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Myxomatosis: the emergence of male and female European rabbit fleas *Spilopsyllus cuniculi* (Dale) from laboratory cultures

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SUMMARY

The sex ratios and the emergence patterns of the European rabbit flea bred under animal house conditions were examined. An overall preponderance of female fleas was found. This was due to the greater preponderance of female fleas in the primary emergence, whereas the sex ratios in the secondary emergence were about 1:1.

INTRODUCTION

European rabbit fleas *Spilopsyllus cuniculi* (Dale) were introduced from the United Kingdom as vectors for myxomatosis (Sobey & Menzies, 1969). In Victoria fleas were introduced first for experimental purposes (Shepherd & Edmonds, 1976) and later on a large scale. The large numbers of fleas required for these widespread field releases were bred at the Keith Turnbull Research Institute under animal house conditions.

The emergence period of fleas under these conditions may last up to 140 days and fleas from any emergence period were released in the field. Differences in the emergence patterns of male and female fleas could have resulted in an imbalance of sex ratios and consequently poor flea breeding. The emergence patterns were therefore investigated to ensure there were sufficient numbers of each sex in each batch of fleas released.

METHODS

The methods used to breed the fleas were similar to those described by Sobey, Menzies & Conolly (1974) and Sobey, Conolly & Menzies (1977).

Each doe was seeded with approximately 500 fleas. The doe and kittens were removed from the nest 15 days after littering and the nest material containing the developing larvae and pupae was placed on a rack above a sweep rabbit. Fleas were combed off the sweep rabbit daily and stored in a refrigerator at 1 °C until they could be sexed and counted. When emergence apparently stopped the nest material was scraped into the cage with the sweep rabbit. Fleas which emerged after this disturbance were also combed off the sweep rabbit. Fleas which emerged

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Table 1. *The sex ratios (range and mean) of adult* S. cuniculi *emergence over* 1 *year*

Doe	No. of nests	No. of fleas		Sex ratio	
		Range	Total	Range	Mean
A263	1	961:1191	961:1191		0·81:1
A07	1	3200:3365	3200:3365		0·95:1
A204	3	1809:2010; 2103:2332	5914:6439	0·90:1–0·95:1	0·92:1
White	3	393:413; 2905:3239	5544;6192	0·88:1–0·95:1	0·90:1
A65	3	628:726; 954:1071	2414:2834	0·80:1–0·89:1	0·85:1
Dutch	3	1702:1957; 3035:2884	6890:7081	0·87:1–1·05:1	0·97:1
T009	3	231:376; 2430:2734	3009:3515	0·57:1–0·93:1	0·86:1
A233	4	705:762; 3704:3924	8626:9152	0·86:1–1·03:1	0·94:1
F140	4	346:467; 1228:1373	3355:3603	0·74:1–1·16:1	0·93:1
T216	4	697:837; 2956:2969	6942:7255	0·83:1–1·11:1	0·96:1
X001	4	316:436; 1156:1535	2813:3384	0·73:1–1·01:1	0·83:1
X005	4	475:480; 1241:1410	3688:4170	0·85:1–0·99:1	0·88:1

without disturbance are referred to as 'primary emergence' fleas and fleas which emerged following disturbance as 'secondary emergence' fleas.

All fleas were sexed by eye.

RESULTS AND DISCUSSION

Fleas were sexed and counted from one nest of each of two does, from three nests of five does and from four nests of five does, giving a count of 37 nests from 12 does.

Primary emergence fleas began to emerge from the undisturbed nests about 15 days after littering and their numbers usually peaked between day 20 and day 35. Fleas sometimes emerged in small numbers for up to 110 days after littering. However, in most nests very few fleas emerged after day 80 and very few fleas emerged from nine nests after day 45.

Secondary emergence fleas usually began to emerge the day the nest material was disturbed (in one case the nest material was stored for 31 days after the primary emergence was complete and then disturbed). Peak emergence lasted for about 4 days only and numbers then fell sharply. Emergence could last up to 40 days but was usually complete after 20 days.

The emergence patterns for male and female fleas were consistent during both primary and secondary emergence. Both sexes were present in each daily collection and female fleas usually slightly outnumbered male fleas.

The sex ratios expressed as male:female are shown in Table 1. The doe A263, which was used only once, showed a highly irregular and very short pattern of flea emergence, with a ratio of 0·81:1, one of the lowest. The other doe used once, A07, produced the largest number of fleas with a ratio of 0·95:1, similar to the overall ratio of 0·92:1.

The sex ratio ranged from 0·57:1 to 1·16:1. Sex ratios from nests of one doe were generally similar, e.g. X005 produced a ratio of 0·85:1–0·99:1 and A204

Table 2. *The sex ratios of adult fleas according to the month of littering*

Season littered	No. of nests examined	Mean ratio of male:female fleas	Range
Summer	7	0·96:1	0·85:1–1·16:1
Autumn	7	0·90:1	0·73:1–0·99:1
Winter	10	0·90:1	0·57:1–1·05:1
Spring	13	0·92:1	0·80:1–1·1:1

Table 3. *The sex ratios of primary and secondary emergences of* S. cuniculi

		Sex ratio			
		Primary emergence		Secondary emergence	
Doe	No. of nests	Range	Mean	Range	Mean
A263	1		0·63:1		0·95:1
A07	1		0·91:1		0·99:1
A204	3	0·75:1–0·89:1	0·82:1	1·01:1–1·1:1	1·03:1
White	3	0·82:1–0·87:1	0·82:1	0·98:1–1·14:1	1·05:1
A65	3	0·66:1–0·95:1	0·77:1	0·98:1–1·24:1	1·06:1
Dutch	3	0·74:1–1·01:1	0·93:1	1·03:1–1·31:1	1·14:1
T009	3	0·48:1–0·93:1	0·89:1	0·85:1–0·92:1	0·88:1
A233	4	0·79:1–0·99:1	0·92:1	0·87:1–1·39:1	0·98:1
F140	4	0·78:1–0·92:1	0·83:1	0·77:1–1·03:1	0·98:1
T216	4	0·77:1–1·01:1	0·96:1	0·91:1–1·07:1	0·99:1
X001	4	0·65:1–0·83:1	0·71:1	0·67:1–1·2:1	1·03:1
X005	4	0·74:1–0·93:1	0·84:1	0·87:1–1·1:1	0·92:1

0·90:1 twice and a range from 0·90:1 to 0·95:1. The greatest range was found with the doe T009, 0·57:1–0·93:1. The lowest ratio found was 0·57:1.

Both the highest and lowest ratios were found in nests which produced low numbers of fleas. The high ratios occurred during the autumn and winter (Table 2). However the number of nests counted was too small to do more than indicate a possible seasonal variation in sex ratio in low-producing nests.

The sex ratios were examined as primary and secondary emergence fleas (Table 3). There was generally a greater preponderance of female fleas in the primary emergence than in the secondary emergence. The ranges were 0·48:1–1·01:1 and 0·67:1–1·39:1 respectively. The ratios 0·48:1 from the primary emergence of doe T009 and 0·67:1 from the secondary emergence of doe X001 were from low producing nests. T009 was the only doe to produce a higher mean ratio in the primary emergence than in the secondary emergence (Table 3).

The sex ratios were examined to see if there were any variations according to the buck used (Table 4). There was no apparent buck influence although highest and lowest ratios were found with the buck F058.

Most workers have found a preponderance of female fleas in field collections. Shaftesbury (1934) collected several species of fleas in North Carolina. He found ratios of 0·61:1 for *Pulex irritans*, 0·15:1 for *Echidnophaga gallinacea*, 0·40:1 for *Ctenocephalides felis*, and 0·52:1 for *C. canis*.

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Table 4. *The sex ratios of adult fleas according to the buck used for each mating*

Buck number	No. of times used	Range of ratios
A260	2	0·93:1–1·03:1
T61	2	0·87:1–1·01:1
T355	2	0·88:1–0·89:1
T014	2	0·90:1–0·99:1
T209	2	0·89:1–1·10:1
A72	3	0·94:1–1·05:1
A186	3	0·86:1–1·02:1
T28	3	0·87:1–0·95:1
F058	3	0·57:1–1·17:1

Shaftesbury (1934) and McCoy & Mitzmain (1909) found different sex ratios for *Xenopsylla cheopsis* and *Nosopsyllus fasciatus* collected from North Carolina. These were respectively 0·46:1 and 0·33:1 for *X. cheopsis* and 0·32:1 and 1·16:1 for *N. fasciatus*. Haas & Dickie (1959) reported collecting more female than male *Cediopsylla simplex* and *Odontopsylla multispinosus*. The ratios were 0·66:1 and 0·7:1 respectively. Amin (1976) reported that the ratios of *Megabothris acerbus* from chipmunks was 1:1 whereas with *Orchopeas howardii howardii* on grey squirrels the ratio changed with the seasons. Shepherd & Edmonds (1979) reported ratios of 0·56:1 for *E. myrmecobii* and 0·65:1 for *E. perilis* with a slight difference in the ratios for fleas found on male and female rabbits.

There is no evidence in this study that the preponderance of females in the primary emergence is the result of earlier emergence of females as suggested by Hirst (1924).

The fairly consistent higher sex ratio in the secondary emergence may help explain some of the data presented by Mead-Briggs, Vaughan & Rennison (1975) in their study of the seasonal variations of European rabbit flea numbers in the United Kingdom. They found a marked preponderance of female fleas on adult rabbits during August and September (0·67:1 and 0·76:1) but not during October and November (0·96:1 and 1·28:1). There was a less marked preponderance of female fleas on juvenile rabbits (4–10 months old) during August and September and a preponderance of male fleas by November, the ratio changing from 0·91:1 to 1·53:1.

During August and September, after the breeding season, the adult rabbits would probably still be carrying mainly primary emergence fleas, the juvenile rabbits would be carrying some primary emergence fleas, and some secondary emergence fleas collected from the nest material in which they were littered. The marked increase in the sex ratio by November may coincide with the renewal of warren and stop cleaning prior to the commencement of the breeding season, and the resulting emergence of the secondary emergence fleas.

In Scotland, Allan (1956) also found that female European rabbit fleas were more numerous than males. His graphs indicate that the sex ratios for October and November were lower than those reported by Mead-Briggs *et al.* (1975). The

variations from 1:1 in the sex ratios found during this study were not wide enough to make necessary any changes in the techniques of flea release in the field. The numbers of fleas used at each release point were selected to allow for flea losses and the allowance was more than sufficient to cover the very slight probability that fleas released at any point would be of one sex only.

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