

FEEDING AND BREEDING OF LABORATORY ANIMALS

X. A COMPOUND DIET FOR MONKEYS

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(With 4 Figures in the Text)

INTRODUCTION

Monkeys are commonly thought to be the most messy and tiresome of laboratory animals, largely because they are usually fed on a highly assorted mixture of vegetables and fruit. A need for this anthropocentric diet has never been demonstrated, though several investigators have examined the order in which monkeys select the items of a mixture (Katz & Katz, 1936; Maslow, 1933). Some attempts have been made in the U.S.A. to keep monkeys on simplified diets. Thus, specially prepared 'cookies' and 'crackers' have been used in conjunction with supplements (Hetler, 1934; Tinklepaugh, 1931), as well as dog 'Purina' with extra vitamins* (Cowdry & Scott, 1936). In England, the shortages arising during the war showed that monkey diet could be much simplified without harm to the animals, and it seemed worth while, therefore, to explore further the possibility of keeping monkeys on a compound, preferably cubed, diet similar to those often used for other laboratory animals.

A fair amount of information exists about the dietary requirements of monkeys (Day, 1944), but not enough is known to enable one to design a diet on theoretical grounds. Accordingly, *ad hoc* experiments have been carried out on monkeys with several of the cubed diets under investigation at the Institute during the last few years. Of the diets listed in Table 1, diet 38 was designed for cats but proved to be far more acceptable to monkeys, diet 40 was designed especially for monkeys, while the remaining three were essentially rat and mouse diets. The literature indicated that none of these diets would supply monkeys with an adequate amount of ascorbic acid, and, except in certain deprivation experiments, a twice weekly supplement of about 250 g. of cabbage was given.

* An undated brochure issued by Purina Mills, St Louis 2, Missouri, U.S.A., refers to the possibility of maintaining monkeys on a diet of cubes, greenfood and water.

Table 1. *Percentage constituents of diets 1, 32, 38, 40 and 41, with theoretical composition*(Calculated from *Bull. Minist. Agric., Lond., no. 124.*)

	Diet no.				
	1*	32	38	40	41
Wholemeal flour	35	58	—	—	45
Wheatfeed	—	—	30	45	—
Dried lucerne meal	—	—	10	—	—
Ground oats	30	—	—	—	—
Sussex ground oats	—	—	—	—	40
Dried grass	—	—	—	5	—
Ground-nut meal	—	—	12	20	—
Dried meat and bone meal	10	6	—	—	—
Fish meal	—	—	20	10	8
Dried yeast	6	12	6	5	1
Full-cream dried milk	—	20	20	5	—
Dried skimmed milk	15	—	—	5	3
Cod-liver oil	2	2	1	2	2†
Sodium chloride	1	1	1	1	1
Calcium carbonate	1	1	—	2	—
Digestible protein	16.9	18.4	24.9	24.4	13.6
Soluble carbohydrate	44.4	47.8	25.5	24.4	48.4
Fat	6.3	8.9	8.1	5.4	4.5
Fibre	1.1	0.5	1.7	2.2	1.4

* The original diet as first published (Parkes, 1946) contained 5% dried yeast and 3% cod-liver oil.

† This was later reduced to 1% (Bruce & Parkes, 1949).

Growth and maintenance

In a preliminary experiment, three growing mangabeys were transferred from mixed diet consisting of potatoes, carrots, dog biscuits, greenfood, peas, barley, dried fruit and milk, to diet 38 cubes, water and greenfood. The cubes were eaten readily and the animals maintained growth and condition. When the supply of diet 38 was exhausted a specially prepared cube (diet 40) was brought into use, differing from diet 38 in having less dried milk and a proportion of ground-nut meal to give a cheap source of protein,

and possibly, it was thought, to increase palatability. The mangabeys continued to grow and maintain condition (Fig. 1). The whole of the stock and experi-

generally is excellent. A female mangabey reached puberty and showed typical cyclic changes on diet 40. The only adverse occurrence, an outbreak of

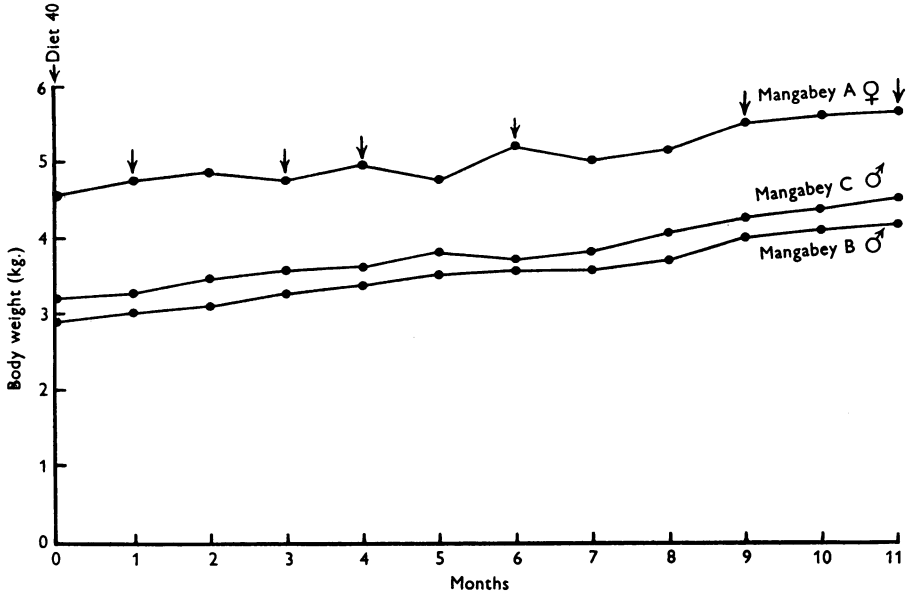


Fig. 1. Growth of mangabeys on diet 40, with 350 g. of greenfood twice weekly, plus water. Arrow indicates mangabey A (female) on heat.

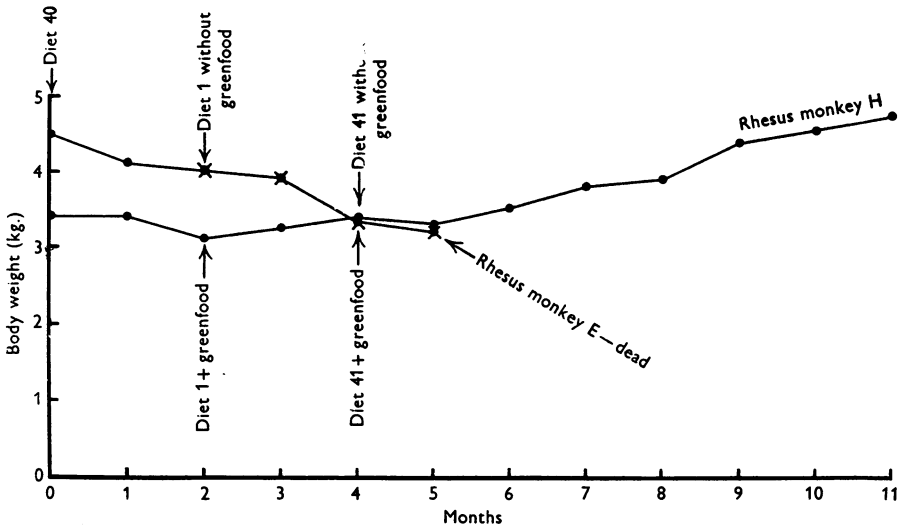


Fig. 2. Growth of rhesus monkeys on diets 1 and 41, with and without greenfood. ●—●, with greenfood; ×—×, without greenfood.

mental monkeys in the Institute, including macaques, baboons, mangabeys, *Cebus* and green monkeys, some eighty in all, were then put on to the cubes of diet 40, greenfood and water. After more than 1 year the health and condition of the animals

tuberculosis in one section of the colony, was associated with the importation of dealers' animals and there is no evidence that the outbreak was exacerbated by the current dietary regime or would have been avoided on a different one. Consumption of

cubes by 3-4 kg. monkeys is at the rate of about 350 g. per day. With diet 41 this ration gives an intake of 48 g. protein, 16 g. fat, and 170 g. carbohydrate, more than double that apparently found adequate by Tilden & Miller (1930) for the colony maintained at the Rockefeller Institute.

greenfood. The pair receiving diet 1 were transferred to diet 41 when the former became obsolete about 4 months after the beginning of the experiment. The member of this pair not receiving greenfood died of overt scurvy 5 months after the beginning of the experiment, eleventh-hour treatment with ascorbic

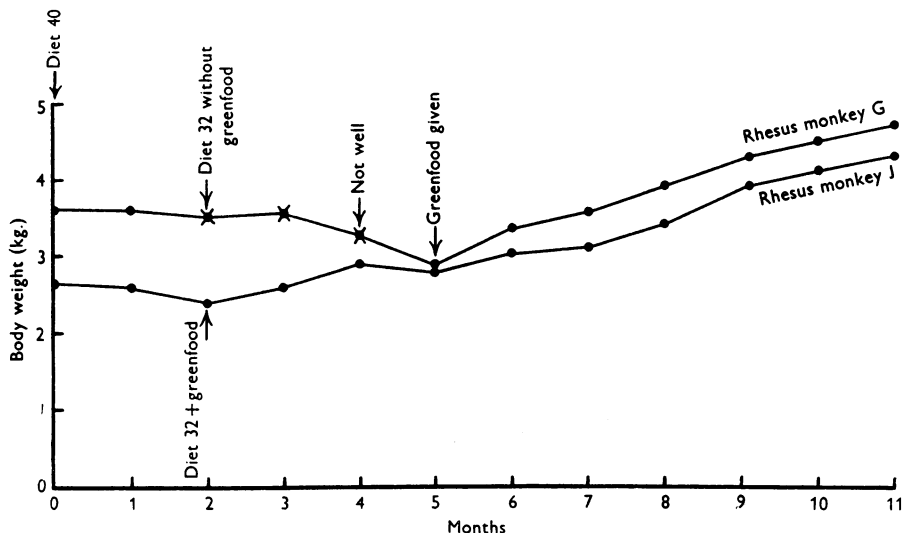


Fig. 3. Growth of rhesus monkeys on diet 32 with and without greenfood.
●—●, with greenfood; ×—×, without greenfood.

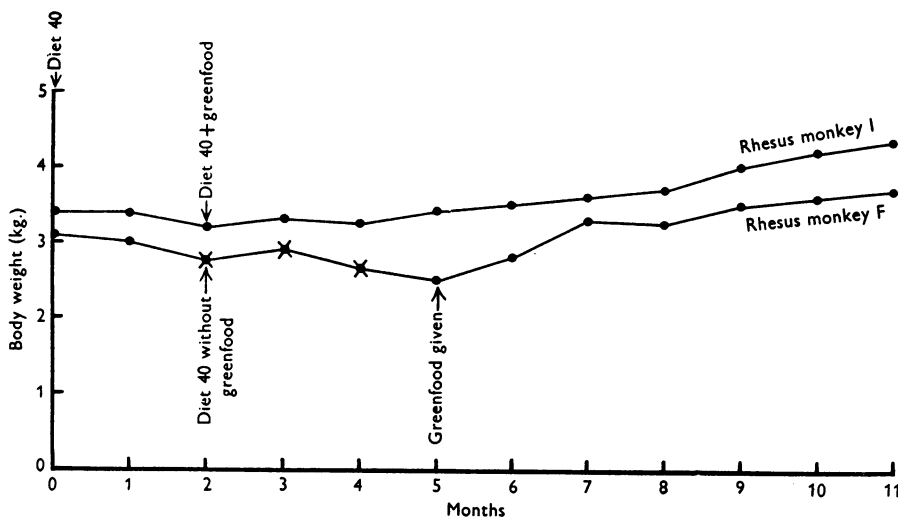


Fig. 4. Growth of rhesus monkeys on diet 40 with and without greenfood.
●—●, with greenfood; ×—×, without greenfood.

In a further experiment, diets 32, 40 and 41 following diet 1, were compared, with and without greenfood. Six young macaques, 2.5-3.5 kg. body weight at the beginning of the experiment, were put on to diet 40 plus greens. After 2 months they were split into three pairs, each receiving one of the three diets under test, one of each pair only receiving

acid being ineffective. The other two animals not receiving greenfood were by that time in bad condition and were put back on to greenfood to avoid losing animals fruitlessly, one receiving in addition a 2-week course of ascorbic acid. Full histories are given in the six weight curves shown in Figs. 2-4.

The following conclusions may be drawn:

(1) Cubed diet of the type used will not support life in macaques unless supplemented by greenfood. It is likely, but not certain, that ascorbic acid is the only necessary constituent of the greenfood.

(2) With greenfood, all three of the diets tested maintained growth and health in the animals. Diet 32 gave good growth, and diet 41 seemed to be nearly as good. Diet 40 was perhaps less satisfactory, but this conclusion depends largely on the relatively poor growth of one monkey.

(3) Recovery from a scorbutic condition is rapid, provided appetite has not been seriously impaired.

These experiments lasted a full year, and it is unlikely that symptoms of dietary deficiency or of inanition caused by unpalatability of the diet would appear after this time. It may therefore be concluded that diets of this type supplemented by greenfood are adequate for monkeys; equally, it should not be assumed that the composition of any one of these diets is optimal.

Pregnancy and lactation

Two rhesus monkeys were maintained through most of pregnancy and four through the whole of lactation on cubed diet and water, supplemented by greenfood twice weekly. Brief protocols are given below:

Rhesus 8

22. viii. 47 Mixed diet. Put with male
 4. xii. 47 Diet 40, water, greenfood
 19. ii. 48 Pregnant. Separated from male. 350 g.
 daily of diets 40, 32 and 1 mixed
 12. iv. 48 One female young born. Diet 32
 21. ix. 48 Young weaned on to Diet 40
 12. i. 49 Weight of young 1.65 kg.

Rhesus 9

22. viii. 47 Mixed diet. Put with male
 4. xii. 47 Diet 40, water, greenfood
 27. i. 48 Pregnant. Separated from male. 350 g.
 daily of diets 40, 32 and 1 mixed
 31. iii. 48 One female young born. Diet 32
 30. ix. 48 Young weaned on to diet 40
 4. x. 48 Mother back to male on diet 40
 12. i. 49 Weight of young 2.20 kg.
 20. i. 49 Mother killed in mid-pregnancy

Rhesus 10

3. iv. 48 Purchased as pregnant. Diet 32
 13. iv. 48 One female young born
 30. ix. 48 Young weaned on to diet 40
 12. i. 49 Weight of young 1.40 kg.

Rhesus 11

9. iv. 48 Purchased as pregnant. Diet 40
 30. iv. 48 One female young born. Diet 32
 30. ix. 48 Young weaned on to diet 40
 12. i. 49 Weight of young 1.50 kg.

Where a mixture of cubes was given to the rhesus monkeys, the order of preference was diet 1, diet 32 and diet 40. The mangabeys, by contrast, exhibited a strong preference for diet 32. The reason for the preferences was not obvious, but colour (diet 32 was dyed pink) did not seem to be a factor. It was noticeable that diet 40, designed especially for monkeys, was the least acceptable of the three.

Water was supplied from inverted bottles on the system commonly employed for other laboratory animals. The containers used for the monkeys were 1 pint blood transfusion bottles with an aluminium spout fitted to the cap. Somewhat to our surprise, the monkeys treated these bottles with care and became extremely skilful at drinking.

DISCUSSION

The results described above show that a cubed diet rich in full-cream dried milk, supplemented by greenfood and water, will sustain growth, pregnancy, and lactation in rhesus monkeys. There is little doubt, therefore, that this diet is nutritionally complete for and psychologically acceptable to monkeys.

Less information is available for the other cubes described (diets 38, 40, 41), but the only female with the opportunity to do so became pregnant on diet 40, and it is likely that the other diets would permit of reproduction as they do of growth. Diet 41 is now the standard food of all rats and mice at the Institute; it is also the cheapest of the diets investigated. For these administrative reasons diet 41 will become also the standard diet of the monkeys, supplementary liquid milk being given, if necessary, to pregnant and lactating animals.

SUMMARY

1. The use of compound cubed diets for monkeys is discussed.

2. Experiments are described which seem to show that a cubed diet, supplemented only by greenfood and water, can be completely adequate for growth and reproduction.

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