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Myxomatosis: breeding large numbers of rabbit fleas (*Spilopsyllus cuniculi* Dale)

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SUMMARY

A simple method of breeding large numbers of rabbit fleas in a rabbit house with minimal disruption to the general routine is described.

INTRODUCTION

A study into the methods of breeding rabbit fleas was prompted by the need for large numbers of freshly emerged, healthy fleas, free from myxoma virus, in experiments concerning the usefulness of the flea in terms of rabbit control. Fleas are required for establishing fleas in wild rabbit populations, for disseminating virus in wild rabbit populations and for seeding domestic and wild rabbits for the production of fleas. The life-cycle of the rabbit flea is intimately connected with that of the rabbit (*Oryctolagus cuniculus*) (Mead-Briggs, 1964; Mead-Briggs & Vaughan, 1969; Rothschild & Ford, 1964, 1966; Sobey, Menzies & Conolly, 1974). Based on this information a simple method of breeding large numbers of fleas in a rabbit house with minimal disruption to the general routine has been developed and is described below.

METHODS AND RESULTS

Basic plan

For many experimental and practical purposes newly emerged vigorous fleas are needed in large numbers, often at short notice. To achieve this end use was made of the observations made by Sobey *et al.* (1974) that flea emergence was largely bimodal with one peak of emergence occurring 15–30 days *post partum* and a second occurring in response to disturbance after 30 days *post partum*. Nests were stored undisturbed above a 'sweep' or flea collecting rabbit, to allow the first emergence fleas to drop down and be collected while the second emergence fleas remained quiescent in the pupal stage. When freshly emerged fleas were required, a nest, stored longer than 45 days *post partum*, was scraped out onto the floor of the 'sweep' cage, whereupon second emergence fleas rapidly emerged; these collected on the sweep rabbit from which they were easily recovered.

Cages

The breeding cages used in the present work are illustrated in Plate 1. Constructed from 12 mm water pipe and 24-gauge galvanized sheet metal each compartment measured 0·9 m wide, 0·75 m deep and 0·5 m high. The floor, the wire front and the food hopper fitting into the wire front were all detachable. Each compartment had a water nipple connected to a low pressure water supply. A generous supply of good quality straw was spread on the floor of the compartment and in the nest box in each compartment. Nest-boxes 0·5 m long, 0·3 m wide and 0·2 m high had a removable floor tray with an 8 cm surround (Plate 2; A–C). Dimensions of cages and nest-boxes are not critical; final dimensions in the present work were determined by the sizes of available construction materials. Cages were painted with an epoxy resin non-corrosive paint.

Temperature and humidity

The animal house was maintained at a mean temperature of 20 ± 2 °C while the air conditioning plant was functioning adequately; during breakdowns temperatures up to 25 °C were reached. Yield decreased with increasing temperature (Sobey *et al.*, 1974) and temperatures in excess of 20 °C were avoided where possible. A mean relative humidity of 70% was maintained with a range of 60% to as high as 90% for short periods during cage washing. Excess humidity for extended periods led to the outbreak of mites (*Acarus siro* Linnaeus, *Proctolae laps* sp. Barlese, *Cheyletus malaccenis* Oudemans, and *Macrocheles* sp. Latreille) on the fleas and should be avoided.

Rabbits

A randomly bred strain of European domestic albino rabbits was used. White rabbits had the advantage over wild rabbits in that they were easy to handle and fleas were readily seen on them.

Fleas

European rabbit fleas imported from England (Sobey & Menzies, 1969) have been bred by us since 1966. Fleas are now established in wild rabbit populations scattered throughout the whole range of country occupied by wild rabbits in Australia. Fleas recovered from the field from time to time have been added to the breeding stock. Fleas used for breeding were freshly emerged or stored on rabbits to ensure maximum fertility. The number of fleas to be put onto a pregnant doe to give the maximum yield has not yet been established; 500 has proved a useful number but further investigation is needed to establish the optimal number, particularly in view of the finding (see Fig. 1) that the ability to breed appears to be affected by storage at 1 °C. The depressed flea yield with high seeding rates reported by Sobey *et al.* (1974) may have been due to the need at that time to store fleas in order to accumulate the numbers required for high seeding rates; the storage causing a spuriously low yield.

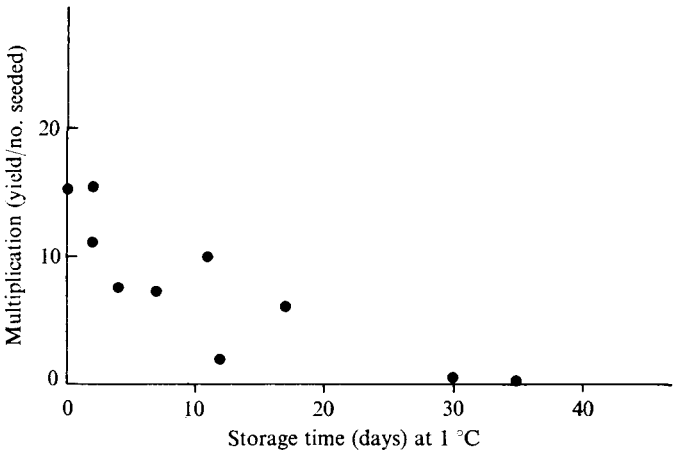

Fig. 1. The decline in the ability of fleas to breed with storage at 1 °C.

Breeding procedure

Breeding does were palpated at 19–20 days after mating to confirm pregnancy, seeded with 500 fleas and introduced into breeding cages. The doe and her kittens were removed from the breeding cage at 12 or 15 days *post partum*, combed free of fleas and transferred to a clean breeding cage; 12 or 15 days were chosen for organizational convenience. Does were mated on a Thursday so that littering usually took place during the quiet of a weekend, on Saturday or Sunday and 12 days *post partum* was then a Friday and 15 days a Monday, thus avoiding the need to move rabbits over the weekend. First emergence fleas began to emerge at or soon after 15 days *post partum* and in order to avoid excessive numbers of fleas on the doe and kittens the nest-box removal was not delayed beyond this time. The nest-box trays were placed on weldmesh grids above a 'sweep' rabbit (Plate 2D–F). Up to six nest-boxes were stored above a single sweep rabbit occupying a total of two breeding cages. The sweep rabbit was combed once or twice a week to collect the first emergence fleas falling down from the stored nests. When large numbers of freshly emerged fleas were needed one or more nests stored longer than 45 days *post partum* were scraped into the floor of the cage occupied by the sweep rabbit; large numbers of the newly emerged fleas were combed off the sweep during the following 24–48 h. The time after which the bulk of 2nd emergence fleas will emerge with disturbance appears to be temperature dependent (Sobey *et al.* 1974), the lower the temperature the longer the time. At 20 °C a time of 45 days *post partum* has been found to be adequate. To ensure the quiescence of the second emergence fleas it was found essential that the stored nests be left undisturbed; any movement or disturbance could result in flea emergence. It was found that where nests were piled one on top of the other with intermittent disturbance an average yield of 3500 fleas/nest was recorded, ($\times 7$ yield). However, where nests were left carefully undisturbed (Plate 2F) for storage periods ranging between 30 and 60 days from the time the nests were put above the sweep to the time they were scraped into the sweep's cage (45–75 days *post*

Table 1. *The 1st and 2nd emergence yields of nests removed 15 days after littering and stored without disturbance above a 'sweep' rabbit for varying intervals of time (to collect 1st emergence yield) before being scraped out into the 'sweep' rabbit cage (to collect 2nd emergence yield)*

No. of nests	Time stored undisturbed before scraping (days)	Time *post partum* (days)	$\bar{x}$ yield before scraping 1st emergence	$\bar{x}$ yield after scraping 2nd emergence	$\bar{x}$ total yield
4	30	45	2060	1422	3485
2	42	57	750	2100	2850
2	48	63	1972	2550	4522
2	54	69	1288	2826	4114
3	56	71	3018	2066	5084
1	58	73	2505	4250	6755
2	60	75	3412	1750	5162
$\bar{x}$			2165	2161	4237

partum), first and second emergence yields were similar with a total average yield in excess of 4000 fleas/nest ($\times 8$ yield, see Table 1).

Harvesting fleas

Fleas were combed from sweep rabbits in a flea collector consisting of a tray with 0·25 m sides, a bottom sloping to an orifice with a screw fitting leading into a 1 oz McCartney bottle and a weldmesh floor to support the rabbit during combing. Plate 3A, B. The flea collector was painted white. To separate the fleas from hair and other debris the McCartney bottle when removed from the flea collector was emptied into a Mules-type flea trap (Mules 1940; Plate 3C) from which fleas were collected in a small measuring cylinder (Plate 3D). Flea numbers were estimated from their volume on a scale of 1000 fleas/ml (see Sobey *et al.* 1974).

DISCUSSION

Probably the most important factor in breeding rabbit fleas is to breed healthy rabbits, the life-cycle of the flea being so intimately dependent on the breeding cycle of the rabbit. The ability of fleas to breed appears to decrease with storage at 1 °C and to obtain high and consistent yields it was found best to use freshly emerged fleas, or fleas which had been stored on a rabbit, for seeding pregnant does. To achieve the optimal storage of 2nd emergence fleas the nest trays, after the removal of the doe and her kittens, must be kept undisturbed.

The method of breeding fleas described above leaves plenty of scope for improvement and there is little doubt that yields well in excess of 3500–4000/nest could be achieved. We have on occasions had individual nests yielding in excess of 10 000 fleas. Apart from optimizing such things as seeding rate, temperature and humidity it is likely that experiments involving the addition of dried blood, urine and pheromones to nests and the use of appropriate hormones at the right time would significantly increase yield.

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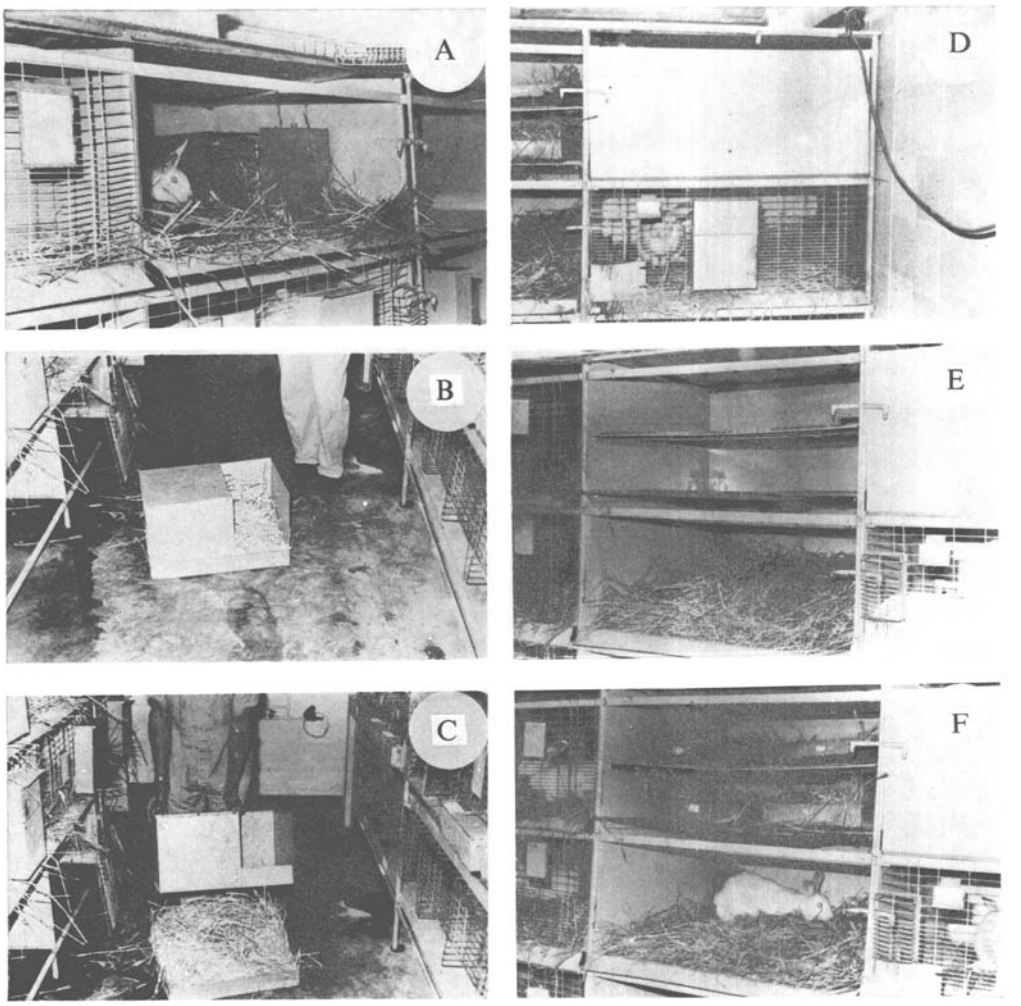

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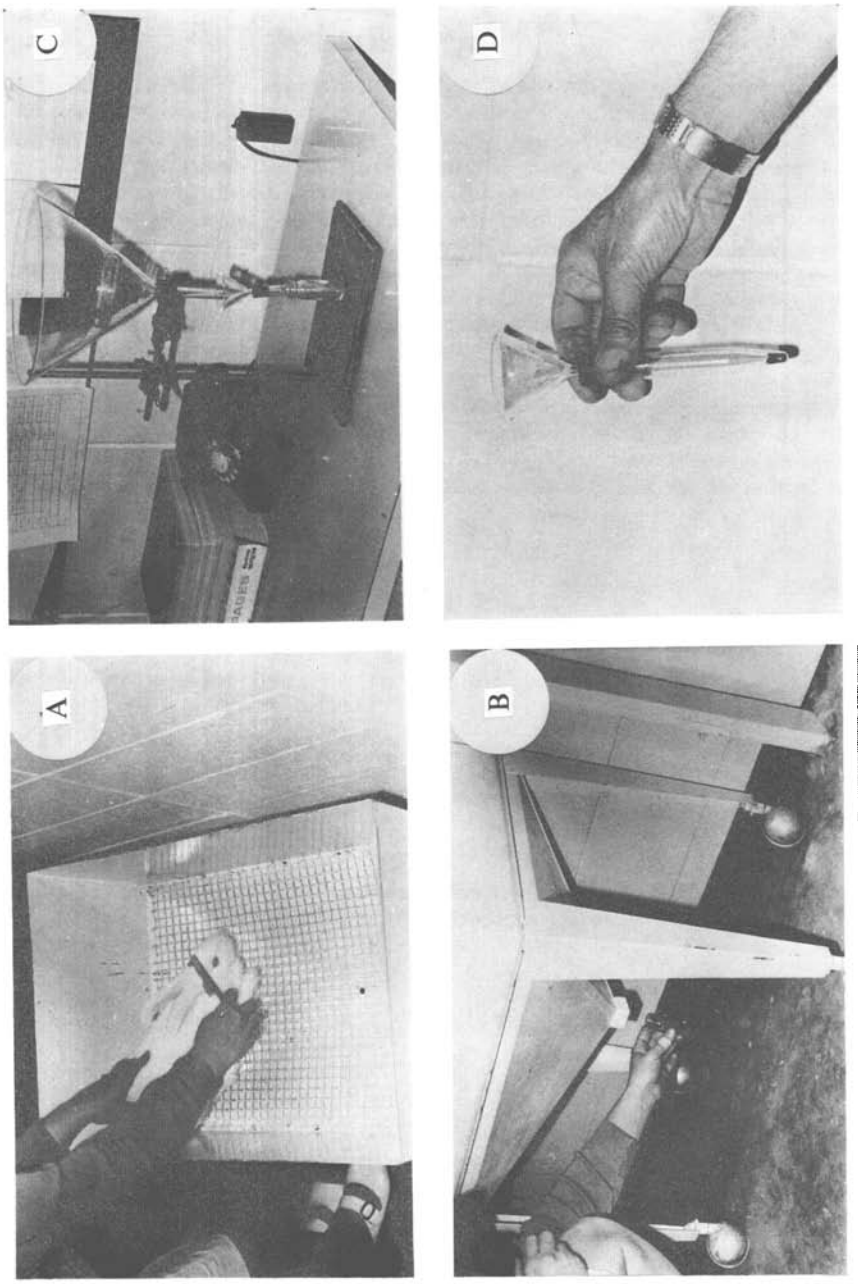

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EXPLANATION OF PLATES

PLATE 1

The various components of breeding cages and how they were assembled.

PLATE 2

(A–C) The nest-box with a removable tray bottom. (D–F). The storage of nest-trays above a sweep rabbit. The metal shield shown in C was to prevent fleas jumping out onto the floor.

PLATE 3

(A, B) A flea collector used when combing fleas from a sweep rabbit. (C) A Mules-type flea trap to separate the fleas from fur and debris after combing. (D) Measuring flea volume in a graduated tube to estimate numbers.