FEEDING AND BREEDING OF LABORATORY ANIMALS

XIV. SIZE OF BREEDING GROUP AND PRODUCTION IN MICE

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(With 3 Figures in the Text)

INTRODUCTION

Limitation of space, particularly in an urban animal house, often makes it difficult to meet an increased demand for experimental animals. Improved production is generally sought by alteration of the stock diet (Mendel & Hubbell, 1935; Bittner, 1936; Loosli, 1945), or by consideration of genetic factors. Much less attention is given to husbandry, and traditional methods of breeding and general care tend to be accepted without question, though it is evident that such factors may greatly influence production.

Fenton & Cowgill (1948) reported that alterations in the method of housing and handling alone led to improved lactation in mice; and the relative inefficiency of large breeding groups by comparison with smaller groups was demonstrated by Crew & Mirskaia as long ago as 1931.

Reproduction and vitality in mice are affected by temperature, high temperatures (90–91° F.) being more harmful than low temperatures (Mills, 1945).

The breeding system may have an even greater effect. Mice paired monogamously and permanently, so that mating could take place at post-partum oestrus, produced twice as many young as when the pregnant females were isolated from the males before parturition (Bruce, 1947). These observations have now been extended to determine what further economies of space or of stock could be effected without loss of production. The results are reported herewith.

MATERIAL AND METHODS

Housing and general care were as previously described for the earlier experiment (Bruce, 1947). Only one size of box, originally designed to house six adult mice, was used for the mating groups. It was $11 \times 8 \times 4$ in. high, made of zinc, and had a perforated lid. Larger boxes of a similar type, $20 \times 18 \times 5$ in. high, were used for growing stock.

Nestling mice were not individually identified during lactation, but the identity of separate litters was retained whenever possible, if necessary by snipping the tip of the tail of newborn young. Litters born on the same day in the same box could not be differentiated. At weaning, litter-mates were earmarked and litters were coloured, for individual identification of all mice kept for growth experiments.

Young virgin females about 8 weeks old were used for mating.

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Standard cubed diets known to be satisfactory for reproduction were fed and fresh drinking water was always available. Sawdust was used as a floor covering, with wood wool as nesting material.

Polygynous groups, each containing one male, of five, four and three mice, were studied. Pairs were used for comparison in each experiment.

RESULTS

(1) *Groups of one male and four females*

Three attempts to establish a breeding colony in groups of this size failed because of disease. The serious overcrowding which occurred when litters were born favoured the outbreak and spread of infection, and this size of group in the type of breeding box available was clearly unsatisfactory. However, none of the in-

Table 1. *Young born within* 10 *weeks from start of test*

Test	Breeding group: Male	Breeding group: Female	No. of females	Av. no. of young born per female	Av. no. of young weaned per female
1	1	1	18	12·4	10·5
	1	4	13	9·8	7·2
2	1	1	18	15·4	13·8
	1	4	15	11·9	8·9
3	1	1	17	14·9	13·9
	1	4	14	12·3	8·6

Table 2. *Combined results from three tests, young born within* 10 *weeks from start of test*

	Breeding group: One male, one female	Breeding group: One male, four females
Number of females	53	42
Total number of young counted at birth	753	479
Total number of young weaned	675	358
Weaning rate (%)	89·6	74·7
Average number of observed births per female	14·2	11·4
Average number of young weaned per female	12·7	8·5
Relative reproductive efficiency (%) (i.e. young weaned per female)	100	67

fections became manifest for about 10–12 weeks; the results from litters born before this are instructive. All females which ultimately became sick, and their progeny, have been excluded from the tables (Tables 1 and 2). Apparent birth-rate was lower in the groups than in the pairs by about 20 % and weaning rate by nearly 30 % in all tests, the overall production in the three tests combined being 8·5 young weaned per female for the groups, and 12·7 young weaned per female for the pairs.

(2) *Groups of one male and three females and of one male and two females*

The trios and quartets were tested at the same time. The males were removed after 16 weeks, and, allowing for the completion of existing pregnancies, the whole experiment covered about two-thirds of the effective reproductive life of the

females. Owing to increased mortality during lactation in late parities and with older females (Bittner, 1935; Bruce, 1947) it is rarely economic to keep mice in a breeding colony after they are 8 months old.

The comparative production by pairs, trios and quartets is shown in Figs. 1 and 2, and in Table 3. No difference was found in the number of litters born (Fig. 2A), but fewer newborn young per female were counted from the quartets, probably

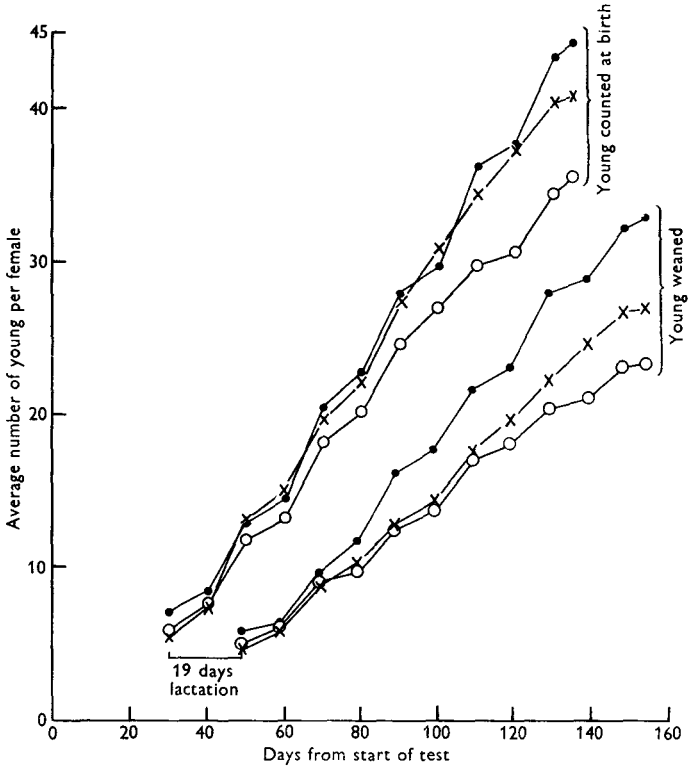

Fig. 1. Production per female. ●, one male plus one female; ×, one male plus two females; ○, one male plus three females.

because, in the crowded conditions, more young died from suffocation or neglect shortly after birth and were eaten before the count was made. This increased loss of newborn young was apparent very early in the test, showing as a trend from about 7 weeks (Fig. 1). Weaning rate per female was highest from the pairs.

After 4 months of mating, the average number of young weaned per female was thirty-three, twenty-seven and twenty-three for pairs, trios and quartets respectively.

(3) *Growth of young after weaning*

Young mice must usually be kept after weaning until they are large enough for use. High mortality or slow growth during this period can considerably reduce efficiency of production. All litters from the first two experiments (pairs and groups of five mice) were therefore kept for a further 3 weeks, to check the vigour of the young born in the polygynous groups. The sexes were separated at weaning, and

the young kept in large boxes, forty to fifty per box. These conditions, though similar to those frequently found in large colonies, were far from ideal and provided a good test of the vigour of the young. At weaning young from the pairs and those of similar age from the groups were housed in the same box. The large number of mice kept together resulted in a high mortality (Table 4), but it was much higher

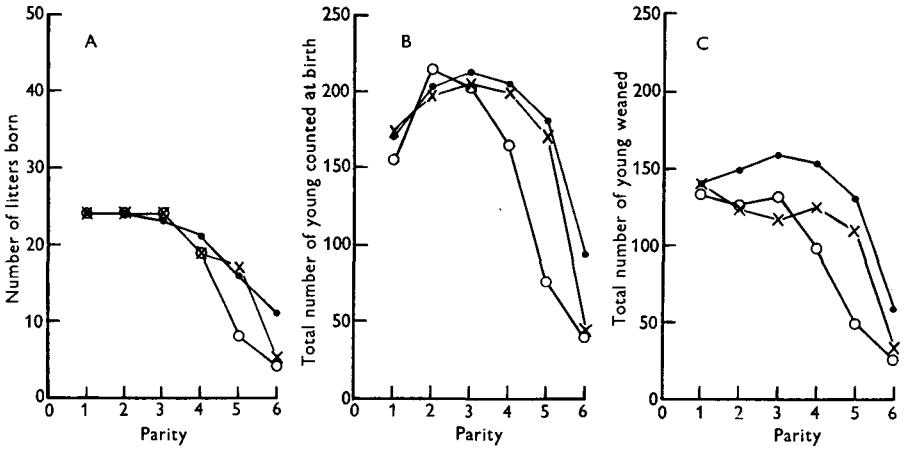

Fig. 2. Parity and the production of young during a breeding period of 16 weeks. ●, one male plus one female (observed for twenty-one females calculated for twenty-four females); ×, one male plus two females (twenty-four females); ○, one male plus three females (twenty-four females).

Table 3. *Effect of size of group on total production for a breeding period of* 16 *weeks*

	Breeding group		
	One male, one female	One male, two females	One male, three females
Total number of females	(observed for 22♀ calculated for 24♀)	24	24
Total number of litters born	119	113	103
Total number of litters weaned	103	93	84
Total number of observed births	1065	985	853
Total number of young weaned	793	649	563
Average litter size at weaning (young)	7·7	7·0	6·7
Average weight of young at weaning (g.)	9·0	8·8	9·0
Average number of recorded births per female	44*	41	36*
Average number of young weaned per female	33**	27	23**

* Difference statistically significant, $P = 0{\cdot}02$–$0{\cdot}05$.
** Difference statistically significant, $P = 0{\cdot}01$–$0{\cdot}02$.

in young of both sexes from the groups than from the pairs—27 % as compared with 19 %—and the crowded conditions during lactation appeared to have reacted unfavourably on the vigour of the young.

The growth of the survivors from both sources, however, was the same (Fig. 3A). The net result was the successful rearing of fewer but not less vigorous young from the groups, and accords with Crew's findings that some individuals are able to adapt to conditions of overcrowding, while others are not (Crew, 1932).

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Because of the high mortality in this experiment, further observations were made on the behaviour of weanling mice under two other conditions of housing.

(i) Five young per small box—17·6 sq. in. floor space per mouse.

(ii) Twenty young per large box—18·0 sq. in. floor space per mouse.

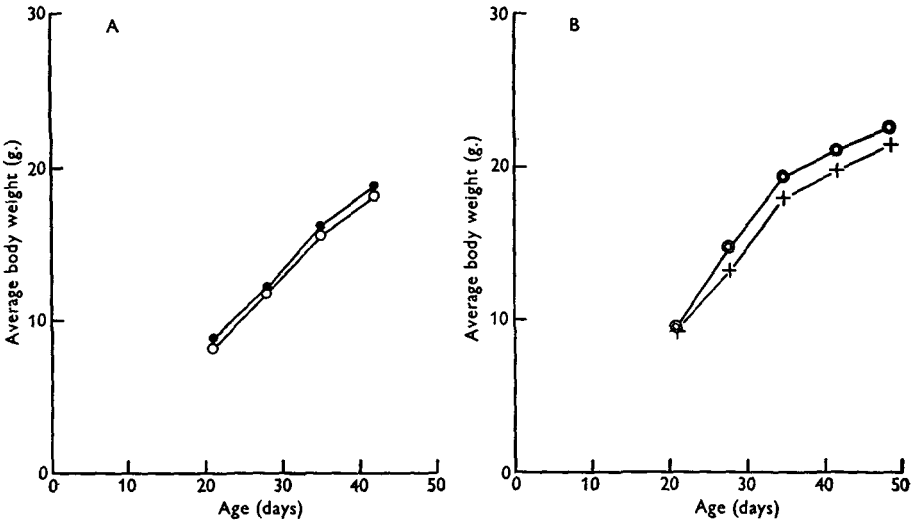

Fig. 3. Growth of young from 3 to 6 weeks of age. A, size of mating groups; ●, 485 young from pairs (236 males and 249 females); ○, 241 young from groups of five mice (115 males and 126 females). B, size of group after weaning: ◎, young housed five per small box; +, young housed twenty per large box. Thirty-eight litter-mates per group (nineteen males, nineteen females).

Table 4. *Mortality of young from* 3 *to* 6 *weeks of age*

Origin		No. of young weaned	Sex ratio at weaning (♂/100♀)	No. of deaths	Mortality (%)	Sex ratio at 6 weeks (♂/100♀)
Young from monogamous pairs: one male, one female	♂	303	99·0	61	20	96·4
	♀	306		55	18	
Young from groups: one male, four females	♂	159	94·1	46	29	89·6
	♀	169		43	26	

For this test twenty pairs of litter-mates of each sex were used. Mortality was normal, one male (large box) and one female (small box) only dying during the test. The respective litter-mates have been omitted in calculating the average growth rates which are shown in Fig. 3B. Young housed five per small box reached an average body weight of 20 g. about 5 days sooner than their litter-mates housed twenty per large box, though the floor area available per mouse was the same.

DISCUSSION

Mice choose to spend most of their time huddled together in a pile, however much room for exercise is allowed. Optimum conditions for growth, maintenance and reproduction are not therefore determined by population density but by the size of the group living together. The effect which the size of the breeding group has on

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certain aspects of reproduction, as recorded in these experiments, is shown in Table 5.

The maximum production per female is given by pairs, but this system makes excessive demands on space and stock. With two females to one male there is a saving of 50 % in floor space, and 25 % in stock, economies which more than offset the slightly reduced production per female and which allow an increase of about 60 % per unit area. With four adults together, the group becomes critically large. In spite of economies in stock (33 %) there is no increase in production per head. Moreover, effective reproduction in the quartets fell progressively during the test by comparison with that in the pairs and in the trios (Table 6). The high production per unit area, twice that from the pairs, therefore gives a misleading impression.

Table 5. *Size of breeding group and relative productive efficiency (number of young weaned per female)*

Breeding group				Production per female			
Male	Female	Space saved	Stock saved	Young born within 10 weeks of start of test (%)	Total number of young born during test (%)	Production per unit area (%)	Production per head of stock (%)
1	1	0	0	100	100	100	100
1	2	$\frac{1}{2}$	$\frac{1}{4}$	—	82	164	109
1	3	$\frac{2}{3}$	$\frac{1}{3}$	—	70	209	105
1	4	$\frac{3}{4}$	$\frac{3}{8}$	67	—	—	—

Table 6. *Relative production per female according to size of breeding group*

Breeding group		Young born per female within days			Young weaned per female of those born within days		
Male	Female	60	61–90	91–120	60	61–90	91–120
1	1	100	100	100	100	100	100
1	2	104	91	101	91	71	92
1	3	92	84	61	86	67	52

For long-term large-scale production these results suggest that small breeding units of one male with two females are the most suitable. This system has been applied to the main mouse-breeding colonies, housed in 80-drawer mouse batteries manufactured by the National Iron Wire Works, Blackley, Manchester, and has proved very satisfactory in practice.

The same considerations apply to growing stock. Mortality rises steeply when large numbers of young are kept together, and growth rate is inversely related to the size of the group. Unless there is adequate provision for housing, increase in the number of young weaned may be offset by high mortality and slow growth in the post-weaning period.

SUMMARY

1. The production of weaned young from pairs or groups of three, four and five mice, each containing one male, has been compared.

2. For long-term large-scale production, small breeding groups of one male with two females are proposed.

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