Growth and Longevity of Rats Fed Different Diets

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The average life span of the male laboratory rat is considered to be about 700 days; females are reported to live about 10 per cent longer (Carlson and Hoelzel, 1947; Sherman et. al., 1949; French et al., 1953; and Sperling et al., 1955): Maximum life may reach 1200 days in the male and 1300 days in the female (Berg and Harmison, 1957). Many factors, including nutrition, are known to influence longevity. Considerable evidence is available to show that certain types of food restriction or undernutrition may result in longer life span than high nutrient intakes which permit maximum growth (McCay, et al., 1935; McCay, 1947; Silberberg and Silberberg, 1955; Ross, 1959; Berg and Simms, 1960; and Berg, 1960).

The rat is considered to remain in a continuous state of growth (Dunn et al., 1947), but maximum body weight may be expected just beyond 400 days. A decline in weight accompanies aging and may equal 30 per cent during the last 300 days (Everitt, 1957; Everitt et al., 1957).

Many different strains of laboratory rats and different dietary regimes are used in research. The purpose of the study reported here was to determine the growth and longevity of Long-Evans rats fed natural, semi-purified, and purified diets.

Procedure

Weanling rats of the Long-Evans strain produced in this laboratory from a closed colony were used as experimental animals. The experimental young were weaned at 23-24 days of age from females which had been fed a complete commercial pelleted rat diet (Purina Laboratory Chow). At the time of weaning they were placed on the respective dietary regimes and housed individually in stainless steel cages maintained in an air conditioned room at 77-79° F. Experimental diets and fresh tap water were supplied *ad libitum*. No other treatments were given throughout the life span other than periodic removal for weighing and transfer to clean cages. No exercise was enforced and the only activity was voluntary movement within the individual cage.

The diet referred to as the natural diet was a complete com-

mercial pelleted ration considered to supply nutrient requirements of the rat.

The semi-purified diet contained, in per cent: corn meal, 38; corn starch, 10; vitamin free casein, 10; zein, 10; sucrose, 25; minerals (USP XIV), 3; corn oil, 2; NaCl, 0.5; and vitamins (Vitamin Diet Fortification, Nutritional Biochemicals Corp.), 1. This diet was also modified for an additional treatment by replacement of the casein with zein in order to provide a diet deficient in the amino acids lysine and tryptophane. Fourteen rats were fed this amino acid deficient diet, and 14 were fed the control with casein. In addition, 13 rats which had been fed the amino acid deficient ration for 4 to 8 weeks were changed to the control diet. In preliminary studies, this deficiency had resulted in growth failure and early mortality of the rats. The change to a diet supplemented with lysine and tryptophane was made in order to observe the effects of this early dietary deficiency upon longevity after the change to a normal diet. The transfers to the control diet were made at 4 to 8 weeks after consuming the deficient diet, and the time of change was selected for each rat when severe symptoms of deficiency were so evident that it apparently would not have survived without amino acid supplementation.

The control purified diet contained, in per cent: corn starch, 40; sucrose, 22; casein, 26; corn oil, 4; cellulose, 3; minerals, 4; and vitamins, 1. Two similar diets containing less casein (8 and 14 per cent) and corresponding increases in carbohydrates were fed to additional rats in order to study the effect of level of protein intake upon longevity. The control diet supplied 22 per cent protein, considered to be adequate for normal growth; the two lower levels of casein were considered inadequate.

Growth data were obtained from weekly body weight measurements during the first two months after weaning and at approximately monthly intervals throughout the life span. Statistical comparisons were based upon the analysis of variance.

RESULTS AND DISCUSSION

Data representing the average and range of life span of rats fed the three diets are recorded in table 1. Longevity was not affected by the different types of diets. Male rats consuming the semi-purified diet appeared to live longer than those consuming

TABLE 1

Longevity of Rats Fed Different Diets

Diet	Sex	No. Rats	Life Span (days) Av.	Range	Excess ♀ over ♂ Days	%
Natural	♂	5	657	379-993	232	35
	♀	5	889	640-1045		
Purified	♂	8	667	227-1293	234	35
	♀	10	901	511-1211		
Semi-purified	♂	7	805	340-1154	92	11
	♀	7	897	552-1270		
Av. all treatments	♂	19	718	227-1293	179	25
	♀	20	897	511-1270		

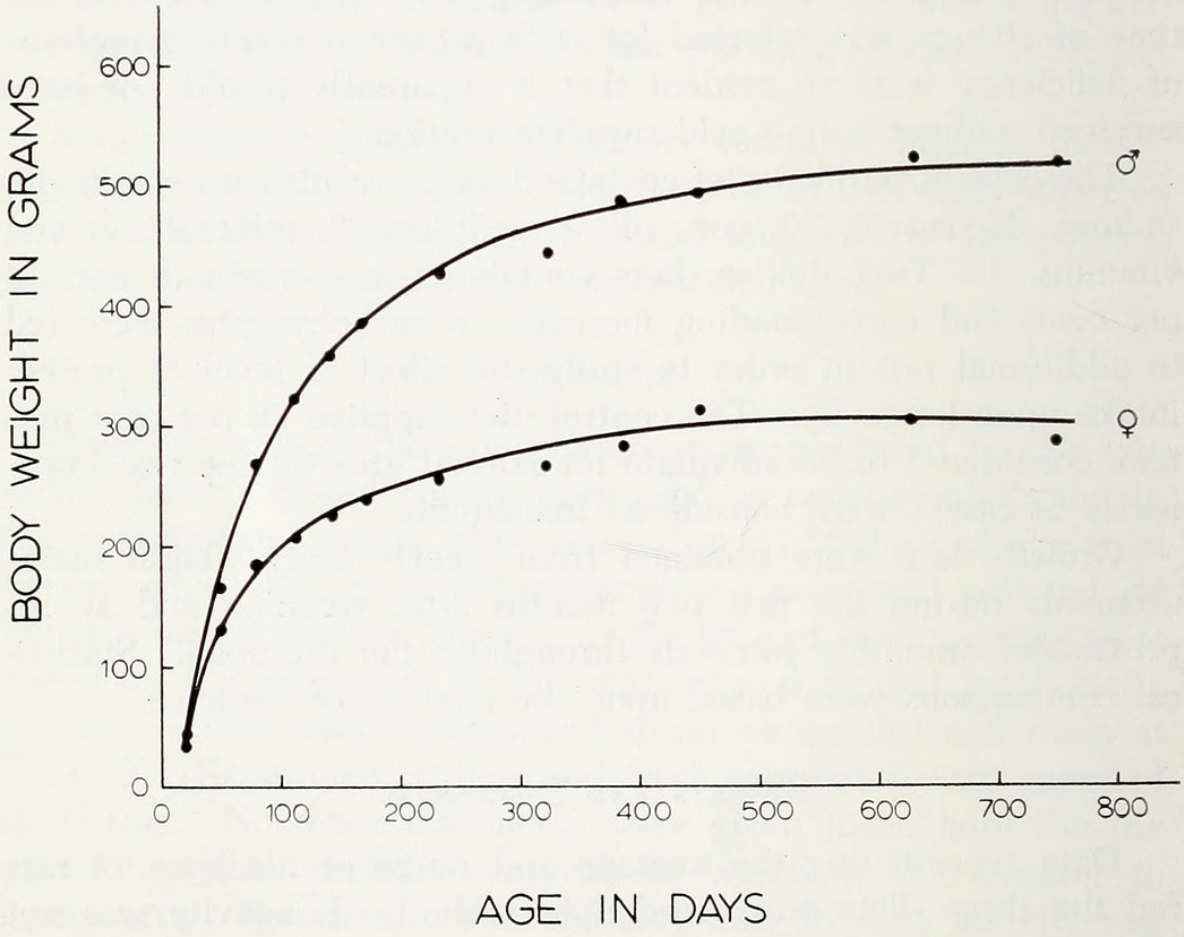

Fig. 1. Weight changes of Long-Evans rats during life span.

the natural or purified diets, but considerable variation was observed and the difference was not statistically significant. Within all treatments, females lived longer than males. The average excess of females over males was 179 days or approximately 25 per cent longer. This additional survival time of females is greater than that reported by others (Carlson et al., 1947; French et al., 1953; Sperling et al., 1955). No evidence of specific infections was observed and all deaths recorded were included in the average.

Average body weights of the two sexes through the major portion of the life span are plotted in figure 1. The weights represent the combined average of those consuming the natural, control semi-purified, and highest level of protein in the purified diet. It should be noted that the number of rats surviving the latter portion of the period had been decreased and the body weight averages represent a progressively smaller number of animals. During the terminal stages of life most of the rats lost weight for periods which ranged from a few days to several months. Using the highest weight attained and the lowest near death, the average decreases for males was 18 per cent, for females 13 per cent.

Rats fed the amino acid deficient diet gained very little and had a very short life span (table 2, figure 2). When other rats which had been fed this diet for 4 to 8 weeks were changed to the control diet containing casein, body weight increased rapidly and the life span was essentially equal to that of rats consuming the adequate diet continuously. The average life span of the former group was numerically less, but considerable variation was observed and the difference was not statistically significant.

The purified diets which were inadequate in quantity of protein (7 and 12 per cent) promoted a slower rate of weight gain than the control, but length of life spran was not affected (table 2). Although the gain of rats consuming the lowest level was much less during the early months of the treatment period, after 16 months the average weight approximated 85 per cent of the higher level. These observations are in general agreement with those of others that certain systems of restricted feed or nutrient intake do not decrease life span (McCay et al., 1935; McCay, 1947; Silberberg et al., 1955; Ross, 1959). The quality of protein fed in this trial was considered satisfactory and quantity only was restricted.

TABLE 2

Effect of Amino Acid Deficiency, Change from Amino Acid Deficient to Adequate Diet and of Protein Intake Upon Longevity

	No.	Life Span (days)	
	Rats	Av.	Range
Amino acid deficient*	14	187	30-431
Amino acid deficient changed to adequate*	13	737	397-1082
22% Protein**	6	754	253-1059
12% Protein**	6	745	227-1002
7% Protein**	6	796	449-1293

*Semi-purified diet.
**Purified diet, all protein supplied by casein.

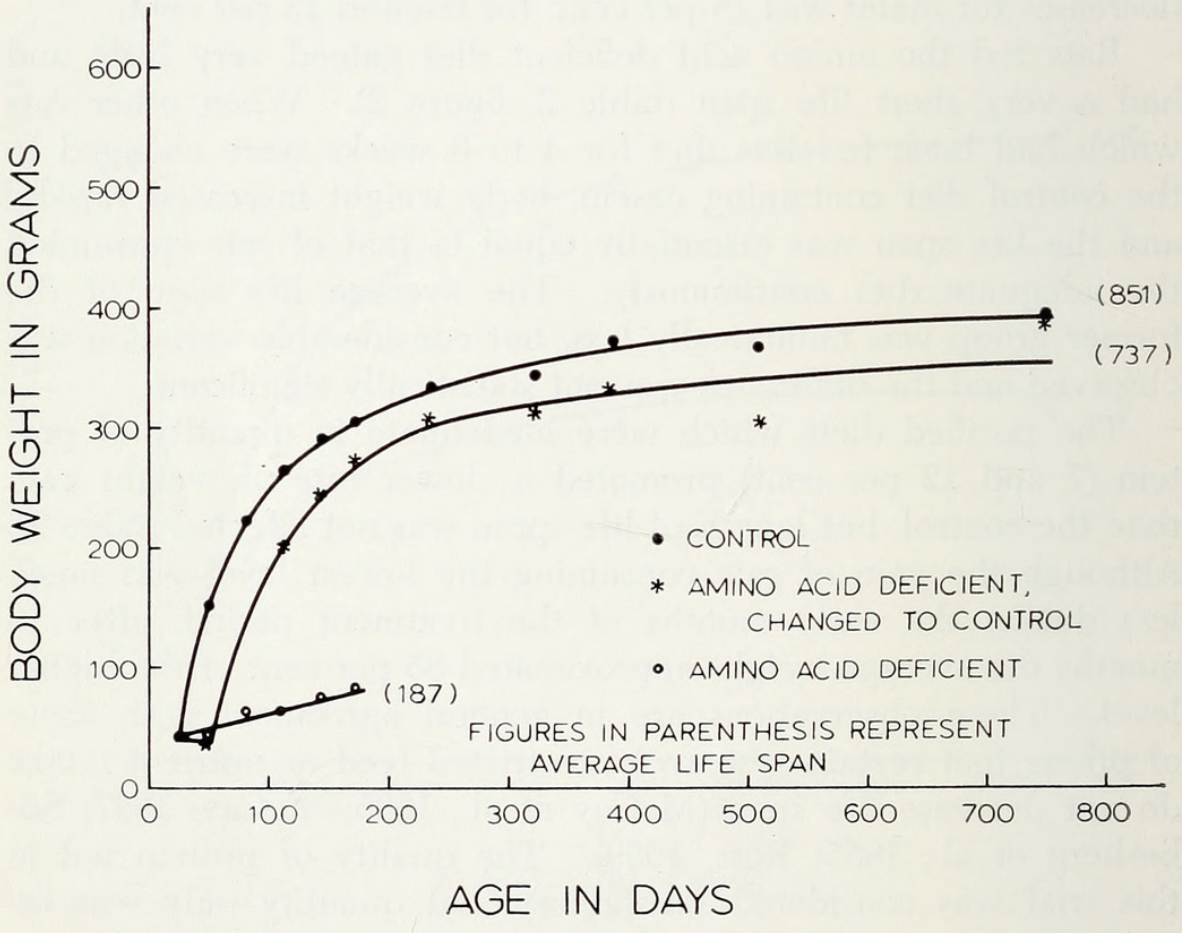

Fig. 2. Growth and longevity of rats fed a semi-purified control diet, amino acid deficient diet, and amino acid deficient changed to control diet.

SUMMARY

Weanling Long-Evans rats were fed natural, semi-purified, or purified diets in a growth and longevity study. For additional studies, the semi-purified diet was modified to be deficient in the amino acids lysine and tryptophane, and the purified diet included three levels of protein, two of which were inadequate for normal growth. The average life span of rats on the different types of complete diets was not significantly different. Combined average for longevity of the males from each group was 718 days; females, 897 days. Growth of rats fed the amino acid deficient diet was severely retarded and average life span was 187 days. Rats fed the amino acid deficient diet for 30 to 60 days and changed to the control increased rapidly in weight and lived essentially a normal life span. Purified diets containing 7 or 12 per cent protein as casein promoted slower growth than the diet with 22 per cent protein but did not significantly affect life span.

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