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Myxomatosis: the occurrence of antibody to a soluble antigen of myxoma virus in wild rabbits, *Oryctolagus cuniculus* (L.), in Victoria, Australia

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SUMMARY

The occurrence of antibody to myxoma virus in wild rabbits following epizootics is highest in the semi-arid north-west of Victoria and lowest in temperate southern Victoria. Occurrence ranges up to about 90% in the north-west and to about 70% in the south except on the Western Plains where epizootics are rare and antibody occurrence seldom exceeds 30%.

The establishment of the European rabbit flea may be changing the pattern of occurrence of antibody in the north-west by causing spring outbreaks of myxomatosis. It is suggested that the effects of the replacement of a simple recurring system of epizootic and breeding season several months apart by the occurrence of myxomatosis twice in the same year, once coincident with the breeding season, will be complex. The occurrence of detectable antibody may be less dependent on the infection rate and may be dependent to some extent on the relative timing of spring myxomatosis and the breeding season.

INTRODUCTION

The immune response of the rabbit, *Oryctolagus cuniculus* (L.) to infection with myxoma virus includes the production of antibodies to several soluble antigens produced during virus replication (Fenner & Ratcliffe, 1965). The presence of these antibodies in wild rabbits has been used as an indication of the occurrence and intensity of myxomatosis outbreaks especially since the description of a simplified technique for testing antibodies to the 'd' antigen (Sobey, Conolly & Adams, 1966).

Testing of blood samples for the 'd' antigen and for antibody to it began in Victoria in 1967. Collections have been made from about 30 sites, before and after the occurrence of myxomatosis outbreaks when possible. Monthly collections have been made at Pine Plains in the Mallee region since 1971. This paper reports the results of this testing and discusses the implications of inter-regional variation in antibody occurrence.

MATERIALS AND METHODS

Collection of rabbits

Several batches of rabbits were collected alive and brought to the Institute. However most rabbits were collected by shooting in the field.

Blood samples

Blood from shot rabbits was collected on strips of filter paper which were dried and stored in a refrigerator. Whole serum samples were also collected from some rabbits in each batch and from all rabbits taken alive to the Institute.

Serological testing

The simplified technique of Sobey, Conolly & Adams (1966) was used for samples collected on filter paper. Sera were tested by double diffusion in agar (Mansi, 1957).

RESULTS AND DISCUSSION

The data are presented in regional groupings in Table 1.

In northern Victoria (Mallee, Wimmera and Northern regions) where the mean annual rainfall ranges from 250–500 mm there is a consistent pattern of low antibody occurrence following the regular spring breeding season and very high antibody occurrence following the regular myxomatosis epizootic. The highest occurrence in a large sample (97 %) was recorded from the semi-arid Mallee region. However the annual maximum at Pine Plains in the Mallee region (Table 2) was about 85 % and this is probably representative of the 250–350 mm rainfall area. Data from north-eastern and central Victoria are similar except that the percentage of rabbits with antibody following the breeding season was lower than in the drier regions. This is probably the result of higher mortality in adult rabbits, which had survived the preceding epizootic, during and after the breeding season.

In the 1000 mm rainfall region of north-eastern Victoria antibody occurrence ranged from 11 to 68 % but there is some evidence (Edmonds *et al.* 1976) that wide local variations occur which are related to environmental changes, mainly from farmland to forest. Farmland rabbit populations undergo fairly intense epizootics with consequent high antibody occurrence. Myxomatosis in forest clearing populations is much less intense and antibody occurrence peaks are lower.

The data from south-eastern Victoria show a very low percentage of rabbits with antibody after the breeding season, and lower post-epizootic peaks. The general pattern is however similar to the pattern in north-eastern and central Victoria.

The pattern on the Western Plains is quite different. The antibody occurrence fluctuates around 25 % with little evidence of sharp increases or decreases (Tighe *et al.* 1977). Our collection with 40 % occurrence probably resulted from a localized outbreak of myxomatosis.

The inter-regional variation in antibody occurrence reflects the differences in epidemiology imposed by climate and vectors. Myxomatosis in northern Victoria has been characterized by short but intense epizootics in every year in which rabbit

Table 1. *The occurrence of antibodies to myxoma virus in wild rabbits* Oryctolagus cuniculus (*L.*) *in Victoria*

(Number tested, % with antibody, and minima and maxima %.)

		Pre-epizootic			Post-epizootic	
Region	Number	Per cent with antibody	Minimum % recorded	Number	Per cent with antibody	Maximum % recorded
Mallee	405	18	9	308	81	97
Wimmera	145	24	18	187	82	85
Northern	145	25	17	93	72	83
North-eastern	69	13	11	112	75	84
Western Plains*	186	24	16	—	—	40
Central	253	14	12	200	71	82
South-eastern	405	9	8	131	60	68

* Epizootics occur rarely and no post-epizootic data have been collected.

Table 2. *The occurrence of antibodies to myxoma virus in wild rabbits* Oryctolagus cuniculus (*L.*) *at Pine Plains in the Mallee region of Victoria*

(Number tested and % with antibody.)

Month	1971		1972		1973		1974		1975		1976	
Jan.	197	30*	N.C.		72	47*	87	62	N.C.*		N.C.*	
Feb.	N.C.*		15	32*	11	70*	46	77*	8	100	21	70*
Mar.	24	56*	19	42*	8	63	21	81*	12	100	51	70*
Apr.	20	85*	44	81*	11	73	23	52	18	82	29	90
May	176	81	22	82*	25	75	35	34	78	88	8	75
June	N.C.		68	75	30	70	22	73	48	45	63	55*
July	31	32	41	68	63	35	45	77	43	42	45	33
Aug.	209	24	70	72	78	42	56	41	73	23*	49	81
Sept.	52	10	32	39	61	19*	44	17	42	45*	51	75
Oct.	60	15	46	35	19	67*	75	34*	84	25*	85	16*
Nov.	33	15*	142	24	N.C.		10	70*	42	33	34	32*
Dec.	39	13	50	20*	49	73*	32	73*	90	12	93	26*

N.C. = no collection made. * Myxomatosis observed.

breeding has provided sufficient susceptible rabbits. When these intense mosquito-borne epizootics occur in a large population most susceptible rabbits are infected.

In central and south-eastern Victoria the infection rate in the most severe epizootics is usually less than 80 %. This suggests that mosquito vectors are the limiting factor in central and southern Victorian epizootics.

The effect of the absence of efficient vectors is shown on the open wind-swept Western Plains where the common mosquito vectors occur in very low numbers (Tighe *et al.* 1977). Under these conditions myxomatosis rarely occurs as an epizootic but is present almost continuously as a low intensity disease in a largely susceptible population. In consequence antibody occurrence is consistently low.

The sequential data from Pine Plains in the Mallee region (Table 2) showed the typical semi-arid region pattern in 1971, 1972 and 1973 when the percentage of

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rabbits with detectable antibody rose to about 80% each summer-autumn. The extent to which these increases were the result of the myxomatosis epizootics alone is not definitely known.

The increases can be correlated with epizootics which were observed in mid-December 1971, in late February 1972 and in late November 1972. They could be the result of infection of most of the population, including restimulation of the antibody response in old rabbits, and of the loss from the population of rabbits without antibodies, i.e. high mortality from causes other than myxomatosis in the rabbits born during the preceding breeding season (Shepherd, Edmonds, Nolan & Gocs, unpublished data). This point will be discussed in detail elsewhere.

In October 1973 the pattern of antibody occurrence changed when the first observed spring outbreak of myxomatosis occurred in the area in which the European rabbit flea *Spilopsyllus cuniculi* was being established (Shepherd & Edmonds, 1976). Increases in antibody occurrence in the late winter or spring have been observed in each subsequent year but the time and degree of increase have varied. The time of increase is probably dependent on the presence of sufficient young rabbits to carry an outbreak of myxomatosis and the presence of enough rabbit fleas to act as vectors. The degree of increase may be limited by the occurrence of maternal antibodies in the young rabbits.

The significance of maternal antibodies depends on the length of time between the recovery of the does from infection and the breeding season, i.e. on the antibody titre in the does, and on the length of time between the birth of the kittens and the subsequent epizootic.

Before 1973 the combination of regular summer–early autumn epizootics and peak breeding during the later winter–spring resulted in a period of several months between the recovery from infection of the does and breeding, and a period of at least three months between birth of most kittens and infection. Under these conditions the titre of antibodies in the does was low (Williams, Dunsmore & Sobey, 1973) and hence the titre of maternal antibodies in the kittens was low. The already low titre in the newborn kittens then decreased to insignificance before the kittens were infected (Fenner & Ratcliffe, 1965).

Although there is no evidence that there has been any change in the time of the summer epizootics or of the breeding season other than the normal response to climatic variation, and therefore no shortening of the period between the recovery of the doe from summer infection and the breeding season, the occurrence of spring myxomatosis means that some does will be littering about one year after recovery from infection. The titre of maternal antibodies in their kittens will depend on whether or not the antibody response in the does was restimulated in the following summer or in the current spring. There is therefore likely to be a wide range in the antibody titres in the does at breeding.

The occurrence of spring myxomatosis implies that some kittens may be infected while the titre of maternal antibodies is significant. In some kittens the effects may be accentuated by an unusually high titre of maternal antibodies at birth. These kittens may show no antibody response when collected and tested several weeks after birth although they have in fact been infected, and the infection rate in the preceding outbreak may be underestimated.

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