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The Effect on Wild Dogs, *Canis f. familiaris*, of 1080-Poisoning Campaigns in Kosciusko National Park, N.S.W.

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Abstract

Nine wild dogs, *Canis f. familiaris*, radio-tracked over periods of 28–61 days in Kosciusko National Park, N.S.W., occupied home ranges of 220–5420 ha (mean 2193 ha). These home ranges were similar in size to those observed for dingoes, *C. f. dingo*, in other areas of south-eastern Australia. The maximum distance that any of the nine dogs moved between successive daily locations was 11·2 km. On the basis of this information and that obtained by others, we suggest that the control of wild dogs on Crown Land in south-eastern Australia should be confined to those areas adjacent to private grazing land. Furthermore, a control zone 12–20 km wide should be adequate.

Two successive trail-baiting campaigns with 1080 poison in March and April 1982 killed only two (22%) of the nine wild dogs carrying radio transmitters. Traps, in comparison, caught 15 out of 27 (56%) of the dogs known to be in the area. The main factors which reduced the success of the poisoning campaign were the rapid loss of toxicity of the baits after their distribution, the rapid rate at which they were removed by other animals, particularly foxes *Vulpes vulpes* and birds, and the dogs' apparent preference for natural prey.

Introduction

Wild dogs *Canis f. familiaris*, dingoes *C. f. dingo*, and their hybrids (hereafter collectively called dogs) are considered by many landholders to be important pests in some areas of Australia because of their attacks on livestock, particularly sheep *Ovis aries*. Their presence in National Parks is also often a controversial matter because of allegations that some dogs move many kilometres out onto adjacent private grazing land at night to attack stock, and then return to the shelter of the Park during the day. In the Southern Highlands of south-eastern Australia attempts at controlling their numbers have frequently included laying meat baits containing 1080 poison along the sides of roads and access trails, including those in National Parks. The effectiveness of this technique has never been assessed, but there is some evidence (McIlroy *et al.* 1986) that it is not very effective, possibly in part due to bait removal by non-target animals. Consequently, we decided to assess the technique by monitoring both the removal of dyed and undyed meat baits by target and non-target animals, and the movements and fate of a sample of the dogs in a National Park during two trail-baiting campaigns. While carrying out this study we also obtained data on the movements and home ranges of some of the dogs present. This information has management implications for the control of wild dogs, particularly those on Crown Land, in south-eastern Australia.

Study Area

The study was carried out near Yarrangobilly Village in Kosciusko National Park, New South Wales (Fig. 1). This area, 20 km south-east of the nearest private grazing land, was

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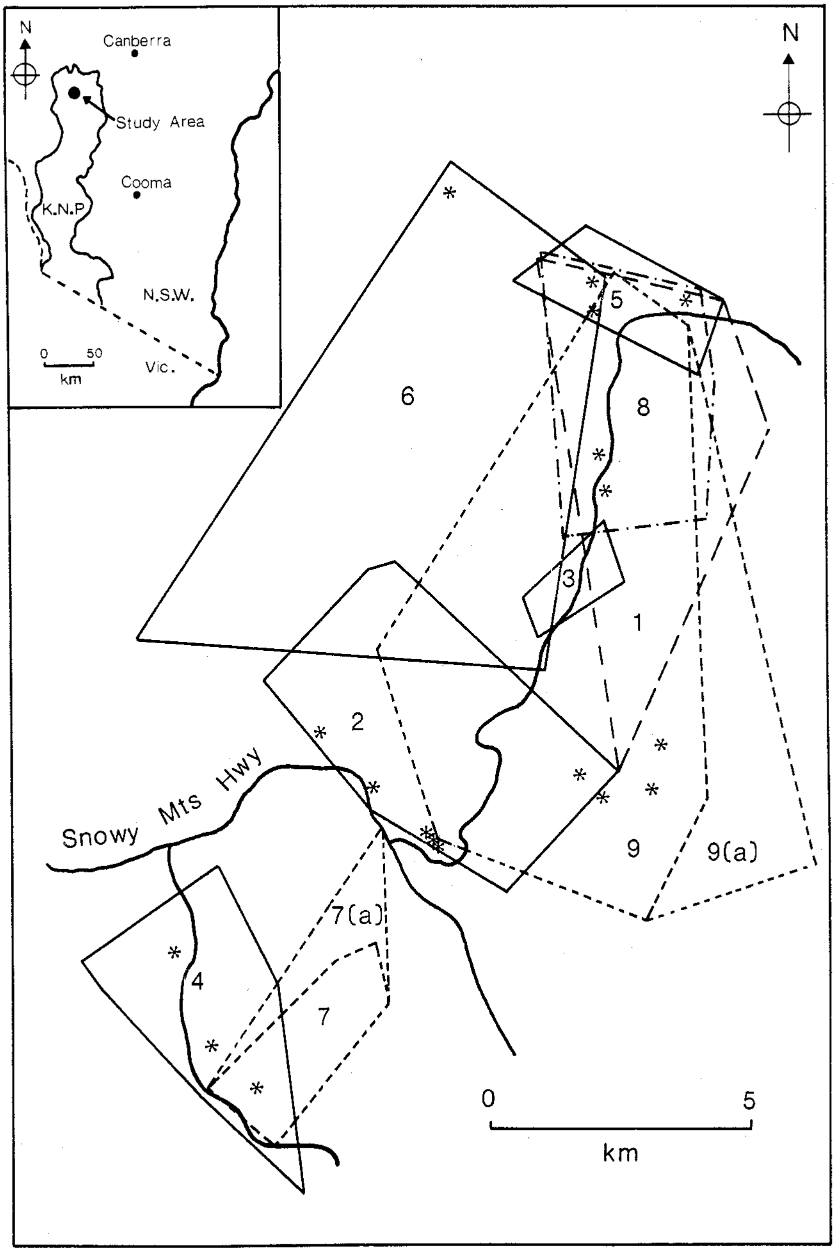

Fig. 1. Home ranges of the nine radio-tracked dogs in the Yarrangobilly study area, Kosciusko National Park. Letters in parentheses indicate subsequent extensions of ranges after the end of the field study. Asterisks mark locations of other dogs seen during the study. The thickest solid lines radiating from the Snowy Mountains Highway represent trails baited.

chosen because a high density of dogs was present, because it provided suitable terrain for radio-tracking studies, and because through it there were bushfire control access trails similar to those regularly baited in peripheral areas of the Park. Habitats in the area included swampy creeks, open grassy flats, partly cleared undulating land, rocky gorges and steep ridges covered with open and tall open forest.

Methods

Trapping

There were two trapping periods, one of 23 days (ending 6 days before the first baiting) to fit radio transmitters to dogs, and a second at the completion of the tracking to recover the transmitters. During these periods, up to 28 Oneida No. 14 jump traps were set each day along the fire trails, at selected sites where dogs were likely to urinate or defaecate. The traps were modified by filing away the interlocking spikes on the jaws, and binding the jaws with muslin cloth, to prevent serious injuries to the dogs. Each trap was attached to a steel post in the ground by a short chain and a coil spring which absorbed the strain when the dog tried to escape (Rowe-Rowe and Green 1981). Dog faeces collected from other areas were used as a trap lure. The traps were checked daily.

Handling of Animals

Trapped dogs were anaesthetised with a mixture of M99 (etorphine hydrochloride) and acetylpromazine (Green 1976). Tritiated water and ^{22}sodium were then injected, and samples of blood taken 3 h later as part of a separate study to measure each dog's food and water requirements (Green 1978). During that time each dog was weighed and described, and a radio transmitter on a collar was attached to it. When these procedures were completed each dog was injected with the antagonist M285 (cyprenorphine hydrochloride) (Green 1976) and left to recover at the site of capture.

Radio-tracking Equipment and Methods

The transmitters used (403 MHz range) were similar to those described by Newgrain and Horwitz (1979). Daily ground searches for each dog were made with a multi-channel receiver and Yagi directional antenna from the top of a vehicle driven slowly along the fire trails and from vantage points such as the tops of hills or ridges. The dog's location was determined by triangulation of two or more bearings. A light aircraft was also used for radio-tracking on six occasions; on the days when baits were laid and when specific dogs had not been located for several successive days. The locations of each dog were plotted on a 1 : 25 000-scale map, and the shape and size of their home ranges determined by the convex polygon method (Macdonald *et al.* 1980). The distances between successive daily locations were measured from the map.

Baiting Details and Bait Removal Studies

One week before bait distribution, the Ranger responsible for wild dog poisoning campaigns in the National Park indicated every spot along the trails where he would lay a bait. To avoid bias in this selection of bait sites, we withheld details of our trapping and radio-tracking results from him until the end of the study. Each of the 160 sites selected along the 25·4 km of trails to be baited was then serially numbered with a peg and, to facilitate identification of the spoor of animals removing the baits, a 1-m^2 plot of ground around it was cleared and raked. Sand was also placed on rocky or stony sites. Other studies have shown that dogs do not avoid disturbed soil (R. J. Burt, personal communication).

The bait used was meat from cattle, cut into approximately fist-sized pieces the day before the baiting and left to drain on wire netting in a refrigerated room for approximately 24 h. The Ranger then injected each bait with 5 mg of 1080 poison in solution. This was the normal loading of technical-grade 1080 used by the National Parks and Wildlife Service at that time for wild dog poisoning campaigns. Finally, the baits were dyed green (a practice adopted by the National Parks and Wildlife Service to reduce the chances of birds eating or removing them) or left undyed, depending on our study requirements, and then distributed along the trails. On 30 March one green-dyed bait (mean ± SE, 227 ± 6 g, range 90–490 g) was placed in the middle of each of the freshly raked sites. Samples of baits were also placed in small-meshed cages for studies of the temporal loss of bait toxicity. These procedures were repeated on 4 April with undyed poisoned meat baits (206 ± 4 g, range 100–335 g). The purpose of this was to see if the dogs would take more baits when foxes *Vulpes vulpes*, which had removed the first baits and been poisoned by them, were no longer removing them. Finally, on 14 April, 55 green-dyed baits and 55 undyed baits were laid at alternate sites along two sections of the trails. These baits were not poisoned and were part of a trial to determine whether birds preferred feeding on undyed or green-dyed baits.

After the baits were distributed we used the fire trails only when radio-tracking and for daily inspections to record the rate of bait removal and identity of the animals responsible. During each inspection we also removed five poison baits from the cages and subsequently measured their 1080 content by a method adapted from that developed by C. L. Batcheler (personal communication). This method measures the fluoride ion concentrations with a specific ion electrode after alkaline digestion of the samples.

Results

Trapping

During the trapping period before the first baiting campaign we caught eight dogs at an average rate of 67 trap-nights per dog: these were a juvenile female, five adult females and two adult males (Table 1). On 30 March, while laying the baits during the first campaign, we found another male dog caught in one of several traps set without our knowledge by someone else. The dog was not badly injured, so it was fitted with a radio transmitter and released. Another six dogs were caught at an average rate of 60 trap-nights per dog near the end of the study when we were attempting to recover the transmitters. All the dogs resembled hybrids as described by Newsome and Corbett (1985), being mainly brindle in colour with either normal long tails or short bobtails.

Table 1. Details of radiotracked wild dogs

Maximum distances are between locations on successive days

Dog No., age and sex	Date of capture	Wt (kg)	No. of days dogs carried radios	No. of locations	No. of days located	Max. distance between successive locations (km)	Home range (ha)
1. Juv. F	19 Mar.	11·7	41	22	20	9·0	2530
2. Ad. F	10 Mar.	16·5	61	40	38	3·4	2300
3. Ad. F	18 Mar.	17·1	34	10	8	1·8	220
4. Ad. F	5 Mar.	15·4	44	20	18	2·4	1260
5. Ad. F	21 Mar.	17·2	31	8	7	2·0	590
6. Ad. F	15 Mar.	15·9	45	16	15	3·0	5270
7. Ad. M	5 Mar.	19·3	28	8	6	1·4	610 (970)[A]
8. Ad. M	30 Mar.	17·4	40	16	13	4·8	1540
9. Ad. M	7 Mar.	19·0	50	22	20	11·2	5420 (6760)[A]

[A] Includes extra location of each dog after field study ended.

Home Ranges

During the radio-tracking period the nine dogs occupied home ranges of 220–5420 ha (mean 2193 ± 648 ha) (Table 1). Home range data consisted of 8–40 locations per dog collected over 28–61 days. Males tended to have larger home ranges than females (i.e. 2523 ± 1474 ha and 2028 ± 747 ha, respectively) but the differences were not significant ($t = 0 \cdot 34$; 7 d.f.). The longest axis of any home range was 12·2 km.

Movements

The average distance between locations ($n = 64$) of dogs on successive days was 2·0 ± 0·3 km. The maximum distances between locations on successive days per dog varied from 1·4 to 11·2 km, and tended to be larger for males (5·8 ± 2·9) than females (3·6 ± 1·1) but the difference was not significant ($t = 0 \cdot 886$; 7 d.f.).

Density and Social Behaviour of Dogs

We trapped or observed a total of 27 dogs in the study area, so the minimum known density was one dog per 560 ha. The structure and composition of the groups of dogs present showed considerable flexibility. Three of the dogs (Nos 1, 5 and 8) were observed together and known to share their home range with five or eight other dogs; two dogs (Nos 2 and 9) were observed together and shared their ranges with seven or fourteen others; two dogs (Nos 4 and 7) were seen together and shared their ranges with one or three others; dog No. 3 shared its range with four others; and dog No. 6 shared its range with nine others.

Dog No. 4's group occupied a clearly separate home range of 2600 ha in the south of the area (Fig. 1), and the other radio-tracked dogs occupied a general area of 11 400 ha to the north. Some of these dogs restricted their activities to the north of this area (e.g. Nos 8 and 5), others were mainly located to the south (e.g. No. 2) or in the centre (e.g. No. 3), and others ranged over much of the area (e.g. Nos 6 and 9).

Bait Removal

During the first poisoning campaign foxes removed the greatest proportion of baits, followed by birds, dogs and pigs *Sus scrofa* (Fig. 2*a*). The birds seen interfering with baits were pied currawongs *Strepera graculina*, Australian ravens *Corvus coronoides*, Australian magpies *Gymnorhina tibicen*, and wedge-tailed eagles *Aquila audax*. Altogether 92% of the baits were removed within the first 4 days and 99% within 21 days. The remainder of the baits were never taken and finally rotted away.

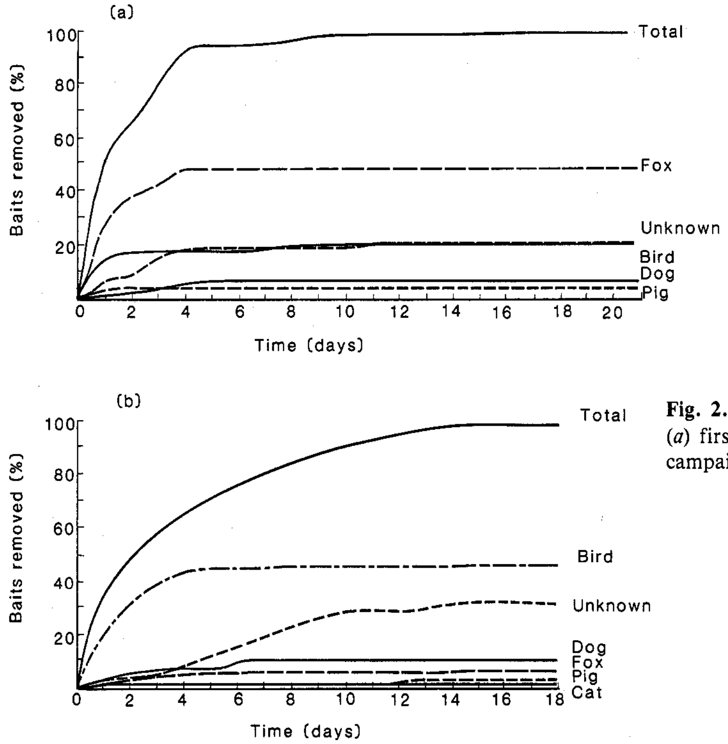

Fig. 2. Rate of bait removal; (*a*) first campaign; (*b*) second campaign.

During the second poisoning campaign birds removed most of the baits, followed by dogs, foxes, pigs and cats *Felis catus* (Fig. 2*b*). The rate of bait removal was initially much slower than in the first campaign, but 99% of the baits had disappeared after 18 days. Once again the remaining baits were not eaten and eventually rotted away.

During the first two campaigns birds pecked at 28 undyed baits compared with 4 dyed baits, and dragged 55 undyed baits, compared with 10 dyed baits, away from the raked sites, giving the impression that they found undyed baits more attractive. However, although

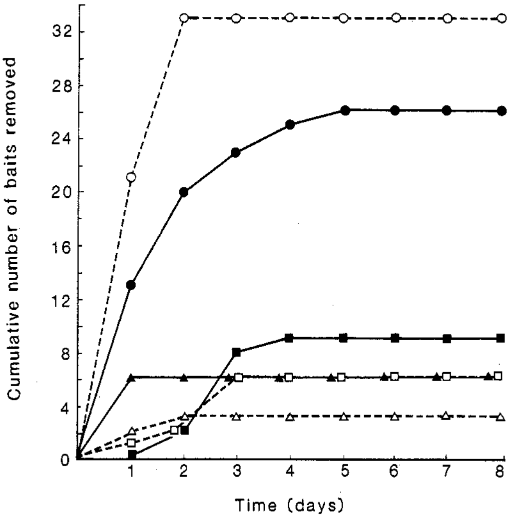

Fig. 3. Rate of removal of dyed and undyed baits by different animals: ○---○ plain baits by birds; ●—● dyed baits by birds; □---□ plain baits by foxes; ■—■ dyed baits by foxes; △---△ plain baits by pigs; ▲—▲ dyed baits by pigs.

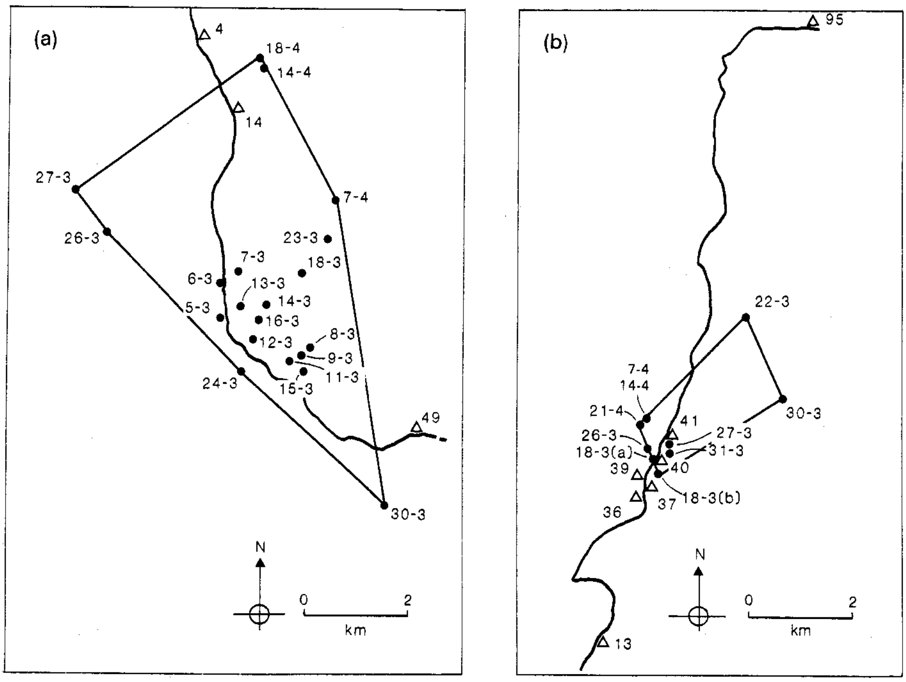

Fig. 4. Home ranges of bitches: (*a*) No. 4; (*b*) No. 3. ● Their locations on different dates. △ Where baits were removed from the trails by dogs.

in the trial with unpoisoned baits they initially took more undyed than green-dyed baits (Fig. 3), analysis by means of 2 by 2 contingency tables revealed there was no significant difference between the numbers of either type removed by them or other animals (χ^2 on first day 1·243, 1 d.f.; χ^2 on second day 2·60, 1 d.f.).

Fate of Dogs during Poisoning Campaigns

Although dogs removed a total of 27 poisoned baits during both campaigns, only two of the nine dogs carrying transmitters were killed. No. 4 was found dead 19 days after the first baiting, at the same site she had been located at 4 days earlier. Isotope levels in the tissues and the condition of the corpse indicated that she had died probably about 11 days after the baiting. During the first campaign only three baits were removed by dogs from the southern part of the study area, bait 14 on the first night and baits 4 and 49 on the third night (Fig. 4*a*). No baits were removed by dogs from this area during the second campaign.

Because of limited radio-tracking data we were unable to precisely document the events leading to the death of No. 4. One bait was taken on the first night 6 km from her location on the day they were laid (30–3: Fig. 4*a*), and two 1·2 km and 6·9 km (respectively) from that position on the third night. Assuming that she took one or more of these baits, she subsequently moved at least 4·4–6·9 km in the 4–11 days before dying.

No. 3 was found dead on 21 April at the spot where she was located from a light aircraft on 7 and 14 April (Fig. 4*b*). The condition of her corpse suggested she had been dead for at least a fortnight. Only two baits were removed by a dog or dogs from within her home range, both on the first night of the second campaign. Another three baits were removed by a dog or dogs on the same night within 0·65 km of her home range boundary (Fig. 4*b*).

Table 2. Loss of toxicity of meat baits after distribution

Initial loading was theoretically 4·69 mg of 1080. Values of 1080 contents are means ± standard errors. Day 0 is the day of distribution

Day	1st poisoning campaign		2nd poisoning campaign	
No.	*N*	1080 content (mg)	*N*	1080 content (mg)
0		–[A]	4	3·09 ± 0·31
1	5	2·32 ± 0·17	5	2·43 ± 0·36
2	5	3·16 ± 0·36	5	2·36 ± 0·28
3	5	2·92 ± 0·32	4	2·23 ± 0·42
4	5	1·68 ± 0·29	5	1·79 ± 0·27
5	5	1·50 ± 0·21		
6	5	1·36 ± 0·23		
7	5	1·20 ± 0·15		
8	3	1·32 ± 0·24		

[A] Bait samples not analysed because of breakdown of storage freezer.

The nearest other baits removed during both campaigns were at least 2·9 km from the boundaries of her home range. It seems probable, therefore, that she ate at least one of the five baits within 100–700 m of where she had last been located 4 days before the poisoning, and then moved at least 0·5 km within the next 3 days to where she was found dead.

Only one other dog was found dead within the area during the study, an uncollared male discovered 2·9 km from the bait line on 25 April.

Loss of Bait Toxicity

Baits sampled at the time of distribution did not contain the intended amount of 1080 (Table 2) and quickly lost much of their toxicity after different periods of exposure.

Discussion

Control of Wild Dogs and Dingoes in National Parks in South-Eastern Australia

Because of the limited number of times each dog was located, and the short study period involved, the measurements obtained of the home ranges of the dogs in the Yarrangobilly area may underestimate the area in which they normally live. For example, two of the dogs were observed outside their home ranges 34 and 66 days, respectively, after the study had ended. These extra locations increased their calculated home range areas by 25% and 29%, and appeared to be natural extensions of their ranges rather than dispersal movements (Fig. 1). However, this underestimation might be countered to some extent by our method of drawing the boundaries as straight lines connecting the outermost location points rather than by using the 'field-worker's estimate' as advocated by Macdonald *et al.* (1980). Overall, though, the measurements of home range areas we obtained were similar to those obtained for dingoes in the Tin Mines area of Kosciusko National Park (1763 ± 155 ha: P. Catling, personal communication), Nadgee Nature Reserve in south-eastern New South Wales (1020 ± 85 ha: P. Catling, personal communication) and the Northern Tablelands of New South Wales (2700 ± 1060 ha: Harden 1985).

The results from the present study, together with those of Catling (personal communication) and Harden (1985) indicate that dingoes, wild dogs and their hybrids living more than 12–20 km inside National Parks in south-eastern Australia are unlikely to move out onto adjacent private land. Consequently, the killing of dogs well inside the Parks, as a professional trapper did in our study area, is a waste of control effort. It would be better to concentrate such efforts on dogs living on the periphery of Crown Land (e.g. National Parks, State Forests or catchment areas). Thomson (1984) recommended that buffer control zones in the semiarid Pilbara District of Western Australia should be 15–20 km wide but that elsewhere their width would depend on the social stability, territory size and movement patterns of the dingoes. Although our data, and those of Catling (personal communication) and Harden (1985), indicate that buffer zones in south-eastern Australia should be of a similar width (i.e. 12–20 km), Newsome *et al.* (1983) suggest that a zone 3 km wide is probably adequate.

Success of Baiting Campaigns

Neither poisoning campaign was regarded as an outstanding success. Only one out of nine (11%) marked dogs was killed during the first campaign and one out of eight (12·5%) during the second, giving an overall reduction of 22%. Only 12 out of the 27 dogs known to be in the area during the study were not seen again after the baitings, so even if all these dogs are assumed to have been poisoned there would still have been only a 44% reduction in numbers. The following factors were considered as possibly responsible for the limited success of the campaigns.

Amount of 1080 in baits. The LD_{99} of pure 1080 for captive dingoes and wild dog hybrids is 0·123 (0·110–0·137) mg kg^{-1} (McIlroy, unpublished data), hence each of the nine dogs with transmitters would have required between 1·44 and 2·37 mg of pure 1080 for a 'lethal dose'. Sufficient 1080 (i.e. 5 mg of technical grade 1080 equal to 4·69 mg of pure 1080), however, was injected into each bait to kill any of the dogs, so the toxic loading of the baits could not have been responsible for the limited success of the campaigns.

Loss of toxicity. The length of time that any particular bait would have contained a LD_{99} for each of the radio-tracked dogs varied, depending upon the rate of loss of 1080 from the baits and the weight of each dog. Although the equivalent of 4·69 mg of pure 1080 was injected into each bait, some of this subsequently seeped out, so that by the time the baits were laid they had already lost some of their toxicity.

During the night when No. 3 was poisoned, samples of baits contained 2·19–3·93 mg of 1080, but during the four days when No. 4 had access to baits samples contained 1·66–4·99 mg. No. 3 required 2·10 mg of 1080 for a LD_{99}, so perhaps one bait was sufficient to kill her. No. 4 required 1·89 mg of 1080 for a LD_{99}. Circumstantial evidence indicates that she ate only one bait, and the long time until her death (i.e. 4–11 days), compared with times of up to only 11 h observed in captive dingoes and hybrids during toxicity trials (McIlroy 1981), suggests that this bait contained just enough 1080 to kill her.

Bait removal by non-target animals. The removal of 92% of the baits by non-target animals (especially foxes) during the first 4 days of the first campaign obviously reduced the chances of dogs finding and eating baits containing lethal doses of 1080. During the second campaign bait removal was initially slower, presumably because many foxes had been poisoned in the first campaign, but there was still no marked increase in removal by dogs (i.e. 7% in first campaign versus 10% in second campaign) and after 12 days the total number of baits removed was similar to that in the first campaign. Birds removed the most baits during the second campaign, but it is not clear whether this was because more baits were available following the poisoning of some of the foxes or because the birds found the undyed baits more attractive.

Disturbance of dogs. Disturbance by trapping and vehicular traffic along the fire trails does not appear to be a valid reason for the poor poisoning results, because we continued to observe dogs, fresh tracks and faeces along the trails throughout the study. Each radio-tracked dog was also known to be within 0·1–4·0 km of the bait lines during the first 4 days of each campaign, distances well within the range of their respective longest known daily movements and in most cases little different from the average distances they were known to move on successive days.

Preference for natural prey. We have no evidence about the food preferences of the dogs in the area. Some dogs ate the baits, others walked up to them but ignored them and some, to judge from examination of the dogs' faeces and 'kills', ate feral pigs, common wombats *Vombatus ursinus*, and grey kangaroos *Macropus giganteus*. Availability of prey, however, has been suggested as a factor that affects bait consumption by dingoes during aerial poisoning campaigns in Western Australia (Anon. 1982).

The use of 1080 poison to control wild dogs should be a very effective method because of the dog's extremely high sensitivity to the poison (McIlroy 1981) and in practice has resulted in a 62% mortality of dingoes carrying radio-transmitters during aerial baiting trials in arid areas of Western Australia (Anon. 1982). However, the results from the present study confirm previous doubts (McIlroy *et al.* 1986) regarding the effectiveness of current trail-baiting campaigns in the Southern Highlands of Australia. The problems appear to centre on the preparation, availability and acceptability of the baits: the initial loading and subsequent retention of lethal doses of 1080 in the baits; the removal or consumption of baits by non-target animals; the resultant length of time that baits remain available to the dogs after distribution; and whether the dogs will eat the baits.

Trapping, compared with poisoning, proved to be a more effective method of control during the present study. Fifteen (56%) of the 27 individual dogs known to be in the area during the study were trapped either initially for attachment of transmitters or later during efforts to recover the transmitters. In comparison, only three (11%) were known to have been poisoned and, in the unlikely event that all the individual dogs not seen again after the baiting were killed, only 44% were poisoned. However, trapping requires a considerable amount of effort (e.g. 60 trap-nights per dog) and some expertise, and it can be an inhumane practice, especially if traps are not visited each day. It can also result in the death of non-target animals (Newsome *et al.* 1983). In contrast, trail-baiting is less time-consuming and appears to have a negligible effect on non-target animals (McIlroy *et al.* 1986). The main task in the future is to increase its effectiveness against its intended targets.

Acknowledgments

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