Aust. Wildl. Res., 1977, **4**, 241–7

A Relationship between Plagues of the House Mouse, *Mus musculus* (Rodentia: Muridae) and Prolonged Periods of Dry Weather in South-eastern Australia

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Abstract

A review was conducted of literature relating to plagues of the house mouse in three agricultural regions of south-eastern Australia for the period 1900–70. Meteorological data, particularly in relation to rainfall, was surveyed during the same period. The two sets of data indicated that in each region plagues of the house mouse were preceded by drought conditions. The role of mouse predators and disease agents are discussed as possible explanations of this relationship.

Introduction

Plagues of the introduced house mouse, *Mus musculus*, have occurred periodically throughout south-eastern Australia. Many of these plagues have been localized in the agricultural areas only, but some have been severe and widespread. One such outbreak in the summer of 1969–70 affected New South Wales, Victoria and South Australia. This plague caused considerable damage to grain crops and stored grain (Ryan and Jones 1972).

Field populations of the house mouse reach maximum numbers in the late summer and autumn, as the mice do not breed in the field during the winter months (Newsome 1969*a*; Berry 1970). A seasonal increase in mouse numbers may not be considered as a plague until the mice become conspicuous and troublesome by invading houses and storage sheds.

Various factors have been found to limit the size of field populations of the house mouse. Below-average temperatures during the winter may limit the size of the overwintering population (Pearson 1963; Berry 1968). In contrast, the breeding season may be extended if the autumn is warm and wet, increasing the numbers (De Long 1967). A large mouse population, which has eaten its available food supply (Newsome and Crowcroft 1971) or experiences an outbreak of disease (Murnane 1934), may be suddenly reduced in number. Also, competition with other small mammals may inhibit the survival of a population to the stage where it becomes extinct (Lidicker 1966), and predators are capable of reducing the size of a population over a large area (Pearson 1966).

Only one field study of the house mouse has been carried out in Australia (Newsome 1969*a*, 1969*b*). From this study, Newsome concluded that a mouse population could erupt only if good rain fell the previous winter and spring, the summer was hot enough to crack the soil and provide suitable burrowing conditions, and there was sufficient midsummer rain to keep the subsoil damp, to prevent desiccation of the mice and to provide an adequate feed supply.

Table 1. Droughts in winter and spring (June–November) and mouse plagues, 1900–70

+ Drought year. — Non-drought year. * Mouse plague. A plague lasting from early summer into autumn is entered under both calendar years, and distinguished by)

Year	Northern N.S.W.		Southern N.S.W.		Northern Victoria	
	Winter–spring drought	Mouse plague	Winter–spring drought	Mouse plague	Winter–spring drought	Mouse plague
1900	+		—		+	
1901	+		+		+	
1902	+		+		+	
1903	—	*)	—	*)	—	*)
1904	—	*)	—	*)	—	*)
1905	+	*	—	*	—	*
1906	—		—		—	
1907	—		+		+	
1908	—		+		+	
1909	—		—		—	
1910	—		—		—	
1911	+		+		+	*
1912	—		—		—	
1913	+		+		+	
1914	+		+		+	
1915	+		—		—	
1916	—	*)	—	*)	—	*)
1917	—	*)	—	*)	—	*)
1918	+		+		+	
1919	+		+		+	
1920	—		—		—	
1921	—		—	*)	—	
1922	+	*	+	*)	+	*
1923	—		—		—	
1924	—		—		—	
1925	—		+		+	
1926	+		+		+	
1927	+		+		+	
1928	+		+		+	
1929	+		+		+	
1930	—		+		—	
1931	—		—		—	*)
1932	—	*	—	*	—	*)
1933	—		+		—	
1934	—		—		—	
1935	—		—		—	
1936	+		—		—	
1937	+		+		+	
1938	—		+		+	
1939	+		—		—	
1940	+		+	*	+	*
1941	+		+		—	
1942	—		—		—	
1943	+		—		+	
1944	—		+		+	
1945	+		+[A]		—	
1946	+		+		+	
1947	—		—		—	*
1948	—	*	—	*	—	

Table 1 (*Continued*)

Year	Northern N.S.W.		Southern N.S.W.		Northern Victoria	
	Winter–spring drought	Mouse plague	Winter–spring drought	Mouse plague	Winter–spring drought	Mouse plague
1949	—		—		—	
1950	—		—		—	
1951	—		—		—	
1952	—		—		—	
1953	+		—		—	
1954	—		—		—	
1955	—		—		—	
1956	—		—		—	
1957	+		+		+	
1958	—		—		—	
1959	+		+		+	
1960	—		—		—	
1961	—		—		+	
1962	—		—		—	
1963	—		—		—	
1964	+		—		—	
1965	—		—		—	
1966	—		—		—	
1967	+		+		+	
1968	—		—		—	
1969	—	*)	—	*)	+	*)
1970	—	*)	—	*)	—	*)

[A] Rainfall during this period was insufficient to break the drought (Foley 1957).

While we agree that Newsome's criteria must be satisfied before a mouse plague can occur, there appear to have been many years in which the above conditions were met in some areas of New South Wales, but in which there were no mouse plagues. This apparent anomaly led us to examine the timing of mouse plagues in relation to weather conditions in preceding seasons for three agricultural regions of south-eastern Australia. The results of this examination for the years 1900–70 are presented here.

Methods

The occurrence of mouse plagues was determined by a search of the relevant literature (Cleland 1918; Wood Jones 1923; Le Souëf *et al.* 1926; Osborne 1932; Finlayson 1939; Elton 1942; Corr 1970; Newsome and Crowcroft 1971; Ryan and Jones 1972). To supplement this, a search was conducted of two major newspapers, the Melbourne *Argus* and the *Sydney Morning Herald*, for the years 1900–70. The contents indices of these newspapers were obtained from the Mitchell Library of New South Wales.

A review of droughts in Australia by Foley (1957) was used to determine objectively the rainfall patterns from 1900 to 1955. Foley defined 'drought' and 'non-drought' seasons by consideration of the cumulative deviation of monthly rainfall from the mean of that month over the period from the earliest years of settlement to 1955. To obtain the average monthly rainfall deficiency for each geographical region, he pooled rainfall records from a specified number of meteorological stations in each area. From this information he constructed cumulative rainfall deficiency graphs to describe the actual rainfall patterns over several geographical regions.

In the present paper we examined data from the following regions, described by Foley (1957): (1) northern wheat belt of New South Wales, represented by five weather stations; (2) southern wheat belt of New South Wales, represented by five weather stations; (3) wheat belt or Mallee of northern Victoria, represented by 10 weather stations.

To extend rainfall data from 1955 to 1970, we followed Foley's procedure for these three regions. Rainfall records were not available for one of the meteorological stations used by Foley in northern New South Wales, and two of the stations in southern New South Wales; data for six of the stations in northern Victoria were not obtained.

To investigate any relationship between rainfall patterns and the occurrence of mouse plagues, each 'winter–spring' period (June–November) was classified as drought or non-drought. Drought periods were considered to be those with a below-average cumulative deficiency in rainfall over the 6-month period, and non-drought periods were considered to be those with rainfall that was average or above.

Results

All mouse plagues to which a reference was found are listed in Table 1, with the occurrence of drought winter–spring periods for northern New South Wales, southern New South Wales and northern Victoria between 1900 and 1970. Table 2 indicates the relationship between the eruption of mouse plagues and the occurrence of drought preceding each plague for the three geographical areas. It should be noted that on some occasions the number of non-drought winter–spring periods between a drought and a mouse plague differed from the actual number of years which passed. For example, the plague of 1932 in northern New South Wales was preceded by drought winter–spring periods ending in 1929. However, the drought actually did not break until June 1930, and the mouse plague erupted in the early months of 1932, so there were only two non-drought winter–spring periods (1930, 1931) separating them.

It is obvious that in the three areas studied there was a strong tendency for plagues to follow a prolonged or severe drought over two or more winter–spring periods, but separated from it by one or two good winter–spring periods. There are exceptions to this generalization. The most prominent are the plagues of summer and autumn 1969–70. These were preceded by only one drought winter–spring, but this drought lasted for 12 months and was extremely severe. At many places in south-eastern Australia rainfall in the year 1967 was the lowest on record (Bureau of Meteorology 1968).

Four times there have been droughts over two or more winter–spring periods which were not followed by a mouse plague within two years. The first of these was in 1907–08 in southern New South Wales. However, a drought in the same years in northern Victoria was followed by a mouse plague in 1911. The drought of 1936–37 was not followed by a mouse plague in northern New South Wales, but was in southern New South Wales and northern Victoria. In 1939–41, two or more successive drought winter–springs, in both southern and northern New South Wales, were not followed by mouse plagues within two years. In both areas 1939–45 was virtually a continuous drought, with occasional good falls of rain (Table 1). There were no recorded outbreaks of mice following these partial breaks, but in all three agricultural areas mouse plagues followed within two years of the drought breaking completely in 1946 (Table 2).

From the data there is considerable evidence to substantiate the hypothesis that mouse plagues follow a prolonged or severe drought over two or more winter–spring periods and then only after one or two good winter–spring periods. For the three areas studied, each plague since 1900, with the exception of those in 1969–70, would have been predicted. Similarly, there was a plague each time a prediction would have been made except on two occasions in both northern and southern New South Wales.

The data is regarded as not suitable for statistical analysis as the occurrence of droughts in the three areas cannot be regarded as independent events nor can that of mouse plagues. Also, the number of mouse plagues and droughts within each area are inadequate for analysis.

Table 2. The relationship between mouse plagues and droughts
Minimum duration of the droughts is 12 months

Mouse plague years	Period of rainfall deficiency: Years and months	Mean monthly deficiency (mm)	Duration (months)	Non-drought winters before plague: No.	Years
		Northern New South Wales			
1903–04	Aug. 1900–Mar. 1903	19·08	31	1	1903
1905					
1916–17	Apr. 1911–Apr. 1916	8·72	60	1	1916
1922	Feb. 1918–Jan. 1920	21·50	28	2	1920, 1921
1932	June 1926–Oct. 1927	17·44	16	2	1930, 1932
	May 1928–June 1930	14·72	25		
1948	Feb. 1943–Jan. 1944	13·62	23	2	1947, 1948
	Sept. 1945–Aug. 1946	22·89	12		
1969–70	Dec. 1966–Dec. 1967	15·70	12	2	1968, 1969
		Southern New South Wales			
1903–04	Feb. 1897–Dec. 1902	15·90	70	1	1902
1905					
1916–17	June 1913–May 1915	27·50	23	2	1915, 1916
1921–22	Sept. 1918–June 1920	19·62	21	2	1920, 1921
1932	May 1928–Aug. 1930	16·35	27	2	1930, 1931
1940	Feb. 1937–Feb. 1939	17·89	24	1	1939
1948	Dec. 1943–June 1945	22·99	18	1	1947
	Apr. 1946–Oct. 1946	22·99	7		
1969–70	Dec. 1966–Dec. 1967	24·38	12	2	1968, 1969
		Northern Victoria			
1903–04	Sept. 1900–Dec. 1902	15·47	27	1	1903
1905					
1911	Dec. 1906–Apr. 1909	7·74	28	2	1909, 1910
1916–17	June 1913–May 1915	15·02	23	2	1915, 1916
1922	Sept. 1918–June 1920	13·65	21	2	1920, 1921
1931–32	Apr. 1928–July 1930	12·29	27	2	1930, 1931
1940	Feb. 1937–Feb. 1939	13·65	24	1	1939
1947	Dec. 1942–June 1945	15·47	30	2	1945, 1946
1969–70	Dec. 1966–Mar. 1968	19·00	15	2	1968, 1969

Discussion

As a method of predicting the likely occurrence of mouse plagues in south-eastern Australia, the use of their association with prolonged droughts shows considerable promise. Widespread and severe mouse plagues in New South Wales and Victoria since 1900 have always been preceded by a drought of at least 12 months. In fact, in all cases except 1969–70, all plagues were preceded by two consecutive drought winters. Only four times were droughts involving two or more consecutive drought winters not followed by mouse plagues. For the first of these, it is conceivable that plagues did occur but either references were not located in the literature search or the plagues were not severe enough to warrant a mention in local reports. These conjectures are backed up by the reported occurrence of mouse plagues in other areas following the same two droughts.

The reason for the apparent association between mouse plagues and preceding droughts is not clear. One possible explanation is that predator populations, which are usually capable of keeping mouse populations in check, decline during prolonged droughts because of food shortage and then lag behind their prey in recovery after the drought. The view of the predator as an effective influence on fluctuations of rodent populations is a conventional one, which has been hypothesized and demonstrated on a number of occasions (Pearson 1964, 1966; Krebs and Myers 1974).

During the plagues of three rodents (*Rattus villosissimus*, *Notomys alexis* and *Mus musculus*) in central Australia between 1967 and 1969, Newsome and Corbett (1975) reported a marked increase in the abundance of the dingo *Canis familiaris*, the European fox *Vulpes vulpes*, the feral domestic cat *Felis catus*, the letter-winged kite *Elanus scriptus* and the barn owl *Tyto alba*. Although numbers were not estimated, we observed a marked and widespread increase in the abundance of the black-shouldered kite *Elanus notatus*, and the barn owl, in New South Wales during the summer of 1969–70. These two birds are known predators of mice (Frith 1969). Our observations indicate that the black-shouldered kite is still (1976) far more abundant than it was before 1969. Foxes and feral cats are also currently abundant; these are known to prey on mice (Coman and Brunner 1972; Coman 1973; Ryan and Croft 1974).

If predation on an overwintering mouse population reduced the numbers of adults at the beginning of the breeding season, the population would increase only slowly during summer and autumn, thus substantial population peaks might not occur before breeding ceased in the following winter. Also, a substantial mouse population in spring would favour the survival of predators born then. These, with their food requirements increasing with age, would maintain predation pressure on the mouse population.

Another possible explanation for the association between droughts and mouse plagues may be through pathogens and parasites. Firstly, dry conditions reduce the chance of survival of most parasites and pathogens in the environment. Secondly, a drought would cause a decline in mouse numbers, affecting the weaker, diseased mice preferentially. At the end of a drought, the surviving mice may be relatively immune to infection by pathogens and parasites from the environment or from other mice. This would allow the population to increase, with a reduced mortality, when the weather conditions become favourable. Predators and disease agents are clearly not the only agents limiting mouse populations. Although they provide a partial explanation for the relationship between mouse plagues and droughts, much more work is needed before we can confidently interpret such an association.

The relationship of mouse plagues with prolonged periods of dry weather could prove extremely useful for making control recommendations and initiating forms of crop protection. Predictions by this method may be incorrect, but, presumably, a mouse plague is preceded by a period of relative abundance in the spring and early summer. Thus, an assessment in likely plague years of the status of mouse populations in crops and other refuge areas should help to refine the prediction.

Acknowledgments

The authors would like to thank Dr G. Robards for his assistance in the preparation of this manuscript, Mr G. Ryan for having read and criticized it, and to the Wheat Industry Research Council for providing financial assistance.

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Manuscript received 4 April 1977