

POST-PARTUM BREEDING IN THE GUINEA-PIG

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(With 3 Figures in the Text)

As the guinea-pig, in common with several other small laboratory rodents, experiences a post-partum oestrus accompanied by ovulation, it is clear that if mating were permitted at this time, the rate of littering could be increased above that obtained by the conventional method of breeding, and would thus raise the productivity of a colony over a given space of time. The incidence of post-partum oestrus, as determined by the proportion of fertile post-partum matings in a control stock colony of guinea-pigs, was found by Eaton (1941) to be 47·8%, who also observed that in different in-bred families it fell within a range of 60 and 33·8%. More recently, however, Bruce & Parkes (1948) have reported that in a colony of the Medical Research Council strain of guinea-pigs bred as monogamous pairs 74% of matings occurred at post-partum oestrus.

The pair method of breeding described by Bruce & Parkes, as they point out, is not practicable in a large colony because of the large numbers of males that would have to be maintained. To overcome this disadvantage I have observed post-partum mating in small polygamous groups kept permanently together throughout their breeding life in floor pens of a standard size, and have compared their fertility with that of others in which mating occurred at post-lactational oestrus, to assess the practicability of adopting post-partum mating as the basis of a breeding method in the main colonies at this Field Station. The total number and the proportion of the sexes in the colonies were varied to ascertain as far as possible the optimal ratio of males to females to be kept in one pen. A summary of the observations, which extended over a period of nearly 2 years, is given below.

MATERIAL AND METHODS

Animals and diet

The guinea-pigs were reared at this Field Station by Method 3, described below, from stock originating from the Medical Research Council's colonies at Mill Hill. They received daily 30 g. of pelleted food (M.R.C. Diet 18), 4 oz. fresh green vegetables, hay and water. The green-stuff consisted of chicory, spinach, kale or cabbage, according to a crop rotation devised by Mr S. L. Hignett for this Station.

Breeding methods

(1) *Post-partum mating in colonies (intensive breeding)*. Seventy sows and ten boars were distributed as shown in Table 5 between six pens (pens 1-6) each of which was 7 ft. x 3 ft. 6 in. Except for a week (see below), the sexes remained together from January 1946 to September 1947. Litters were born and reared communally on the floor of the pens. Further colonies (pens 20-23) were established during the above period.

(2) *Normal colony breeding*. Another thirty sows and six boars were placed in pens 7-9 (see Table 5) which were partitioned to allow separation of the pregnant sows from the males. Farrowing and rearing occurred communally on the floor. The sexes were put together for re-mating 1 week after the last litter in the order had been weaned.

The sows breeding by both the above methods were identified by colour markings; the young at birth received the marking of the mother. The young were sexed and weighed at birth. Litters were weaned and weighed on the 28th day.

(3) *Normal colony breeding with isolation of sows for rearing*. This is a method adopted for the breeding of a closely recorded 'Stock' colony established in 1944 to build and maintain 'Production' colonies from which the young are used to supply laboratory needs. It consists of units of six sows to one boar kept in tiered compartments of adjustable size and allows every pregnant sow to be isolated for farrowing. The sows in this colony are withdrawn from breeding after they have each reared a maximum of 7 litters, which on the average requires a period of 2 years. The breeding records of the first thirty-four discarded sows have been analysed to compare the efficiency of the system with that of Methods 1 and 2.

POST-PARTUM MATING

Onset of oestrus following parturition

The infrequency with which parturition occurs during day-time prevents extensive observation being made on the onset of oestrus in relation to parturition or on the duration of oestrus. In the whole series, parturition and the mating which followed were observed in only three sows, and the

interval elapsing between the two events was $1\frac{3}{4}$, $2\frac{1}{4}$ and 3 hr. respectively. As each sow mated only once, it would appear that oestrus was only of very short duration.

The gestation period

The period of gestation following post-partum mating may be regarded for all practical purposes as the interval elapsing between the births of successive litters. All three sows noted above produced a litter on the 68th day following the observed mating; further observations on the inter-parturition interval

which might conceivably occur during early lactation. Its effect on the intervals between the births of second and third litters of sixty-one sows is shown in Fig. 2. It can be seen that, though the incidence of inter-parturition intervals up to 70 days in length remains unchanged, not one of 71–87 days' duration was observed. The remaining sows in which the interval was 88 or more days did not mate at post-partum oestrus. Though the maximum duration of pregnancy resulting from a post-partum mating is considered to be 70 days, the data given in Table 1, showing that the period of gestation is determined to

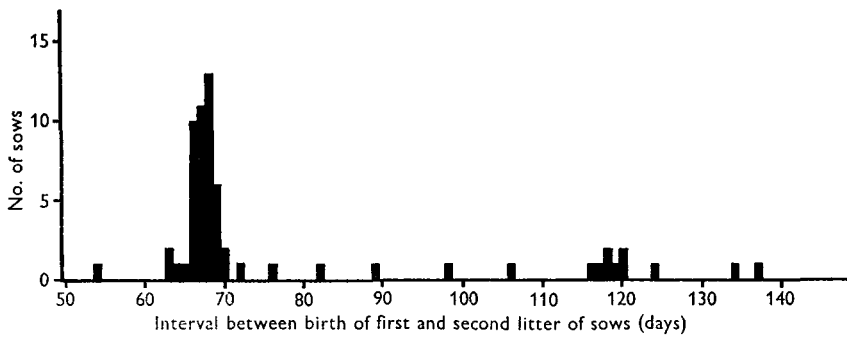


Fig. 1. Inter-parturition (1st to 2nd litters) intervals in sixty-three sows having free access to males in the colonies.

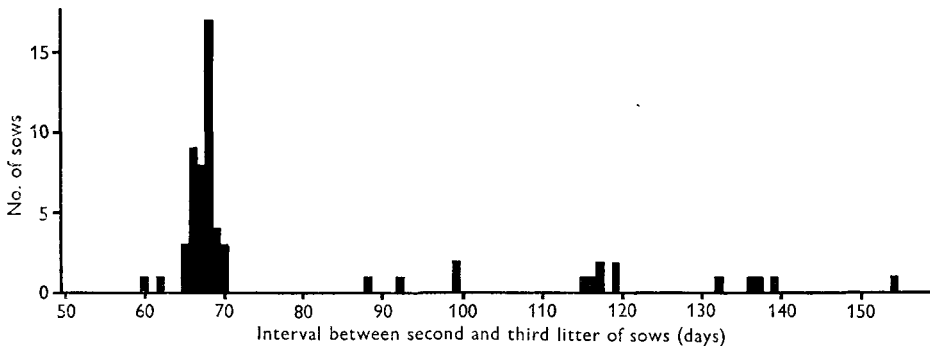


Fig. 2. Inter-parturition (2nd to 3rd litters) intervals of the same sows which were removed from the males for a period of 1 week beginning about 15 hr. after the births of the 2nd litters. Note the absence of inter-parturition intervals of 71–87 days' duration.

are given in Figs. 1 and 2. The former shows that in 75% of animals the interval between the births of the first and second litters of sixty-three sows does not exceed 70 days. The occurrence in two sows of an inter-parturition interval of 72 and 76 days, however, renders the definition of the maximal period of gestation following post-partum mating rather difficult. This maximal period was discovered by removing all sows from the males for a period of 1 week beginning not later than 15 hr. after the births of the second litters. This action, whilst allowing of immediate post-partum matings, served to prevent any others

some extent by litter size, suggest that when the litter to be born contains only a single young, pregnancy following post-partum mating may be as long as 72 days.

Post-partum mating in relation to size of colony

One of the main objects of this investigation was to determine the optimal size of colony and the proportion of the sexes to be used. The results, which are summarized in Table 2, have become affected to some extent by disturbances to the original pro-

portions of the sexes in some colonies on account of deaths amongst sows during this prolonged period of intensive breeding. Nevertheless, they indicate that the occurrence of post-partum mating is not lowered until the proportion of females to males is greater than 12 to 1, and that it is not affected by increasing the number of males in colonies containing up to twelve sows. This latter fact is supported by the observation that when two or three males are present in a colony one becomes dominant and it is highly probable that all the matings are effected by this boar.

Table 1. *The relation between gestation period (inter-parturition interval) and litter size*

Gestation period (days)	No. of litters of different sizes (Litter size)									
	1	2	3	4	5	6	7	8	9	10
62	—	—	—	1	—	—	—	—	—	1
63	—	—	1	1	1	—	—	—	—	—
64	—	—	—	1	1	1	—	—	—	—
65	—	1	1	—	—	3	3	—	—	—
66	—	—	1	10	10	8	2	1	—	—
67	—	4	1	13	18	9	1	2	1	—
68	3	8	22	24	20	8	1	1	—	—
69	2	4	10	11	6	3	—	—	—	—
70	6	6	6	3	4	1	—	—	—	—
71	1	3	1	1	—	—	—	—	—	—
72	1	—	—	—	—	—	—	—	—	—
Average	69.6	68.7	68.3	67.6	67.4	67.0	66.1			

Table 2. *Post-partum mating and colony size*

The figures given in parentheses refer to the number of sows breeding at the end of the experiment. The average inter-parturition intervals given in the final column include those between litters which were not conceived at post-partum mating.

Pen no.	Size of colony		No. of litters born*	No. of fertile post-partum matings (%)	Interval between litters (days)
	Females	Males			
1	5 (4)	1	31	87	68.6
2	10 (8)	1	58	83	73.6
3	15 (12)	1	94	73	74.8
4	10 (7)	2	53	83	71.6
5	15 (9)	2	78	73	76.6
6	15 (7)	3	62	87	72.0
20	12 (12)	1	12	83	69.0
21	12 (11)	1	11	73	71.3
22	20 (19)	1	19	58	71.7
23	20 (19)	1	19	47	80.0

* Excluding all 1st litters born.

Post-partum mating in relation to order of litter (parity)

The gradual rise in the proportion of fertile post-partum matings with increase of parity, as shown in Table 3, probably results from the elimination (by

death) of the less fertile sows during the long course of intensive breeding. Of all fertile matings, 80% occurred at post-partum oestrus. Under Method 1 the average interval between births of all successive litters was 74 days, but it was only 68 days when the litters (80%) were conceived at post-partum oestrus. In the absence of post-partum mating (Method 2) the average interval between litters was 118 days.

Table 3. *Post-partum mating and parity*

The average inter-parturition intervals given in the final column include those between litters not conceived at post-partum mating.

Parity	No. of sows	No. of fertile post-partum matings (%)	Interval between litters (days)
2	63	74.5	77
3	61	74.0	80
4	58	79.3	71
5	57	82.4	70
6	54	75.9	73
7	47	85.1	70
8	34	91.2	70

Post-partum mating in individual sows

Table 4 summarizes the proportion of fertile post-partum matings that occurred in each of sixty-three sows having two or more litters. Only one animal failed to conceive post-partum; she had four possible post-partum oestrous periods. More than half the litters of the great majority of sows were conceived post-partum. Every litter born to fifteen sows was conceived at post-partum mating and of these animals, eight and two mated at seven and eight consecutive post-partum 'heat' periods respectively.

Table 4. *The proportion of matings occurring at post-partum oestrus in sixty-three guinea-pigs having two or more litters each*

No. of matings/sow occurring at post-partum oestrus (%)	No. of sows
0	1
40-49	1
50-59	1
60-69	16
70-79	9
80-89	20
90-99	0
100	15

FERTILITY AND LITTER VIABILITY

The records of the sows bred by the three methods described on p. 281 are summarized in Table 5. The figures given in parentheses refer to the number of sows that reared seven litters each (Methods 1 and 3) and five litters each (Method 2). The other data given for all three methods were drawn from these

litters of the above-mentioned sows, and from those of sows dying during the period of breeding. Mortality amongst breeding stock is greatest under Method 1, but in this group four of the seventy sows died before breeding commenced.

(d) *In relation to season.* The fluctuations in litter size noted above (Methods 1 and 2) are probably related to seasonal changes in fertility, because in both of these two groups the majority of litters of the same order were born within fairly narrow time

Table 5. *Summary of breeding records of guinea-pigs bred by different methods*

For explanation of figures in parentheses see Table 2.

Breeding method	Pen no.	Breeding stock		No. of litters born	Average litter size and s.e.*	Live births (%)	Young weaned (%)
		Females	Males				
1	1	5 (4)	1	32	4.15	94.0	91.0
	2	10 (8)	1	63	4.22	95.1	85.3
	3	15 (12)	1	101	4.10	96.8	86.0
	4	10 (7)	2	55	3.89	94.4	85.5
	5	15 (9)	2	88	3.78	94.6	84.4
	6	15 (7)	3	67	3.75	97.2	82.5
		70 (47)		406	3.98 ± 0.07	95.6	84.7
2	7	5 (2)	1	19	4.16	93.7	89.9
	8	10 (10)	2	49	3.80	97.9	91.9
	9	15 (12)	3	71	3.75	92.8	80.8
			30 (24)		139	3.82 ± 0.10	94.7
3		34 (32)		234	3.69 ± 0.07	95.8	93.9

* Standard error σ/\sqrt{n}

Litter size

(a) *In relation to the proportion of the sexes in the colony (Methods 1 and 2).* Though the original proportion of the sexes in the various colonies has been disturbed by deaths occurring during the breeding period it is clear that litter size is not affected (Method 1) when the proportion of females to males in a colony varies between 4:1 and 12:1. No advantage is to be gained from having more than one male in a colony containing up to twelve sows; in fact, this procedure appears to have an adverse effect on litter size.

(b) *In relation to method of breeding.* The average litter sizes given in Table 5 for Methods 1 and 2 do not differ significantly. A similar result is obtained when the average size of 267 litters conceived at post-partum oestrus (4.15 ± 0.09) is compared with that of seventy-three litters conceived at post-lactational oestrus (3.93 ± 0.15), both these groups being included under Method 1. Animals bred in pens on the floor (Methods 1 and 2) yield slightly larger litters than others bred in tiered compartments, the lower being about 2 ft. above floor level.

(c) *In relation to order of litter (parity).* The average sizes of successive litters given in Table 6 confirm the previous observations of Bruce & Parkes (1948) on the small size of first litters born to sows. The size of subsequent litters, particularly those listed under Methods 1 and 2, appears to fluctuate, the fluctuation being unrelated to parity or age of sow.

limits. Litter size in relation to time of littering is represented diagrammatically in Fig. 3. Maximum litter size is obtained from matings occurring in late spring.

Table 6. *Litter size in relation to parity*

Parity	Method 1		Method 2		Method 3	
	No. of litters	Average size	No. of litters	Average size	No. of litters	Average size
1	66	3.2	30	3.5	34	3.2
2	63	4.3	30	4.4	34	4.1
3	61	4.7	28	4.3	34	3.8
4	58	4.3	27	3.6	34	3.7
5	57	3.6	24	3.6	34	3.9
6	54	3.6	—	—	33	3.5
7	47	3.9	—	—	32	3.5
8	33	4.2	—	—	—	—

Viability of young

(a) *At birth.* The summarized records given in Table 5 show that, irrespective of the breeding method, the proportion of live births is about 95%. The main cause of death at birth is asphyxia due largely to the failure of the sows to remove foetal membranes. It was observed that deaths were more common in large litters, probably as the result of the exhausted condition of the sow. The relationship given in Table 7 between mortality and litter size confirms this observation (see also Fig. 3).

The death-rate amongst young at birth is not related to age or parity of the sows.

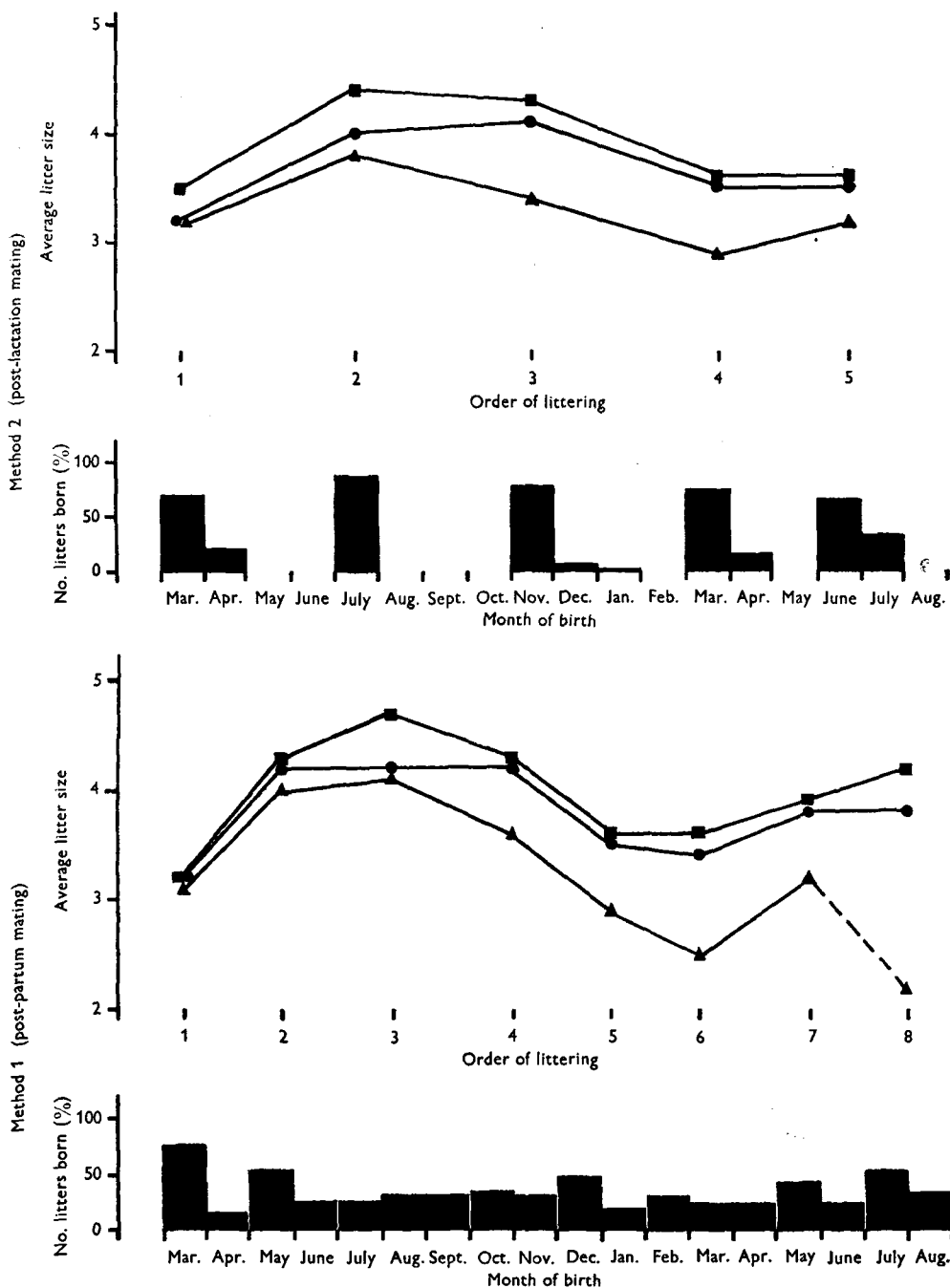


Fig. 3. Seasonal effect on litter size and viability. ■—■, average litter size at birth; ●—●, average litter size (live) at birth; ▲—▲, average size of litter weaned. It should be noted that the average size of the 8th litters reared under Method 1 (bottom half of diagram) is affected by the high death-rate caused by disease (see text).

Table 7. Mortality in relation to litter size

P.N. = post-natal mortality, refers to the proportion of young born alive that died before weaning on the 28th day.

Litter size	Method 1			Method 2			Method 3		
	No. of young born	Mortality (%)		No. of young born	Mortality (%)		No. of young born	Mortality (%)	
		At birth	P.N.		At birth	P.N.		At birth	P.N.
1	17	0	11.8	3	0	33.3	4	0	0
2	82	0	12.2	28	0	7.3	36	0	0
3	252	1.2	13.7	123	3.2	12.6	237	0.8	0.8
4	528	2.5	7.8	152	2.7	6.0	364	3.6	1.4
5	400	4.8	11.5	175	5.7	9.5	150	8.7	4.4
6	228	6.1	11.2	36	19.4	13.8	66	12.1	6.9
7	56	5.4	17.0	14	42.9	25.0	7	0	0
8	32	28.1	34.8	—	—	—	—	—	—
9	9	44.6	40.0	—	—	—	—	—	—
10	10	60.0	50.0	—	—	—	—	—	—

Table 8. Annual production of guinea-pigs bred by Method 1 (post-partum) and Method 2 (post-lactation)

	Method 1	Method 2
Interval between births of successive litters (days)	74	118
Estimated number of litters born per annum	5	3
Litter size at birth	3.98	3.82
Weaning rate (%)	84.7	86.0
Annual production of young (reared) per sow	16.8	10.1

(b) *From birth to weaning.* As shown in Table 5, the number of young weaned (93.9%) by Method 3 in which all litters are reared in separate units is considerably greater than that given by Methods 1 and 2 where the young are reared communally in floor pens. The greater mortality occurring amongst young reared by the latter methods is ascribed to trampling in the frequent and unavoidable stampeding which occurs in the floor pens. It would appear (see Table 7) that only in the case of young animals bred by Method 3 does there exist a direct proportionality between litter-size and post-natal mortality.

Fig. 3 shows that for Methods 1 and 2 there is a seasonal effect on the rate of survival of young guinea-pigs during the first 4 weeks of life. Thus, whereas during the summer months the average death-rate is about 0.1–0.2 young/litter, in the winter months it is as much as 0.6 to 0.9 young/litter. This fact is explained in all probability by the difficulty of providing adequate supplies of fresh green vegetables during winter. These observations were carried out during the severe winter of 1947 when the cabbages, grown on the Field Station, were badly frozen for lengthy periods. It may well be, therefore, that in milder winters this seasonal difference in the death-rate may not be so marked and perhaps not noticeable, though Durham & Woods (1932) recorded a seasonal influence on the death-rate.

The sudden decrease in the number of young weaned from 8th litters by Method 1 (see lower half of Fig. 3) is attributed to an outbreak of Salmonel-

losis (*typhi-murium*) which caused the abandonment of the experiment. It may be significant that though the animals breeding by Method 2 were in the same room as the above, they did not become infected. The possibility that intensive breeding leads to a lowering of resistance to bacterial infection cannot be overlooked and, with this in mind, the time over which animals should breed by this method requires careful attention. It is advocated that animals breeding at post-partum oestrus be withdrawn after they have produced five litters, i.e. after about 1 year's intensive breeding.

ANNUAL PRODUCTION BY POST-PARTUM BREEDING

The average interval between the births of any two successive litters of the same animal having the opportunity of post-partum mating was found to be 74 days compared with one of 118 days in guinea-pigs in which mating at the post-partum oestrus is not permitted. The fertility of matings and the viability of the young born by both these breeding systems being similar (see Tables 5 and 8), it has been calculated that the annual production of young is increased by about 68% when post-partum mating takes place. In practice, however, the increase in productivity is slightly less than this amount because of the higher death-rate amongst sows breeding by this method. Thus, it was observed that the output of young during 1 year's breeding by Method 1 (first five sets of litters) is 62% greater than that of

young animals from sows bred by Method 2 (first three sets of litters). It should be remembered, however, that on account of the possible dangers to the health of animals bred by this intensive method, the period of breeding should be restricted to 1 year; whereas those animals breeding more slowly can continue to do so for upwards of 2 years without showing any marked deterioration of health. The rate of replacement of the stock bred at post-partum oestrus is, therefore, twice as rapid as is required in a colony breeding at the slower rate.

BODY WEIGHT AND RATE OF GROWTH OF YOUNG

The information set out in summary below (Table 9) is included solely for the purpose of demonstrating that the quality of the young conceived at post-partum mating is in no way affected by the more rapid rate of littering which this breeding method entails.

This table shows that, irrespective of the breeding

Table 9. *Birth and weaning weights of young conceived at post-partum (Method 1) and post-lactation (Method 2) oestrus*

Only litters in which no deaths occurred after birth and before weaning are considered.

Breeding method	No. of litters	No. of young		Body weight (g.)			
		Males	Females	Birth		Weaning	
				Males	Females	Males	Females
1	288	562	485	95	93	281	271
2	95	182	164	94	93	277	272

method, the body weights of the young at birth and weaning are closely similar.

SUMMARY

Information relating to post-partum mating has been described in guinea-pigs kept in six small colonies containing variable numbers of the sexes running together continuously in floor pens of standard size. Litters were born on the floor and rearing was communal (Method 1). Three other like colonies were similarly maintained, except that the females in late pregnancy were separated from the male to avoid post-partum mating (Method 2). The conditions of farrowing and rearing were similar to those of Method 1. The data given by thirty-four sows of a closely recorded (stock) colony bred in units of six females and one boar, but in which every litter was born and reared under 'cage' conditions

(Method 3), were used for comparative purposes only.

Post-partum mating was considered to have occurred only when the interval between the births of any two consecutive litters of the same sow did not exceed 70 days. Of litters born under Method 1, 80% were conceived at post-partum oestrus; the mean gestation period was 68 days. The average inter-parturition interval of all sows breeding under Methods 1 and 2 was 74 and 118 days respectively. The optimal ratio of the sexes in a colony breeding by both methods was judged to be twelve females to one male.

Litter size varied between 3.98 (Method 1) and 3.69 (Method 3) and by all three breeding methods, the proportion of young already dead or that died at birth was about 5%. Deaths were more common in summer months when litter size was maximal.

The post-natal death-rate during the first 28 days of life among young reared communally (Methods 1 and 2) was 10% and was fivefold that observed in

litters reared separately by their mothers (Method 3). This death-rate was highest during the winter months due to the difficulty of providing adequate amounts of fresh green vegetables.

The annual output of young guinea-pigs from colonies bred under Method 1 was 62% greater than that from other colonies bred by Method 2. The more rapid sequence of littering did not affect the quality (body weight) of the young at birth or at weaning.

Attention has been drawn to a possible deleterious effect of intensive breeding to the health of the females and their lessened resistance to infection. It has been suggested that, for this reason, the breeding life of the sows should be limited to 1 year.

It is a pleasure to acknowledge the assistance given by Messrs T. Badger and A. Turner, who recorded the breeding data from which these results have been compiled.

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