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The Effect of Drought on Road Mortality of Macropods

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Abstract

Road-kills of eastern grey kangaroos, *Macropus giganteus*, and swamp wallabies, *Wallabia bicolor*, were monitored during and after the severe 1981–83 drought in central Victoria, Australia. These were compared with a survey of the same area prior to the drought. The frequency of road-kills of both species during the drought was higher than pre-drought and post-drought levels, and over 9 years the seasonal frequency of kangaroo road-kills was inversely related to the rainfall of the previous season. Road-kills of kangaroos were predominantly males, and almost half were juveniles.

Introduction

Drought has been shown to reduce population density of kangaroos (Caughley *et al.* 1984; Caughley *et al.* 1985; Bayliss 1985, 1987). This response reflects the combined effects of declining female reproductive success (Kirkpatrick and McEvoy 1966; Newsome 1966; Shepherd 1987) and increasing mortality of the subadult and adult population (Robertson 1986; Norbury *et al.* 1988) due to malnutrition. There is some evidence that mortality due to road-kills may also increase during droughts: a 5-year study (Coulson 1982) of factors influencing the frequency of macropod road-kills suggested a relationship between seasons of poor rainfall and peaks of mortality of eastern grey kangaroos, *Macropus giganteus*. I continued monitoring of this site during and after the severe 1981–83 drought to test this hypothesis.

Method

The study site was the same 20-km section of the Northern Highway in central Victoria, Australia, surveyed in the previous study (Coulson 1982). Surveys resumed in December 1981 after a hiatus at the end of the earlier study in January 1980. The road was surveyed from a vehicle 51 times at irregular intervals and at various hours in daylight. During the drought period (December 1981–March 1983), the sampling effort of 17·3 surveys per year was close to the lowest annual survey effort of 15 per year in the previous study. Less intensive sampling (9·1 surveys per year) was continued between June 1983 and February 1986.

All macropod road-kills were examined to determine species and sex, and the location was recorded to the nearest 100 m. Skulls from all carcasses were collected and cleaned. Molar index was determined from kangaroo skulls to estimate age in years using Kirkpatrick's (1965) regression for this species. Skulls were also used to determine the sex of badly damaged or decomposed kangaroo carcasses. Kirkpatrick's (1967) relationship between molar index and basal skull length of eastern grey kangaroos was not used as it was found to be inapplicable to this population: females were likely to be mistakenly classed as males because, in animals of known sex, basal length was greater than expected for a given molar index using Kirkpatrick's regression, and some females had a greater basal length than the

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maximum recorded by Kirkpatrick. Instead, skulls were sexed by comparison with others from this population that were of known sex and had equivalent molar indices. Younger animals could not be sexed reliably.

Estimated traffic volume at the southern end of the study area increased from a mean of 920 vehicles per day for the period of the previous study to 1171 vehicles per day for 1982–86 ($t=6\cdot11$, 8 d.f., $P<0\cdot001$). Rainfall records at Heathcote, 5 km south of the study area, showed that the area received below-median seasonal rainfall continuously from the spring of 1981 to the summer of 1982–83. The total rainfall for 1982 (256 mm) was equal to the lowest annual rainfall recorded in 104 years.

Results

During the drought period, 30 kangaroos and six swamp wallabies, *Wallabia bicolor*, were found as road-kills. Of these, 11 kangaroo carcasses were extensively decomposed and, as they were not readily visible from the road, may have died before the drought. These were excluded from analyses that required the month of death to be known. The other kangaroos and all wallabies were either freshly killed or, if decomposed, were readily visible and could not have been missed on previous surveys; thus they were certain to have been killed during the drought period. In the post-drought period no wallabies were recorded, but 12 additional kangaroo road-kills were found, and 10 of these definitely occurred in that period.

Because the survey effort was not constant over time, two measures of road-kill rate were used: kills per year and kills per survey. Neither measure was ideal because carcasses did not remain visible from the road indefinitely. The rate at which carcasses persisted would affect the two measures differently. If it were low then kills per survey would be the more sensitive measure and a greater survey effort would be expected to yield more kills; if it were high then kills per year would be the less biased measure provided that some minimal survey effort were made. The actual longevity of carcasses was not known, but observations suggested that some carcasses were removed soon after death (Coulson 1982) while others remained *in situ* and decomposed.

Table 1. Two measures of the frequency of road-kills of eastern grey kangaroos and swamp wallabies recorded before, during and after the 1981–83 drought near Heathcote, central Victoria

Pre-drought data were taken from Coulson (1982); n.s., not significant; $^{*}P<0\cdot01$; $^{**}P<0\cdot001$

Time	Kills per year				Kills per survey			
	Kangaroos			Wallabies	Kangaroos			Wallabies
Pre-drought	4·88			1·42	0·19			0·06
		}*				}**		
Drought	12·67		}n.s.	4·00	0·73		}n.s.	0·23
		}**				}n.s.		
Post-drought	3·64			0·00	0·30			0·00

Table 1 compares the rate of road-kills that definitely occurred in the drought and post-drought periods with the rates from the previous study. Expressed as kills per year, road-kills were significantly more frequent during the drought than in either the pre-drought or post-drought period, which did not differ significantly from each other. A similar trend was evident when road-kill rate was expressed as kills per survey, although there was no significant difference between the drought and post-drought periods. Wallaby road-kills followed the same pattern, but the low frequencies precluded analysis by inferential statistics. The frequency distributions of road-kill rate were highly skewed and had many zeros, precluding tests by parametric statistics. Instead, paired comparisons of time periods were made using χ^2 goodness-of-fit tests of actual frequencies, testing the null hypothesis that observed frequency of road-kills in one period did not differ from the frequency expected if it were equivalent to the kill rate (per year or per survey) in the other time period.

Fig. 1 shows the seasonal rate per survey of the kangaroo road-kills that could be dated with certainty, pooled with equivalent data from table 2 of the previous study (Coulson

1982), and all regressed against the rainfall decile of the previous season. The frequency of kills per year was not used in this analysis because of the disparate survey effort in the two studies. Linear regression revealed a weak but significant inverse relationship between road-kill frequency and rainfall which explained 17·5% of the variance ($y = 1 \cdot 114 - 0 \cdot 122x$, $F = 7 \cdot 432$, 36 d.f., $P < 0 \cdot 001$).

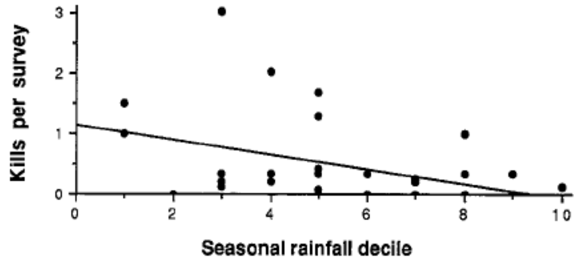

Fig. 1. Seasonal rate of road-kills per survey of eastern grey kangaroos recorded on the Northern Highway near Heathcote, central Victoria, regressed against rainfall deciles for the previous season recorded at Heathcote. The data were pooled over 9 years from Coulson (1982) and the present study.

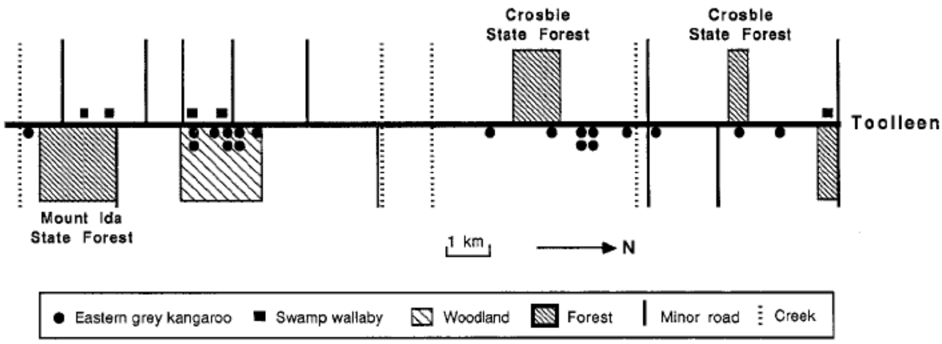

Fig. 2. Schematic map of the 20-km section of the Northern Highway that was surveyed for macropod road-kills, 5 km north of Heathcote, central Victoria. The location and species of road-kills recorded during the 1981–83 drought is shown in relation to the vegetation adjacent to the highway. Cleared pasture (farmland) is indicated by unshaded areas.

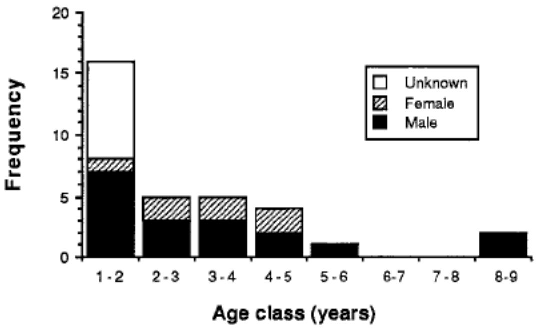

Fig. 3. Age and sex composition of eastern grey kangaroos recorded as road-kills between December 1981 and February 1986 near Heathcote, central Victoria.

During the drought period, 10 kangaroos were found on sections of highway bounded by woodland or forest on one side and farmland on the opposite side, and the remainder were found on sections bounded on both sides by farmland (Fig. 2). All six road-killed wallabies were found where farmland abutted areas of woodland or forest.

Fig. 3 shows the age and sex distribution of the 33 kangaroo road-kills that could be aged from the drought and post-drought periods. A large proportion (48%) of these were juveniles (1–2 years), and the overall sex ratio of 2·6 : 1 (male : female) was significantly different from parity ($P < 0 \cdot 001$) using a χ^2 goodness-of-fit test. Only one (a male) of the six wallaby road-kills could be sexed.

Discussion

The bias towards males in the road-killed kangaroos recorded in this study follows the trend reported in the previous study, but the proportion of juveniles was higher in the present study. In the absence of data on the structure of the population from which these road-kills are drawn, it is impossible to determine whether the predominance of males and of young animals is indicative of variation between age and/or sex classes in their susceptibility to road mortality. However, a bias towards males appears to be a general phenomenon: significantly biased sex ratios in eastern grey kangaroos (3·3 : 1, $n = 34$) and in swamp wallabies (6·5 : 1, $n = 15$) have also been obtained from incidental records of macropod road-kills in other parts of Victoria and southern New South Wales collected between 1976 and the present (unpublished data).

The hypothesis that drought increases the rate of macropod road-kills was supported. The rate of kangaroo road-kills in the drought period was higher than during the 'normal' period of the previous study (Coulson 1982), and a similar trend was evident for wallabies although at a much lower level. An alternative hypothesis worth considering is that the higher traffic volume in the study area may have increased the occurrence of road-kills, as has been reported for swamp wallabies (Osawa 1984) and other species (Sargeant 1981; Allen and McCullough 1976; but see also Case 1978). This hypothesis can probably be discounted since, despite an increase in traffic volume, the rate of road-kills per year returned to near 'normal' levels after the drought. The same trend occurred in the alternative measure of kangaroos road-kill rate and in both measures of swamp wallaby road-kills.

There was a clear response, however, to the rainfall of the previous season when the 9 years of surveys were analysed on a seasonal basis. Finer resolution of this delayed time effect was not possible because of the generally low incidence of road-kills and the irregular survey regime. The effect of rainfall is probably due to modification of normal movement patterns in response to poor feed conditions. Hill (1982) found that eastern grey kangaroos moved out from wooded areas and fed more extensively in open pasture during dry periods. In the present study 47% of kangaroo road-kills occurred away from wooded areas, whereas only 8% were recorded there in the previous study. The grassy roadside reserve may have also attracted macropods, particularly when the surrounding paddocks had been heavily grazed. Osawa (1984) concluded that road-killed swamp wallabies had been attracted to preferred food which occurred mainly beside the road, and similar conclusions have been drawn for other species (e.g. Case 1978; Bashore *et al.* 1985).

The relationship between road mortality and rainfall has implications for the use of road-kills as an index of macropod population density (e.g. Short and Grigg 1982). Any comparison between populations in space or time using a road-kill index should take the potential effects of rainfall into account, because a population that is declining due to drought may, paradoxically, create an impression of increasing density as reflected by a higher frequency of road-kills.

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