

## Population Dynamics of *Mus musculus* and its Parasites in Mallee Wheatlands in Victoria During and After a Drought

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### Abstract

The population dynamics and parasite fauna of wild mice in mallee wheatlands were monitored every 6th week from November 1982 to November 1983. Endo- and ectoparasites were examined in 355 mice sampled from three habitats: farm buildings, crops, and surrounds of permanent water. Presence of ectoparasites was independent of that of endoparasites. Number of parasite species and prevalence of infection were lowest in summer, a period of severe drought. Post drought, seasonal differences in the number of parasite species were not significant but prevalence of parasite infection increased significantly. Prevalence and mean intensity of infection varied for each parasite species. Prevalence of many species differed with habitat, both within and between seasons. Generally, reasons for these differences were not clear. The prevalence and intensity of parasitism was independent of mouse population density.

### Introduction

Populations of *Mus musculus* erupt at irregular intervals to produce 'mouse plagues' in the mallee wheatlands of north-west Victoria (Plomley 1972; Saunders and Giles 1977). Lack of parasites has been suggested as being important for the population increases leading to a plague (Saunders and Giles 1977), and the presence of diseased mice has been reported during the decline from plague numbers (Newsome and Crowcroft 1971). However, nothing is known of the role parasites play in the regulation of mouse numbers in wheatlands because there have been no systematic studies of the parasite fauna of wild populations of house mice in Australia.

A broad spectrum of parasites has been recorded from *M. musculus* throughout the world (Hsu 1982; Weisbroth 1982; Wescott 1982) but only a proportion of these are recorded from the house mouse in Australia (Mackerras 1958). The few overseas studies of mouse parasites have been directed generally at single parasite species (reviewed by Sage 1981) or a single parasitized organ (e.g. Lewis and Bryant 1976; Isaak 1983; Sukhdeo and Mettrick 1983).

This report details the population dynamics of *M. musculus* and its parasites in three mallee wheatland habitats in north-west Victoria between November 1982 and November 1983.

### Methods

#### Study Area

The majority of mice were trapped on wheatlands within a 15-km radius of Walpeup in the Victorian Mallee (Fig. 1). Central mallee soils are principally yellowish brown sands and sandy loams; in this region wheat, barley and sheep are farmed extensively. In 1982 the annual rainfall of 110 mm (32.7% of long-term average) was the lowest ever recorded (1911-83) for the central mallee, and the severe year-long drought eventually broke in autumn 1983. The 1983 annual rainfall was 388 mm (114.7% of long-term average).

### Sampling Procedures

#### (i) *Mus musculus*

Mice were live- or snap-trapped in three habitats: farm buildings, standing crop or stubble, and within 50 m of permanent water (town water supplies, farm dams surrounded by natural vegetation). These sites were chosen because mice commonly occur in these habitats in the study area, and they include habitat features, such as water or domestic animals, which may be important in the life history of parasite species. Live-trapped mice were weighed (in grams), measured from tip of snout to distal margin of anus (in millimetres), and examined for breeding condition. Males with scrotal testes were classified as in breeding condition, and those with abdominal testes as in non-reproductive condition (Lidicker 1966; DeLong 1967; Singleton 1983). Female uteri were classified as thread, string, cord or containing embryos. The presence of uterine scars, and whether or not females were lactating, were also recorded. Snap-trapped mice were not measured and breeding condition of males was not recorded. Indices of abundance of mice in each habitat and an estimate of breeding season were obtained from concurrent studies of the population dynamics of mice at the Mallee Research Station, Walpeup, and from a survey of mice at 57 different sites in the central mallee region (Singleton, unpublished).

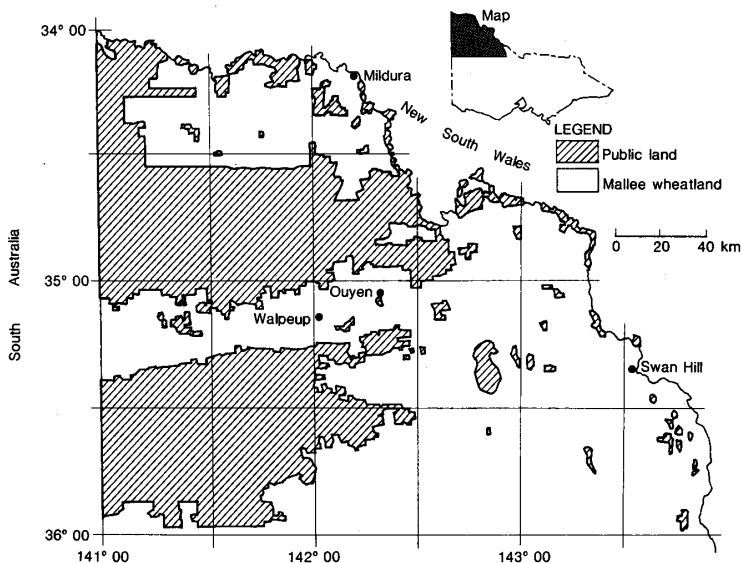


Fig. 1. Map of the study region and of the distribution of mallee wheatlands in north-west Victoria.

#### (ii) Parasites

A total of 355 mice were examined for parasites. Whenever possible, a sample of at least 15 mice per habitat was collected every 6th week.

Mice live-trapped in the field were anaesthetized with ether vapour in sealed plastic bags, shaken vigorously to dislodge ectoparasites, then killed. A thin blood film was prepared and fixed in methanol, and then ectoparasites and mice were stored frozen. Mice snap-trapped were stored frozen. In the laboratory, each carcass was thawed and examined under a stereomicroscope for ectoparasites, then skinned and the skin, lips, tongue, oesophagus, lung, liver, stomach, small intestine, large intestine and nasal passages examined for endoparasites.

Blood films were stained with Giemsa (Humason 1979, pp. 227–8) and examined under a compound microscope for nematode and protozoan parasites. Ecto- and endoparasites were fixed in 70% ethanol; nematodes were cleared in lactophenol and cestode scoleces were mounted in glycerine for identification.

All parasites were counted except the cestode *Hymenolepis fraterna* and the myobiid mites *Radfordia affinis* and *Myobia murimusculi*. In the former case, some scoleces remained embedded in the mucosa and strobilae were an inaccurate estimate of intensity of infection. The extremely abundant mites were not identified

to species under the stereomicroscope. Consequently a pooled index of intensity (mites per carcass) of these two mite species was calculated from a transect count along both sides of the carcass from snout to anus.

Quantitative terms used in this paper follow Margolis *et al.* (1982). Prevalence refers to the percentage of mice infected by a particular parasite species. Mean intensity refers to the mean number of individuals of a particular parasite species per infected mouse.

Representative specimens of all parasite species are deposited in the parasite collection, Division of Wildlife and Rangelands Research, CSIRO, Canberra (see Table 1).

#### Statistical Analyses

##### (i) *Mus musculus*

The abundance indices were determined by dividing the number of mice known to be alive per trapping period by the number of trap-nights, then multiplying by 100 to provide an index per 100 trap nights. For comparisons of mean body weights, *t*-tests were used, or approximate *t*-tests where variances were significantly different (Sokal and Rohlf 1969, p. 374).

##### (ii) Parasites

Samples were pooled by season on account of the small number of mice examined for parasites every 6th week. Significant relationships ( $P < 0.05$ ) between prevalence and host weight, host sex, season and habitat (both within and between seasons) were determined where possible by  $\chi^2$  analysis. Differences in intensity of infection due to host weight, host sex, season and habitat (plus interactions) were examined by correlation analysis (assigning dummy variates to the latter three categories) and multiple linear regression analysis.

For helminths, the frequency distribution of the number of parasite species per carcass was compared to a Poisson distribution for each season.

The association between endoparasites (nasal mites, blood protozoa and helminths) and ectoparasites (myobiid mites and fleas) in the host population was examined by  $\chi^2$  analysis. An estimate of the expected number of hosts infected with both ecto- and endoparasites, given an independent association between these types of parasitism, was determined by multiplying together the frequency of occurrence of endo- and ectoparasites in the host population and then multiplying by the total number of hosts.

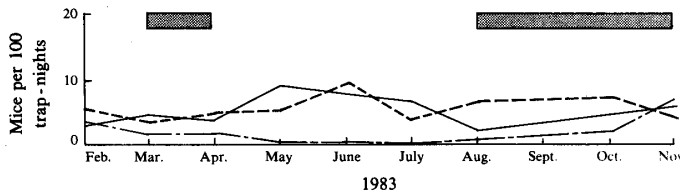


Fig. 2. Mouse abundance in three mallee wheatland habitats. --- Farm buildings. -.-.- Crops or stubble. — Permanent water. Shaded bar represents extent of breeding season.

## Results

### Mouse Dynamics

Few mice were collected in the summer of 1982–83 (six mice caught from 1600 kill-traps and 21 from 250 live-traps in January 1983). Mouse density remained low in all three habitats during February–November 1983. Maximum densities, about 9.5 per 100 trap-nights, occurred in farm buildings and around permanent water during early winter; by contrast, density was near zero in the crops (Fig. 2).

Breeding began at the Mallee Research Station study site in August 1983, when more than 33% of females with a head-body length  $> 72$  mm were pregnant or lactating. A similar level of breeding continued through to November 1983 but the trappable population did not begin to increase appreciably until midsummer 1983–84 (Singleton, unpublished).

Sex ratios of mice examined for parasites were not significantly different between seasons (the percentage of females ranged from 43 to 50).

Within seasons differences in body weight between the sexes were not significant. All between-season differences in mean mouse weight (sexes pooled) were significant (spring,  $17.8 \pm 0.49$  (SE); winter,  $16.4 \pm 0.44$ ; summer,  $14.0 \pm 0.50$ ; autumn,  $12.44 \pm 0.51$ ). The  $t$ -values for the summer-autumn and winter-spring comparisons were  $t_{138} = 2.10$  ( $P < 0.05$ ) and  $t_{191} = 2.14$  ( $P < 0.05$ ), respectively.

**Table 1.** Prevalence and intensity of parasite infections of *Mus musculus* in mallee wheatlands of Victoria, November 1982–November 1983

Parasite species	Accession No.	No. of hosts examined	Prevalance (%)	Intensity (mean $\pm$ SE)
<b>Acarina</b>				
<i>Myobia murismusculi</i>	AR120			
<i>Radfordia affinis</i>	AR121			
<i>M. murismusculi</i> + <i>R. affinis</i>		328	93.9	49.2 $\pm$ 6.37
<i>Paraspeleognathopsis bakeri</i>	AR122	355	0.3	—
<i>Echinonyssus butantanensis</i>	AR123			
<i>Myocoptes musculus</i>	AR124			
<i>Eulaelaps</i> spp.	AR125			
<i>Mesolaelaps australiensis</i>	AR128			
<i>E. butantanensis</i> , <i>M. musculus</i> , <i>Eulaelaps</i> , <i>M. australiensis</i>		98	39.8	3.6 $\pm$ 0.64
<b>Siphonaptera</b>				
<i>Nosopsyllus fasciatus</i>	AR126			
<i>Nosopsyllus londiniensis</i>	AR127			
<i>N. fasciatus</i> + <i>N. londiniensis</i>		98	36.7	2.2 $\pm$ 0.30
<b>Cestoda</b>				
<i>Hymenolepis fraterna</i>	C405	355	7.0	
<i>Taenia taeniaeformis</i> (metacestode)	C431	355	5.3	1.3 $\pm$ 0.16
<b>Nematoda</b>				
<i>Aspiculuris tetraptera</i>	N2259	355	6.2	69.6 $\pm$ 23.78
<i>Syphacia obvelata</i>	N2260	355	67.0	37.9 $\pm$ 3.92
<i>Muspicea borreli</i>	N2078	355	1.7	4.5 $\pm$ 2.00
Protozoa	—	122	0	—

### Parasite Dynamics

#### (i) Total distribution of parasites

Prevalence and intensity of infection of the five helminth and nine arthropod (one internal; eight external) parasites recovered are listed in Table 1. The record of the nematode *Muspicea borreli* is the first for this parasite since its original naming (Sambon 1925) and subsequent redescription from France (Brumpt 1930).

A total of 337 mice were examined for both ecto- and endoparasites; 244 had both classes of parasite, which did not differ significantly from the expected frequency (EF) of 236.7 ( $\chi^2_1 = 0.76$ ,  $P > 0.30$ ). Among mice examined from crops and stubble ( $n = 135$ ), 95 (EF 96.0) had both classes of parasite. Of mice caught near farm buildings ( $n = 106$ ) and near permanent water ( $n = 96$ ), 77 (EF 72.0) and 72 (EF 68.8) respectively had both classes of parasite. None of these differences were significant.

Significant habitat differences in the number of helminth species (0, 1 or  $\geq 2$  helminths) occurred in winter only ( $\chi^2_4 = 12.59$ ,  $P < 0.05$ ) (Table 2). Also, the number of parasite species was significantly lower in summer (habitats pooled) ( $\chi^2_3 = 12.17$ ,  $P < 0.01$ ).

The frequency distribution of helminth species departed significantly from a Poisson distribution within each season. More mice than expected were infected with one helminth species (Table 2). When the most common helminth parasite (*S. obvelata*) was removed from the analysis, seasonal occurrence of helminth parasites closely followed a Poisson distribution (Table 2).

**Table 2.** Frequency of occurrence of mice with 0, 1, 2, 3 or 4 helminth species by season and habitat separately, combined, and adjusted by exclusion from the analyses of *S. obvelata*, the commonest parasite

Calculated Poisson frequencies in parentheses; probability is the significance of the difference between these and the observed frequencies

Season $\times$ habitat	Sample size	Frequency with No. of parasite species:					Probability
		0	1	2	3	4	
<b>Summer</b>							
Crop	32	11	21	0	0	0	
Water	44	18	25	1	0	0	
Buildings	14	6	7	1	0	0	
Combined	90	35 (47.9)	53 (30.2)	2 (9.5)	0 (2.0)	0 (0.3)	<0.001
Adjusted	90	81 (81.4)	9 (8.1)	0 (0.4)	0 (0.0)	0 (0.0)	NS
<b>Autumn</b>							
Crop	37	9	28	0	0	0	
Water	10	4	3	3	0	0	
Buildings	21	3	15	3	0	0	
Combined	68	16 (29.1)	46 (24.7)	6 (10.5)	0 (2.9)	0 (0.6)	<0.001
Adjusted	68	60 (60.3)	8 (7.2)	0 (0.4)	0 (0.0)	0 (0.0)	NS
<b>Winter</b>							
Crop	40	12	26	2	0	0	
Water	16	0	10	5	1	0	
Buildings	45	10	26	8	1	0	
Combined	101	22 (38.3)	62 (37.1)	15 (18.0)	2 (5.8)	0 (1.4)	<0.001
Adjusted	101	78 (75.6)	17 (21.9)	6 (3.2)	0 (0.3)	0 (0.0)	NS
<b>Spring</b>							
Crop	29	4	25	0	0	0	
Water	37	7	22	6	1	1	
Buildings	30	5	19	5	1	0	
Combined	96	16 (34.6)	66 (35.1)	11 (18.0)	2 (6.1)	1 (1.5)	<0.001
Adjusted	96	75 (74.0)	18 (19.2)	2 (2.5)	1 (0.2)	0 (0.0)	NS

(ii) *Prevalence and intensity of infections*

*Seasonal and habitat differences in the helminths.* *S. obvelata* was the only helminth recorded in every habitat throughout all seasons (Fig. 3). There were no significant correlations between the log of intensity of *S. obvelata* infections and host weight, host sex, habitat, or season. None of the regression analyses of the log of intensity of *S. obvelata* infections accounted for a significant part of the variance. In winter the prevalence of *S. obvelata* in mice was significantly higher near permanent water than in other habitats ( $\chi^2_2 = 6.89$ ,  $P < 0.05$ ). For these mice, but not for those in other habitats, there was also a significant difference in prevalence of *S. obvelata*

between seasons ( $\chi^2_3 = 11.3$ ,  $P < 0.05$ ). Seasonal differences (habitats pooled) in the prevalence of *S. obvelata* were significant ( $\chi^2_3 = 10.29$ ,  $P < 0.05$ ). Prevalence of infection increased from the dry summer through the wet autumn-to-spring period (Fig. 3).

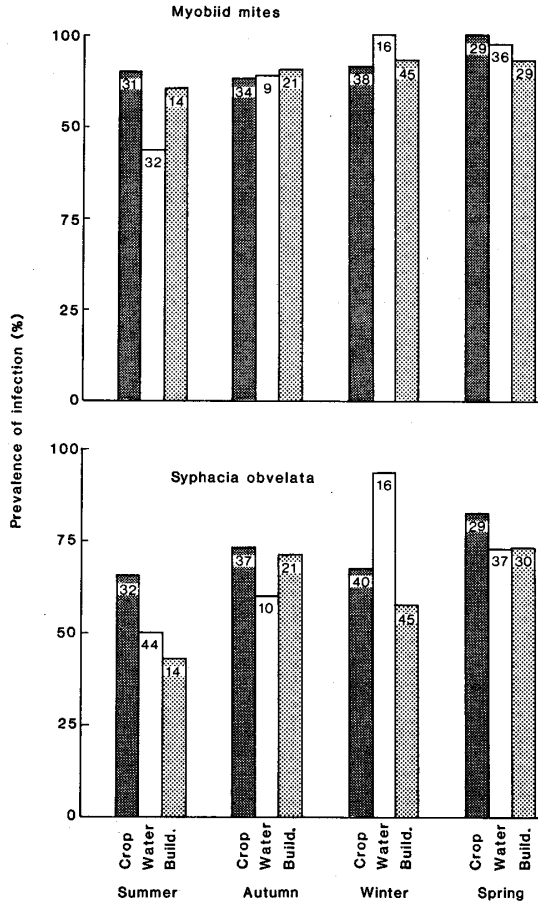


Fig. 3. Prevalence of infection of the myobiid mites *R. affinis* and *M. murismusculi*, and the nematode *S. obvelata*, for each combination of habitat and season. Sample sizes are shown in the columns.

- The prevalence of infection for other helminths was low but the following trends were apparent:
- (1) *A. tetraptera* occurred in mice ( $n = 22$ ) in all seasons, but 50% of infections were recorded in winter. It was more prevalent (81.6%) in mice caught near farm buildings.
  - (2) Prevalence of *H. fraterna* in mice ( $n = 25$ ) was similar in all seasons but higher (64.4%) near permanent water.
  - (3) *T. taeniaeformis* infections were most common in winter (63%) and no infections were recorded in summer. Mice infected with *T. taeniaeformis* ( $n = 19$ ) were recorded only around farm buildings (63%) and near permanent water (37%).
  - (4) *M. borreli* was found in six mice; five near permanent water and one near farm buildings.

*Season and habitat differences in the arthropods.* There were no significant correlations between the log of intensity of myobiid mite infections and host weight, host sex, habitat or season. None of the regression analyses of the log of intensity of myobiid mite infection accounted for a significant part of the variance. There were no significant differences in prevalence of myobiid mites between habitats. Seasonal differences (habitats pooled) in prevalence were significant ( $\chi^2_3 = 17.9$ ,  $P < 0.01$ ) and there was an increase in the number of infected mice from the dry summer through the wet autumn-to-spring period (Fig. 3).

### Discussion

In the mallee wheatlands of north-west Victoria the prevalence and mean intensity of endoparasite infections varied for each parasite species during a year when mice were consistently low in abundance in the three habitats surveyed. The number of endoparasite species was lowest in summer and highest in winter. Together, the above suggest that variation in the number of parasite species and in prevalence and mean intensity of infection of each parasite species was independent of mouse population density.

Fluctuations in the number of parasite species may have been related to changes in rainfall and food availability. Numbers of species were lowest in the 1982–83 summer, during the last months of a severe, year-long drought. Drought-breaking rains in early autumn led to prolific growth of grasses in late autumn and early winter. The seeds of these grasses provided a food source for mice.

Saunders and Giles (1977) suggested that droughts lead to a reduction in survival of parasites both in the host, due to greater mortality of infected individuals, and in the environment. Drought-breaking rains of autumn 1983 may have initiated new infections and lessened the selection against hosts carrying parasite infections, resulting in the increased numbers and prevalence of parasites found post-drought.

The presence of ectoparasites on mice was independent of that of endoparasites. This association was consistent in all three habitats. A similar relationship was reported by Whitaker (1970) in a sample of mice ( $n = 470$ ) in Vigo County, Indiana. This relationship may be independent of prevalences of ecto- and endoparasites, which were only 27.7% and 21.7% respectively in Vigo County but 91.4% and 76.9% respectively in the Victorian mallee.

Seasonal differences in prevalence of infection within and between habitats were apparent in each of the endoparasite species. These differences were independent of host density. The respective life histories of the endoparasites do not explain the seasonal and habitat differences, with the exception of *T. taeniaeformis*, a tapeworm of the domestic cat *Felis catus*. *T. taeniaeformis* utilizes mice as intermediate hosts and its presence only in mice resident near farm buildings and areas of permanent water (such as town water supplies) probably reflects habitat utilization by cats. Personal observations of cat distribution in the study region support this view. The absence of *T. taeniaeformis* in the summer sample may reflect the poor viability of taeniid eggs during the drought. Under conditions of low humidity and reasonably high temperatures, few taeniid eggs survive for longer than 7 days (Coman 1975).

The nematodes *S. obvelata* and *A. tetraptera* have direct life cycles, and embryonate *in utero* (Wescott 1982). Thus the effect of external climatic factors on egg development may be minimal. Consequently, seasonal climatic factors *per se* may not be responsible for the seasonal differences observed in prevalence of infection of each of these nematode species. A study of variation in the prevalence of *A. tetraptera* infection in wild mice highlighted differences in age structure and sex ratios of the host (Behnke 1975, 1976). These factors, plus the possibility that prior exposure to *S. obvelata* may provide some protection against infection with *A. tetraptera* (Stahl 1966), may be responsible for the variation in prevalence of *A. tetraptera* recorded in the current study. The effect of age structure could not be assessed but there was no sex bias in the 22 infected mice.

The life cycle of the cestode *H. fraterna* may be direct or indirect. It is not clear why the majority of infections occurred in mice near permanent water, nor why prevalence of infection was extremely low in mice living in paddocks.

The lowest prevalence of myobiid mite infection occurred in summer, possibly due to the drought conditions, though it is difficult to understand why these occurred in mice caught near permanent water. Identification of the other ectoparasites commenced in the latter part of the study and sample sizes did not warrant detailed analysis. However, the data indicate the diversity of the ectoparasitic fauna, and their prevalence and intensity of infection of mice in the mallee wheatlands of Victoria.

The number of parasite species and the prevalence and intensity of helminth infections in *M. musculus* throughout this study was much lower than that described in *Antechinus stuartii*, a native mammal of similar size (Beveridge and Barker 1976). The difference may reflect habitat dissimilarity in the two studies, i.e. semiarid wheatland and wet sclerophyll forest, respectively. There are no comparable studies in semiarid Australia of parasites of mammal species similar in size to mice. The best comparison is a study of nematode parasites in wild rabbits, *Oryctolagus cuniculus*. Dunsmore and Dudzinski (1968) reported the number of nematodes recovered from rabbits from subalpine, temperate, subtropical, and semiarid habitats. Prevalence and mean intensity of infection was lowest in the semiarid site and highest in the subalpine site. Similar trends in parasites of mice would account for the low indices of parasite abundance and diversity observed in the present study. Future research should examine the impact of climate and habitat on the distribution and abundance of mouse parasites, because mice, like rabbits, are distributed throughout most of eastern and southern Australia.

Intensity of parasite infection in wild vertebrates is frequently characterized by an over-dispersed distribution of parasite numbers per host, where a small proportion of the host population harbour the majority of the total parasite population (Anderson 1978). This was not observed in the present study, which assessed changes in parasite fauna only during a period of low host abundance. Over-dispersion may occur when host density increases. Mouse populations occasionally erupt in the study area and a plague is predicted during the summer and autumn of 1984-85 (Redhead 1983). Future research is directed at an examination of host-parasite relationships during the period of eruption and subsequent decline of a mouse population. Of particular interest will be the role parasites may play in host population regulation.

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