FEEDING AND BREEDING OF LABORATORY ANIMALS

V. USE OF COPE-CHAT RECORD CARDS FOR THE ANALYSIS OF BREEDING PERFORMANCE

By H. M. BRUCE and A. S. PARKES, *National Institute for Medical Research, Hampstead, N.W.* 3

(With 3 Figures in the Text)

INTRODUCTION

The Cope-Chat recording system depends essentially on the use of an index card of standard or other size, round the edge of which holes are punched. A particular fact or piece of information is allocated to each hole, and where it applies to the record in question the peripheral border of the hole is punched out. When a set of cards is suspended on a skewer through a particular hole and shaken, the cards clipped at that hole fall out, and thus all the cards registering that particular datum can be sorted from the rest in a single operation. In this way hundreds or even thousands of records can readily be sorted for various data, and examined for possible correlations. Moreover, when cards are stacked according to one variable, the trends of the other clippings give a graphical indication of correlated variables.

This system has been applied to the recording of various kinds of biological data (Clarke, 1936), and has been extensively used by the Bureau of Animal Population, Oxford, for recording the reproductive state of animals caught in the field (see Laurie, 1946). So far as we know it has not been used hitherto for recording breeding performance in animal colonies. In deciding whether such an application would be useful and practicable the following considerations arose:

(1) The records of breeding colonies tend to become complicated and massive and it is usually very laborious to keep a close watch on a multitude of details of performance which may be of great importance in the management of a colony.

(2) The Cope-Chat system enables a rapid survey to be made of existing information, but when a card has been clipped and filed further information cannot be added without confusion. It follows that the data which the card records should be complete before the card is clipped, and therefore, unless the file is to be perpetually out of date, the space of time covered by the record on one card should not be very great.

It appeared, therefore, that the system could usefully be applied to the records of a breeding colony but that the whole breeding record of an animal, covering perhaps several years, would be unsuitable as the unit of information recorded on one card. For this reason, and also to keep the card to a reasonable size, it was decided that a card must relate to a litter, not to an animal.

The card illustrated (Fig. 1) was designed for recording litters produced by a colony of monogamously mated guinea-pigs. It was designed for the rapid checking of breeding performance. It enables the relationship of litters from the same female to be determined easily, but not that of less closely related litters, and, as designed, the card is unsuitable for genetical work. The headings in the centre panel (e.g. Age of mother at conception (months)) are given in full. Those appended to the holes (e.g. Age of mother) are abbreviated to save space. The card is the standard 8×5 in. size, and therefore fits standard cabinets. A card of this size has 106 holes of which one is destroyed by the cut at the top right-hand corner required to show whether all the cards in a stack are the same way up. Thus 105 different facts can be recorded on such a card, though it is undesirable to use the three remaining corner holes which tend to get torn.

In the Cope-Chat card the record holes are inevitably restricted to the periphery so that even if fairly elaborate legends are used, there is a considerable centre panel left on an 8×5 in. card. This space is commonly used for non-functional information, names, addresses, etc. In the breeding colony card it seemed preferable to use it for tabulating the variables and recording the actual data involved (Fig. 2). In practice, the centre table is filled up and the card passed to a cutter for the appropriate holes to be punched. The back of the card, which like the centre panel can be used only for non-functional information, is inscribed 'Guinea-pig breeding record card', in anticipation of the use of similar cards for other species.

https://doi.org/10.1017/S002217240001398X Published online by Cambridge University Press

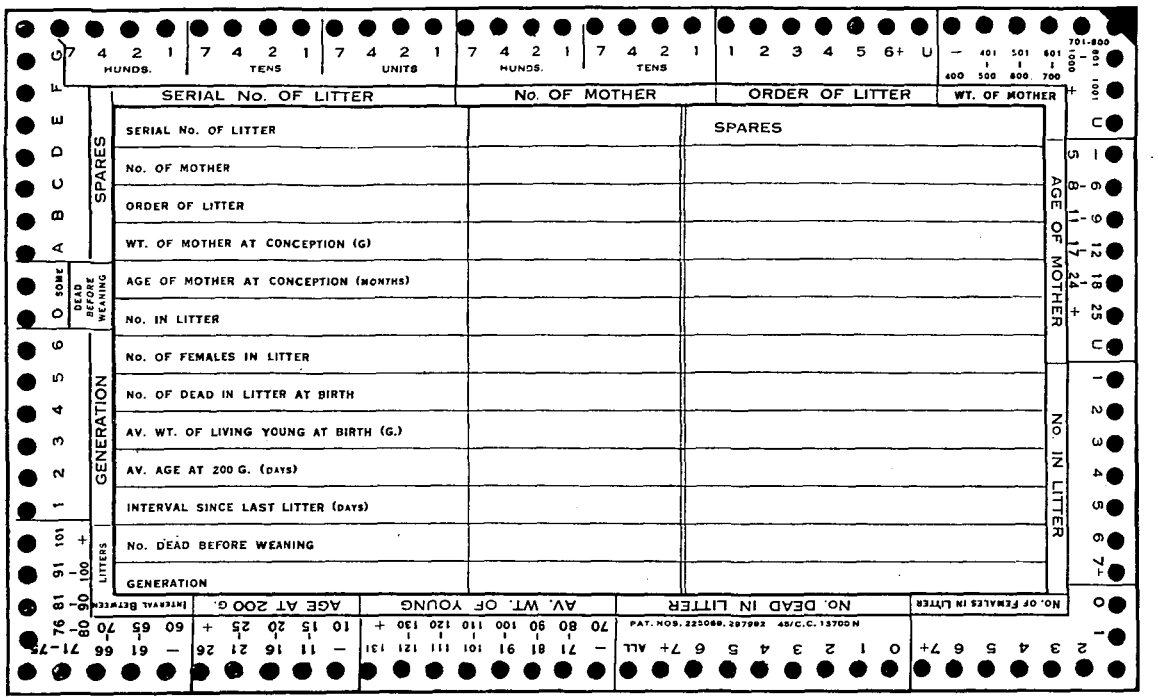

Fig. 1. Face of the card designed and used for recording breeding performance in a colony of monogamously mated guinea-pigs.

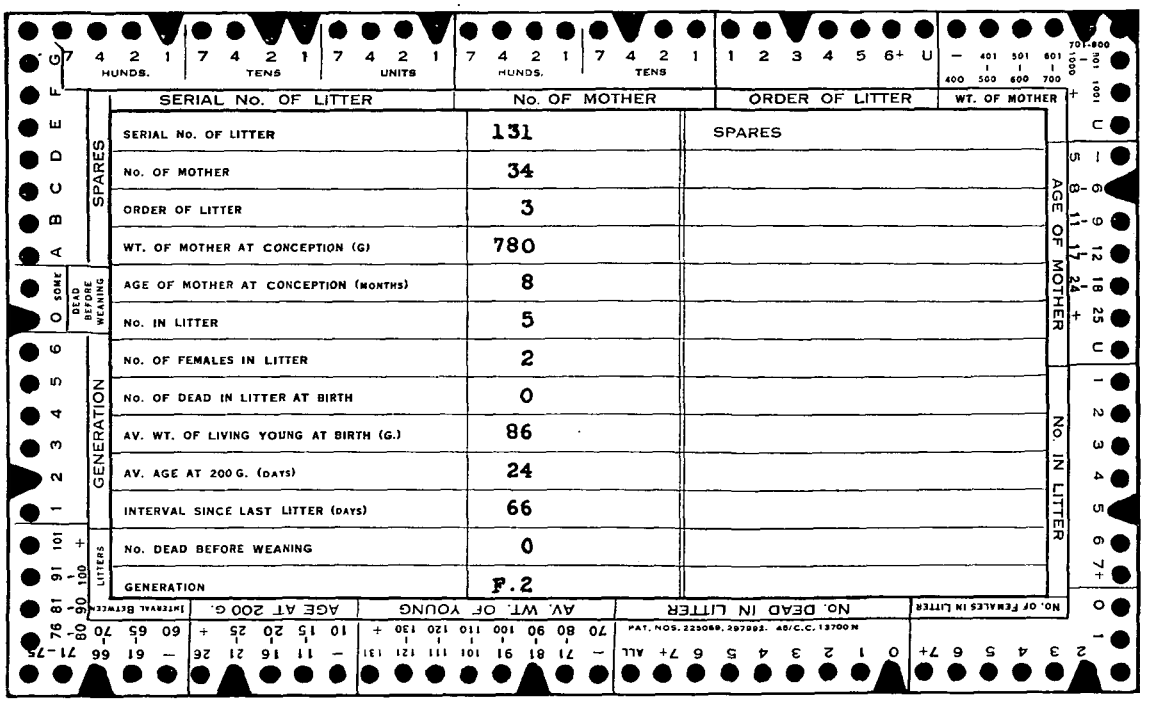

Fig. 2. Similar card completed for filing.

https://doi.org/10.1017/S002217240001398X Published online by Cambridge University Press

It will be seen that on the card illustrated information is recorded under thirteen different main headings using ninety-five holes, seven holes being left as 'spares' for records not envisaged when the card was printed.

DESIGN AND USE OF CARD FOR GUINEA-PIG BREEDING

Serial number of litter. All litters born in the colony receive a serial number in chronological sequence. It is essential to record this on the card and to make provision for numbers up to four figures. In the ordinary way this would involve the use of thirty holes, too large a proportion of the total number available. In the abbreviated system shown on the card 3 is obtained by using the holes for 2 and 1, 5 by using the holes for 4 and 1, and so on. This arrangement involves shaking the cards twice to obtain those bearing numbers which require two punches. To obtain cards bearing numbers with 0 is more difficult since it involves elimination. The method of obtaining the card relating to any particular number of litter is thus cumbersome. The serial number of litter, however, is mainly used for sorting cards by months and years (there is an independent record relating serial number with date of birth) and for this the arrangement described is adequate, and it saves the large number of holes which would be required to indicate date of birth.

Number of mother. This is included so that by sorting the cards for a particular number of mother, the whole reproductive history of the animal can be obtained. Again, the abbreviated system is used, with the addition that unit numbers are omitted altogether so that the final sorting must be done by hand. This piece of information is not likely to be sought for often, as the original animal house notes are kept according to number of mother. In monogamously paired animals the number of mother indicates, on an independent record, the number of the father. To adapt the card to a polygynous pairing and unpairing system, a section would have to be inserted to enable the father's number to be recorded.

Order of litter. The recording of the parity of the litter presents no difficulties. For guinea-pigs it was not thought necessary to take the numbers above 6+ (six and above). If necessary, the application of the existing notation could be extended by the use of two clips, as in the abbreviated system described under number of mother. U = unknown, for litters from animals of unknown history.

Weight of mother and age of mother at conception. For both of these the use of a logarithmic scale might be theoretically desirable, but it seemed difficult to arrange in practice, and apart from the doubling of the last interval, an ordinary scale has been used. In use the notation under the heading 'age of mother' has proved inadequate at the lower extreme. Nearly all females conceive before they are 5 months old—two have conceived when only 5 weeks old. The 'age of mother' scale should therefore run –3, 3–5, etc.

Number in litter. This section needs no explanation. 7+ was thought to be the highest category needed for guinea-pigs.

Number of females in litter. This section enables the combinations of the sexes to be obtained for any given size of litter.

Number dead in litter at birth. In addition to the ordinary scale, a hole is allotted to 'all'. This enables all the cards relating to litters totally stillborn to be sorted in one operation. The alternative would be to do seven pairs of shakings, for 1 in litter, 1 stillborn; 2 in litter, 2 stillborn, etc.

Average weight of living young at birth. This section needs little comment.

Average age at 200 *g.* In seeking a simple single index of rate of growth of young it seemed that the time taken to reach 200 g., the weight at which the young are weaned and usually issued, would be the most satisfactory. In practice neither weight at a certain age, nor age at a certain weight are entirely satisfactory, since both imply daily observations, but since the guinea-pigs are weaned according to weight and not according to age, age at weaning weight was chosen.

Interval since last litter. This is an important piece of information. The guinea-pig has a post-partum oestrus and in the absence of a new pregnancy the usual 14-day cycle occurs during lactation. Our records include 114 pregnancies dating from post-partum oestrus, varying in length from 62 to 73 days with an average of 68 days. It follows, therefore, that where a pair are kept mated, the interval between births cannot be less than 62 to 73 days, and may be greater than this in multiples of about 14 days. In the stock in question, therefore, intervals between births up to about 75 days definitely indicate the duration of pregnancy. Intervals above 75 days may be taken to mean that conception did not occur at the post-partum oestrus. In practice, among 123 intervals recorded, none was between 74 and 81 days duration. This system does not distinguish between failure of oestrus, failure to mate at oestrus, and sterile mating, as a cause of long intervals between births. Such distinction would involve daily vaginal examinations which would not normally be part of the routine of a breeding colony.

It will be noticed that no provision is made for the recording of 'interval not known' or 'no interval' in the case of litters from animals of unknown history and first litters. The former will be rare in an established colony and will, in any case, be recorded under the spare 'G' (see section on 'spares'); the cards of the latter can be removed

before correlations involving intervals between litters are considered.

Generation. It is useful to know the number of generations separating a litter from some fixed genealogical point. The present cards were drawn up for recording a newly established colony.

Number dead before weaning. Deaths between birth and weaning were not sufficiently common to justify a complete classification of the litters according to this index. However, it is convenient to be able to sort out easily those in which no mortality occurred, and two holes were therefore used to distinguish between some mortality and no mortality.

Spares. Two spares have so far been brought into use. A = litter was aborted. G = something unusual about the litter; for instance, incompleteness of the usual data.

The data recorded above make it possible to examine many correlations very quickly. Of the thirteen variables, one, 'number of mother', is completely artificial; another, 'serial number of litter', is itself artificial but enables seasonal variation to be examined. Most of the variables give valuable information about the efficiency of a breeding colony and they require to be watched carefully from month to month if the colony is to be closely controlled. As an example, one might ask: Is it worth while continuing to breed from females after they have had four litters? Or the more academic question: Is there any seasonal variation in litter size, and, if so, is this reflected in the stillbirth and post-natal mortality rates? This and many similar questions can be answered very quickly if record cards similar to that illustrated are kept properly up to date. On any ordinary record system the answering of such questions involves a great deal of searching and tabulating.

As mentioned in the first paragraph, a general idea of correlated variables can be obtained by stacking the cards according to one variable and examining the sides of the stack for the run of other clippings. Fig. 3 shows the right-hand end (Fig. 3*a*) and the bottom side (Fig. 3*b*) of the stack when the

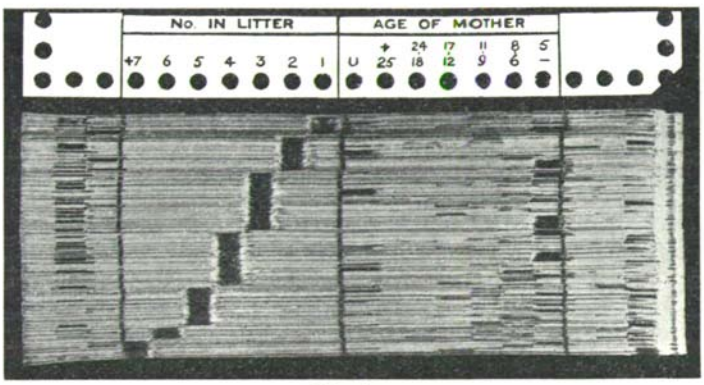

Fig. 3*a*

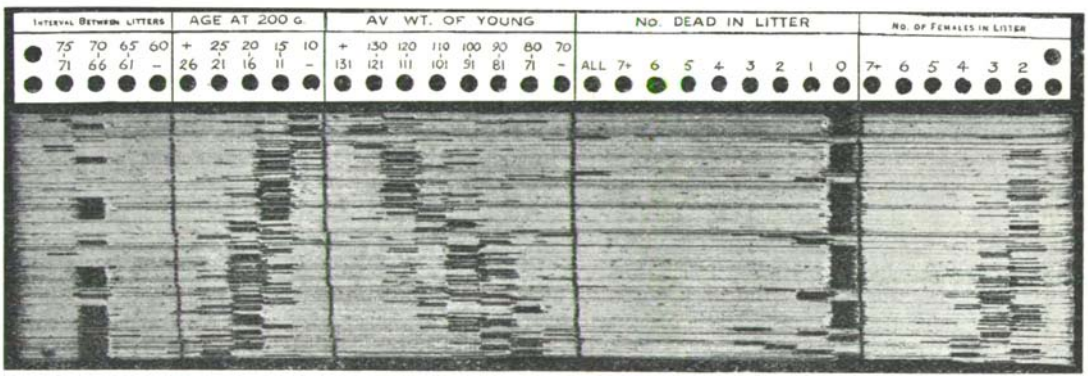

Fig. 3*b*

Fig. 3. Cards stacked according to 'number in litter' showing run of clips under other headings. See description in text.

https://doi.org/10.1017/S002217240001398X Published online by Cambridge University Press

cards are sorted for 'number in litter', and within these groups, sorted secondarily for 'number dead in litter'. Variables clearly correlated with size of litter are 'average weight of young' and 'age at 200 g.' Under the latter heading, the run of the clips shows an unexpectedly abrupt effect on growth rate of increasing the litter size from three to four. The 'age of mother' also shows some apparent relationship with 'number in litter', if the 'age of mother unknown' clips are discounted. The clips for 'interval between litters' give little indication of correlation as yet, since more than 70% of the intervals fall into a single category, 66–70 days, which together with those immediately above and below indicate post-partum conception. The picture for 'interval between litters', however, is complicated by the fact that cards for first litters without an interval clip are present in the stack. 'Number of females in litter' shows, as would be expected, a close connexion with size of litter, but this index, of course, is merely the raw material from which the sex-ratio can be obtained, and gives no direct indication of correlation of sex-ratio with litter size.

ADAPTATION TO OTHER ANIMALS

For rats and mice bred on a paired monogamous system a very similar card would be applicable, but the notations under most of the headings would have to be adjusted in keeping with the different reproductivity, longevity, size and growth rates of the different species. The notation under 'interval between litters' would have to allow both for the shorter period of gestation of the rat and mouse for the fact that following the post-partum oestrus, the cycle is in abeyance during most of lactation.

For rats and mice bred on a polygynous system the same modification would be required as for polygynous guinea-pigs.

The adaptation of the card to the breeding records of rabbits presents greater difficulties. In guinea-pigs, rats and mice, kept in monogamous pairs, or where the female is returned to the male immediately after parturition or weaning of the young, the interval between births gives a good indication of the number of sterile matings and failures to mate, so that no special provision need be made for this information. In rabbits, which ovulate only after mating, which stay on heat indefinitely, and in which the female is usually taken to the buck for a few minutes only, the interval between births is more often an indication of animal house routine than an indication of the breeding performance of the animal. With this species, therefore, it is more difficult than in guinea-pigs to record the complete history of a breeding female on a series of cards recording information about her litters. Moreover, it is much easier in rabbits to distinguish between 'failed to mate' and 'sterile mating' than it is in guinea-pigs, and provision should therefore be made for the information. Nevertheless, the objection to crowding the whole life-history of a female rabbit on a single card, referred to above, is even greater than in the case of guinea-pigs. The rabbit therefore would still require cards based on the litter as a unit, but two new sections would be required, one to show the identity of the father and one to indicate the number and spacing of sterile matings or refusals to mate since the previous litter. The existing section headings in the guinea-pig card would be applicable to the rabbit except that the notations would require to be altered in keeping with the special features of the rabbit in longevity, size, growth rate and reproductivity.

Similar adaptations could be made for other animals in laboratory use. Generally, other polyoestrous animals, cotton rats, voles, hamsters, etc., would require a card of the same design as that for the guinea-pig. Ferrets would require cards similar to those for rabbits, if provision were made for the anoestrous period.

MANAGEMENT OF ANIMAL COLONIES

The above description shows that it is possible, by a fairly simple method, to keep a close watch on the performance of a breeding colony. Is it worth while doing so? The answer to this question depends, first on the advantages to be gained by close control, and secondly on the time and labour involved. As regards the former, the rising cost of housing, feeding and servicing animals makes it imperative for breeding colonies to be as efficient as possible. A small closely controlled colony produces more and better animals than a larger neglected one. Moreover, the cost of housing, feeding and servicing is much less per animal produced. The first essential for an efficient colony is to keep each breeding female working at maximum capacity compatible with the production of first-rate young, and to discard ruthlessly all indifferent performers. To do this, it is necessary not only to keep track of individual histories but also of general trends within the colony. The former is comparatively easy to do with any efficient system of recording. It is for the latter that the Cope-Chat card is so useful. Moreover, the time taken up in preparing the cards, additional to that inevitably used in the proper management of a colony, is small. In the guinea-pig colony for which the card was designed, there are about forty pairs of breeding animals. Young other than those required for replacement are disposed of at weaning. One hour per day on the part of a junior, but trained, laboratory assistant, suffices for

colony management: recording births, weighing animals, weaning young, replacing stock and keeping the individual records for each female and litter to supply the information subsequently recorded on the Cope-Chat card shown in Fig. 1. A very small amount of superintendence by scientific staff suffices to decide matters of policy. From the individual animal house cards the Cope-Chat cards for litters are prepared at suitable intervals. The time taken up by this operation in all is about 1 hr. a month for superintendent and assistant who work together and cross-check the entries and clips at each stage.

The colony in question has produced about 450 young guinea-pigs of 200 g. body weight in 12 months from a room of 135 sq.ft. floor space (about $12 \times 11\frac{1}{2}$ ft.), without any overcrowding and with space for a working table and for rearing replacements. For various reasons the space required by the replacements is not large in a guinea-pig colony. It would seem, therefore, that ten such colonies similarly organized and recorded (not necessarily one colony ten times as large) would produce about 4500 fully documented guinea-pigs a year, and a mass of readily available scientific information. The labour required additional to that absorbed by the usual servicing of the animals and by the minimum of recording and supervision required in even the most primitive breeding colony would be the full-time attention of a junior assistant and supervision occupying perhaps half a day per week on the part of the scientific staff. In the present state of our knowledge of animal breeding the supervision would amount to a research job. The assistant would cost about £150 per year, 8*d.* per head on 4500 guinea-pigs. The whole of this sum should not, however, be added directly to the calculated or estimated cost of a young guinea-pig. With the increased efficiency of the colony made possible by close control the average cost of producing an animal will be much less than where efficiency is low because of lack of control. The cost of producing a young guinea-pig is probably about 5*s.*, of which, under a system of monogamous pairing, some two-thirds is cost of labour for feeding and cleaning. It will readily be seen, therefore, that a system of management which produces even an additional 25% of young from a given size of colony, i.e. decreases the average cost from, say, 6*s.* to 5*s.* per animal, is not expensive at 8*d.* per animal. In practice, close control probably makes a greater increase in production than 25%.

SUMMARY

A Cope-Chat card has been designed and used for the recording and analysis of breeding performance in guinea-pigs.

Modifications required to adapt the card for use with other species are described.

Some general principles of colony management are discussed.

The photographs are the work of Mr C. Sutton.

REFERENCES

CLARKE, S. H. (1936). A use for the paramount sorting system. *Nature, Lond.*, **137**, 535.

LAURIE, E. M. O. (1946). The reproduction of the house-mouse (*Mus musculus*) living in different environments. *Proc. Roy. Soc.* B, **133**, 248.

(*MS. received for publication* 23. XII. 46.—Ed.)