the males on milk show hardly any fluctuation indicating that relatively more use is made of the milk since Palmer and Kennedy (1931) found that there is a close relationship between growth rate and the efficiency index.

Palmer and Kennedy (1931) thought that the difference in the efficiency indices of males and females seemed to offer an explanation of the sex difference in growth rate. In the same article they show that there is a close relationship between the rapidity of growth and the efficiency index. It would, therefore, appear more logical that the slower rate of growth of the females is the cause that their food utilisation is lower than in the case of the males. When the growth rate of males is retarded, then the economy of their food utilisation is decreased. The same is the experience with other animals.

To test this point we selected six pairs of rats from three litters. Each pair consisted of a male and a female from the same litter which had the same weight. They were fed in individual cages for 16 days. Water was given with the meal ration. Each pair received as much food as was consumed by the one eating the least. The initial weights of the males and of the females were 73·2 and 73·3 g. and the average weights after sixteen days 118·3 and 118·0 g. respectively. The average total amount of food consumed by each rat was 186 g. and the efficiency index 4·38.

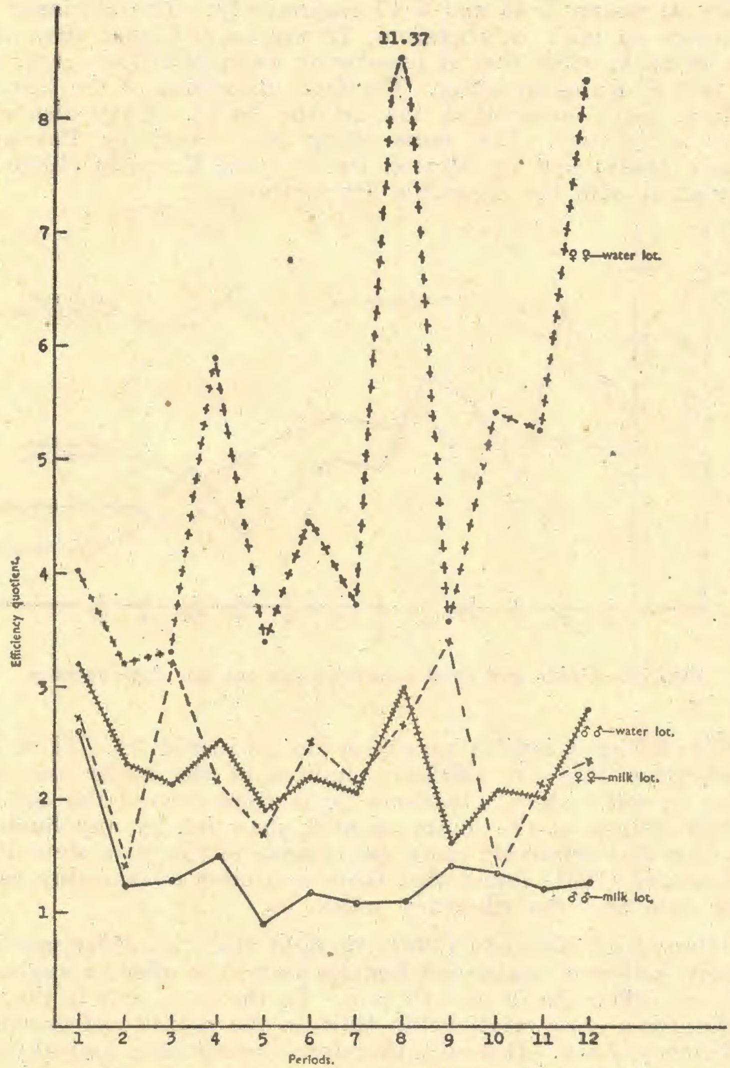

Fig. 71.—The "efficiency quotients" of different groups of rats.

The average daily weights of the rats and the average daily food consumption are given in Table 67. For the sake of comparison the average daily weights of males and of females that received the same ration *ad lib.* are also included. The weights of the rats are illustrated in Figure 72.

It will be seen that when the rats receive the meal ration *at lib.*, the males will weigh 150·3 g. and the females 126·8 g. after 16 days. The efficiency indices of the males and of the females were 2·52 and 3·56 respectively. When the food is restricted and both sexes receive the same amount then there is no difference in their efficiency indices. If Palmer and Kennedy's (1931) suggestion had been correct then the males should have made better use of the food they received than the females. More work should, however, be done to test out further aspects of this question of difference in growth and food utilisation of the two sexes. Males and females could, for instance, be restricted 25, 50 and 75 per cent. of their optimum growth at different ages by means of the food intake and then see what the utilisation will be at different rates of growth and at different ages.

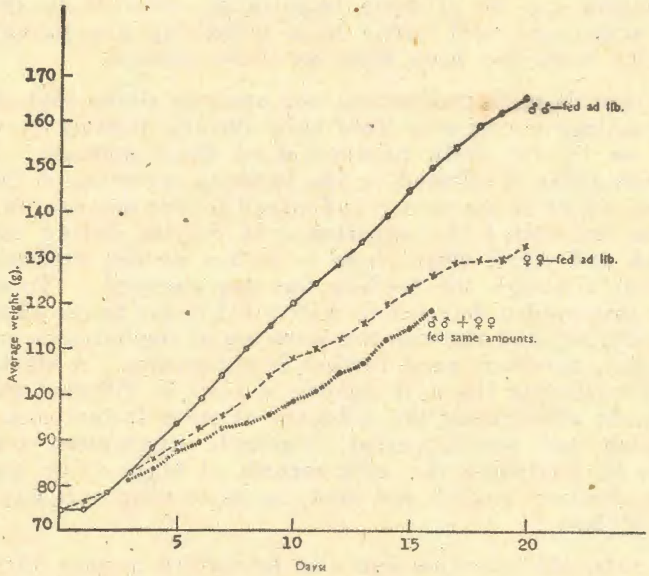

Fig. 72.—Growth curves of rats fed restricted and unrestricted amounts of meal mixture. (All rats were fed individually).

D. The Bearing of the Results on Animal Production.

Our results have shown how the season affects the growing rats, while the new environment affected birth weights and growth rate and mature weights of males, and probably had some effect on foetal atrophy. These results raise the question what factors actually influence the growing rats. But that can only be answered conclusively by carrying out breeding work under controlled environmental conditions. The three most important factors are light, temperature and humidity and a combination of them. We have mentioned the results of some investigators but they are not always in agreement as regards the effects of these factors on animals.

We would like to indicate in how far the present work has a bearing on future work on our domestic animals and also on the white and black races of this country.

The large number of prenatal deaths in our old females as compared with young females, led v. d. Plank (1939) to compare these results with observations on cattle. He mentioned that it has been noticed that heifers served when quite young show greater fertility than when first service is postponed in order to get greater development. It would appear that until the contrary has been proved, it would be wise not to postpone first service unduly long. In this connection, viz., postponement of first service, the results we obtained from suckling females of different weights should be borne in mind. The young heavy females were not such good milkers as the old heavy females. We could not determine whether this was due only to greater fat development of young heavy females. Especially in pigs this question can be of some importance, whereas in the case of mutton sheep and beef cattle it is something one should keep in mind until work has been done on these animals.

As regards milk production, our analysis shows that the growth of the suckling young may have been affected directly by the season as well as by the milk production of their mothers. The milk production again is affected by the hormone secretion of the anterior pituitary, which in its turn is influenced by the decrease in daylight. We then mentioned the experience of dairies during the months of March and April when there is such a sudden decrease in milk production although the feeding has not changed. To make sure whether this sudden decrease in milk yield is due to the effect of light on the pituitary and through the secretion of the hormone on the milk gland, will, however, need further investigation. A start could be made by analysing the milk records of cows in different parts of the country and eliminating the influence of other factors such as period of lactation, age, service period. Valuable information could also be obtained by analysing the milk records of large dairy herds where complete feeding records are kept, so as to eliminate the factor of change of feed.

On rats, this question can also be carried a stage further when they are bred under controlled conditions as regards light. Females of the same age could be divided into two lots, the one lot receiving increasing and the other decreasing illumination. They can then be served at the same time and the resulting young weighed regularly. As we have mentioned, however, increasing or decreasing illumination may effect the young as well as the mothers.

In our material the importance was shown of month of birth on the subsequent growth rate of the young. Those born during the unfavourable time of the year did not grow as fast nor did they attain the same mature weight as those born during the favourable period. Temperature probably played an important part. In this connection it is of interest to mention the work of Huntington (1938). According to him the best season for birth in man is late winter and early spring (February to March in the northern hemisphere) so that conception should be before June or July which is before the summer heat. He also considers temperature to be the dominant factor and shows how the death rate follows the weather. Those born during the favourable season may live four years longer than those born during the unfavourable season. McCay (1933) has shown in rats that the slow growers live longer than the fast growers. It will therefore be of great interest to see whether rats and other animals born during different seasons, show differences in longevity. In analysing such results the effect, if any, of growth rate should first be eliminated.

In the course of the four years during which we had the rats under observation, the birth weights decreased slightly and were appreciably lower than those of the original stock at the Wistar Institute. A longer period of observation is necessary to see how far this change will go. Data on our domestic animals and on man in this country will also be a valuable contribution. In Australia for instance, Robertson (1923) found a change in the birth weights of babies, namely 8 to 10 ounces heavier than in England.

In spite of the low birth weights of our rats, the subsequent weights of our male rats were above those of the Wistar Institute. Some interesting data could be obtained by using castrated males and spayed females. In the introduction we mentioned the rapid growth of South African children. It would be of great importance if weghts and height measurements could be taken systematically to see whether there is any difference between the sexes as compared with European standards. It is also very important to know whether growth stops at an earlier age or whether South Africans are larger than the various European races from which they come. In schools, weights and height measurements should be taken four times a year so as to get the seasonal effect on growth as well.

Another important aspect on which more data are required in our domestic animals and in man, is the influence of season on fertility. We have shown that the largest litters were born in spring and summer, and the smallest in winter. Hammond (1934) observed in rabbits that the number of spermatozoa in spring exceeded the number in autumn. The same may have happened in the rats. Although his results pointed rather to seasonal variations in the number of ova shed, the latter possibility should also be borne in mind. If the lengthening and shortening of the days can influence the regularity of the oestrous cycles in rats, there is also a possibility that the number of follicles which ripen at a time may be affected as well. The effect of light on the anterior pituitary of birds and some mammals is well known. The anterior pituitary secretes the gonadotrophic hormone which causes the follicles to ripen. The number of follicles which ripen at a time appears to be controlled by the amount of the hormone secreted at this time.

That fertility in man may also be influenced by season has been pointed out by Edwards (1938). He determined the ratio of multiple-conceptions (1 pair of twins or triplets = 1 multiple conception) to single-conceptions for babies born in Liverpool during the years 1935-37. The ratio showed two distinct peaks, one around mid-February and another around the middle of August to September. Edwards suggested that the lengthening and shortening of the days offered the best explanation of the phenomenon. For the low level in April he suggested that a possible explanation could be found in the cumulative effects of a debilitating winter environment finally overcoming the light effect at the beginning of the year.

These different observations suffice to show that environment has an influence but they also show how little we still know and stress the importance of making observations on our domestic animals and if possible, on the white and coloured races of this country.

V. SUMMARY.

Observations were made on Albino rats over a period of four years (1933-37); 238 litters were obtained comprising 2043 young at birth; 1789 (872 males and 917 females) were reared and weighed weekly.

Prenatal Growth.

(*a*) *Oestrus and service.*

The length of the oestrous period was 4 days in 60 per cent of the cases observed, 3 days in 20 per cent, and 5 days in the remaining 20 per cent cases. The time that vaginal plugs were visible varied from 6 hours to 10 days after service, the average being 1 to 2 days. Nearly all females were served during the night or early morning.

Quite a large number of the females that had bred, had infected uteri. Here the ovaries were inactive except when only one horn of the uterus was affected; then the ovaries were active but the females did not become pregnant when served.

(*b*) *Weights of pregnant females.*

Different classes of females were used in studying the changes in weight of pregnant females: (1) Those served when the vaginas opened, (2) old virgins 8 to 11 months old and weighing about 200 g. and (3) females that had already had one or more litters. Only those pregnant for the first time showed an appreciable gain during the first two weeks of pregnancy, while rats that had had litters showed practically no gains. The weights of all females, however, increased rapidly during the last 7 to 8 days of pregnancy which is mainly due to the increase in weight of the developing foetuses. Only those rats pregnant for the first time showed an appreciable gain (56 per cent.) after parturition as compared with weight at service. This increase in permanent gain was equal to the gain during the first two weeks of pregnancy.

Litter size at birth had no influence on the gains of the females during the first two weeks, but during the third week the gains of the females increased with increase in litter size.

(*c*) *Weight and number of foetuses.*

Females of the three classes mentioned above were killed at different stages of pregnancy. The pregnant uteri showed an increase in weight only from the 6th or 7th day onward after service. By means of the method we used, foetuses could be weighed only from the 13th day onward, whereas the number of foetuses could be determined macroscopically from the 7th to the 8th day of pregnancy. The three different classes of rats showed large differences in the number of prenatal deaths. In the case of the young females which were about 3 months old and pregnant for the time, there were only two dead foetuses out of 190, average number of living foetuses per litter 9·4. In the case of the old rats 8 to 11 months, pregnant for the first time and of those of more or less the same age but which had already had one or more litters, 38·5 per cent. of dead foetuses were found during the last two weeks, in the former class the average being 4 living foetuses per female, in the latter 5.

Litter Sizes and Weights at Birth.

During the first 24 hours the birth weights remained more or less constant, or could show a slight decrease for young born during the day.

Mortality at birth was 1·4 per cent. This figure may be slightly higher since females often eat the stillborn. Average birth weights of males and females born alive were 5·19 g. and 4·96 g. respectively, and of stillborn 4·88 g. 4·8 g. respectively. Average litter size was 7·4 but for litters in which there were stillbirths average size was 8·8.

Sex ratio for all rats born was 94·5 per cent. It decreased from 163 to 77 as litter size increased from 3 to 9, then increased again to 129 as litter size increased to 12.

Birth weights decreased with increase in litter size. After a litter size of 9 was reached, birth weights showed a tendency to remain constant.

Birth weights increased with age of mothers while litter size decreased. When litter size remained constant then age of mothers did not show any regular effect on birth weights.

Females 2 to 3 months old had average litter sizes of 8·4 and those 12 to 13 months old 4·7. This continuous decrease in average litter size from the youngest age class to the oldest, instead of the expected increase to a maximum followed by a decrease, may have been due to the greater prenatal mortality in the older females. Total litter weight decreased from 43·3 g. to 25·0 g. Age of mothers was more important in determining litter size than parity.

The weight of the mothers immediately after parturition did not appear to influence the birth weights of the young when litter size remained constant.

Litter Sizes and Weights at Weaning.

The average weaning percentage of all litters was 84·0. There was no pronounced drop with increase in litter size as was found in the pig for instance. The average birth weights of young weaned was 5·11 g., but for young that died shortly after birth only 4·87 g. Greatest postnatal mortality occurred during the first week after birth.

Litter size at birth showed the same influence on weights at 2, 3 and 4 weeks as at birth, i.e., first a decreasing decline in average weight as litter size increased up to 9, then weights remained more or less constant up to the largest litter size (12).

Although litter size at birth and at weaning showed practically a straight line, the influence of litter size at weaning on the average weights was quite different and peculiar. There was first an increase, then a decrease, another increase and finally a pronounced decrease. The most likely explanation of this appears to be the effect on milk supply of rats of different ages and weights, which were not kept constant in this case.

Rats in litters of which all were reared were heavier than rats in litters of which some were destroyed by the females.

The young of females 8 to 9 months old were the heaviest at weaning, indicating that the milk supply was the highest at this period. This coincided more or less with the production of the third litter.

As mentioned the weight of the mothers did not influence the average birth weights of the young. The weights of the mothers at parturition, however, had a decided influence on the average weight of the young at weaning. As the weight of the mother increased up to 260 g. the average weight of the young decreased, and after that increased again. This is probably due to difference in milk supply. It appeared that only in the case of young females did increase in weight of the mother accompany a decrease in the average weaning weight of the young, whereas in the case of the old females there was a tendency for the young to increase in weight with an increase of the weight of the mother. Young heavy females therefore appear to be poor milkers, probably due to excessive fat, while weight in old females is more likely due to greater muscle and bone development.

Although the best females, i.e., those rearing the largest and heaviest litters, were retained, it does not appear that the fertility of the population had been raised during the four years. Selection was probably mainly for good mothers, poor mothers being discarded. This strain of albino rat has been inbred for so many generations that the stock is probably nearly homozygous for the number of eggs shed, showing that variation in litter size is probably only due to factors such as foetal atrophy.

Seasonal Influence.

(1) Length of time females took to become pregnant.

(2) Litter sizes and weights at birth and weaning.

(3) Sexual maturity of females.

(4) Weights and tail lengths.

(5) Health.

(1) From March to July, autumn and winter, the females remained long with males before they became pregnant, but from August to February it took a shorter time. After February there was a sudden increase which may have been caused by the decrease in length of days. Females appear to have been affected more than males.

(2) The average birth weights decreased from 5·19 g. during the first year to 4·96 g. during the fourth year. Our average birth weights were appreciably lower than those obtained at the Wistar Institute.

The average litter size was higher during the summer months, November to January (7·8), than during the winter months, May to July (6·8). Birth weights, when effect of litter size was eliminated, did not appear to have been affected.

Weaning percentages showed a decided seasonal trend, being highest between May and June, then decreasing until August and remaining low until October, after which there was an increase.

During the four years the weights at 2, 3 and 4 weeks have decreased. This may have been caused by the effect on milk production of the mothers as well as by the environmental influence directly. There were decided seasonal fluctuations which appeared to be about the same at 2, 3 and 4 weeks. The highest weights were obtained during the winter. with a decline during the spring and the lowest level coinciding with the warm months, October and November.

The weights of the suckling females showed about the same seasonal trends as the weights of the young, so that milk supply may also have been affected.

(3) The sexual maturity of the females was affected as follows. During the first year the vaginas opened when the females were 47·2 days old and weighing 106 g. and during the fourth year when they were 42·7 days old and weighing 95 g.

(4) When the average weights of our rats are compared with those of the original stock at the Wistar Institute, our males are appreciably heavier at the different ages up to 20 weeks, while the females show practically no difference.

There was a marked seasonal effect on the weights. The highest and lowest points shifted about 3 to 4 months as the rats become older—4 to 16 weeks—indicating the influence of the month of birth, also that an early influence may persist until maturity. The highest weights for all ages were obtained for those born during May to August, then there was a decrease with the lowest weights from about October to February. It appears that after 8 weeks the ultimate weight of the rat is not affected any more, or only to a small extent, by the environment under which it grew up.

Tail length was affected less than weight by the environment.

Although temperature may have influenced the weights of the rats, it appears more likely that there may have been an effect by a combination of factors, probably temperature and humiditty, while a change in the length of the days probably also affected the growth of the animals through the effect on the pituitary.

(5) Lung trouble occured in 12·2 per cent. of the males and 6·8 per cent. of the females. This trouble occurred mostly when rats were 16 to 20 weeks old—later cases were not recorded. The disease

was most prevalent during the winter months, 35·1 per cent. of the cases, spring following with 30·5 per cent. and summer and autumn much lower (18·3 and 16·0 per cent. respectively).

GROWTH AND FOOD INTAKE.

Daily gains of suckling young showed an increase from birth to 13 days, milk supply being then adequate, a standstill or decrease in daily gains from 14 to 18 days, milk supply being the limiting factor, and a continuous increase in daily gains from 19 to 28 days after the young have become accustomed to solid food.

As litter size increased from 4 to 7, females required 40 g. additional food for each additional young for the 28 days period and 98 g. for each additional young from 7 to 11.

Food utilisation of females was lower than that of males and showed a much greater variability. When the same amount of food was given individually to pairs of males and females of the same weight, then there was no difference in the food utilization. The difference was, therefore due to the more rapid growth of the males when both sexes were fed *ad lib.*

VI. ACKNOWLEDGMENTS.

The author wishes to express his sincere thanks to Dr. P. J. du Toit, Director of Veterinary Services, who provided the necessary facilities for carrying out the work, and to Dr. John Hammond, School of Agriculture, Cambridge, for the interest he took in the work and for reading the manuscript.

Our thanks are also due to Mr. G. W. Jones, Technical Assistant, who was in charge of the rats for part of the time, and to Mr. T. Meyer for photographing the figures.

VII. REFERENCES.

ANGULO Y GONZALES, A. W. (1932). The prenatal growth of the albino rat. *Anat. Rec.*, Vol. 52, pp. 117-138.

ASDELL, S. A. AND CROWELL, M. F. (1935). The effect of retarded growth upon the sexual development of rats. *J. Nutrition*, Vol. 10, pp. 13-24.

AXELSSON, J. (1934). Einige Resultate der Sauen-Leistungskontrolle in Malmöhus Län. *Züchtungskunde*, Vol. 9, pp. 23-36.

BAKER, J. R. AND RANSON, R. M. (1932 *a*). Factors affecting the breeding of the field mouse (Microtus agrestis). Part I. Light. *Proc. Roy. Soc.* B, Vol. 110, pp. 313-322.

BAKER, J. R. AND RANSON, R. M. (1932 *b*). Factors affecting the breeding of the field mouse (Microtus agrestis). Part II. Temperature and food. *Proc. Roy. Soc.* B, Vol. 112, pp. 39-46.

BAKER, J. R. AND RANSON, R. M. (1933). Factors affecting the breeding of the field mouse (Microtus agrestis). Part III. Locality. *Proc. Roy. Soc.* B, Vol. 113, pp. 486-495.

BAKWIN, H. AND BAKWIN, R. (1927). Seasonal variation in the calcium content of infants' serum. *Amer. J. Dis. Child.*, Vol 34, p. 994.