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The effect of dingo control on sheep and beef cattle in Queensland

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Summary

1. Predation by dingoes *Canis lupus dingo* is regarded as a widespread problem by Australian livestock producers. This study examined five decades of historical data to evaluate the use and effect of dingo control on the distribution of sheep and beef cattle in Queensland.

2. In Queensland, dingo bounties were significantly more numerous in years with high sheep numbers but significantly less numerous in years with high beef cattle numbers. These relationships probably reflected the social and economic attitudes of the two producer groups to dingoes.

3. The relatively high impact that dingoes are perceived to have on sheep compared with beef cattle, the control techniques used by the two producer groups, and the intensity at which these techniques are applied, were the underlying causes.

4. Subsequent to the introduction of baiting using 1080 (sodium fluoracetate), there was an immediate decline in the use of strychnine, the number of dingo bounties presented for payment, and the number of dingo trappers employed by local governments in Queensland. However, these changes were confounded by a simultaneous decline in sheep numbers and dingo control effort.

5. Barrier fences and poisoned 'buffers' were compared for their ability to protect sheep from dingo predation. With few exceptions, sheep numbers declined or increased marginally within 50 km inside a dingo barrier fence or within a boundary between sheep and beef cattle production outside the dingo barrier fence. This contrasted to areas > 50 km from the dingo barrier fence or sheep/cattle boundary.

6. Both poisoned buffers and barrier fences could be equally effective at preventing sheep losses. However, buffers are best suited to open arid areas where large-scale co-ordinated baiting programmes are more feasible and where prey scarcity leads to increased bait consumption. We predict that sheep production outside the dingo barrier fence in Queensland will contract from the north and east. There is a case for re-establishing a barrier fence in this area to prevent such contraction.

7. Co-ordinated predator management, such as barrier fencing or aerial baiting, can protect sheep at a regional level. However, unless the financial burden of pest control is shared through a centralized scheme, sheep producers living along the boundary are likely to leave the industry or substitute cattle for sheep and the sheep-production area will contract.

8. This paper cautions the use of bounties as a measure of relative abundance and illustrates how people's perception of a pest and the type of livestock they produce can affect their level of control effort and the control methods they use.

Key-words: bounties, buffers, fencing, poisons, predator management, regression tree analysis.

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Introduction

The dingo *Canis lupus dingo* Corbett 1995 was distributed all over mainland Australia when Europeans arrived in 1788 (Rolls 1969), although Corbett (1995) maintains that dingo numbers expanded greatly in the 1830s with the development of Australia's pastoral industry and a supply of permanent artesian water. Rolls (1969) claimed that wherever the early settlers moved with their sheep, dingoes caused constant harassment. However, in 1877

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legislation was enacted to regulate vertebrate pests in Queensland. In an amendment to the Marsupials Destruction Act (1881–1918) in 1885, dingoes, defined to include feral dogs *Canis lupus familiaris* Meyer 1793 and hybrids of *C. l. dingo*, were 'declared' as pests. This legislation regulated the destruction of vertebrate pests, both native and introduced, by the extensive use of bounties (Hrdina 1997). Such bounties were paid to dingo trappers on presentation of a dingo scalp and were financed by property owners through their local government rates.

While dingoes have continued to be regulated under Queensland legislation from that time, the agency responsible and the specific Act requiring their control has changed periodically (Payne, Fletcher & Tomkins 1930; Hrdina 1997). With the exception of the toxin 1080 (sodium fluoroacetate), which was first tested on dingoes in Queensland in 1968, the methods and strategies for dingo control have changed little since 1885. The principal measures encouraged or employed by the Queensland government include trapping and shooting, promoted through the use of bounties; the co-ordination of baiting campaigns (strychnine and 1080); and fencing, principally the dingo barrier fence (DBF). The aim of this study was to assess these dingo control methods using five decades of historical data to provide a basis for re-evaluation and management of dingoes in the future. The study examined control options and evaluated their effect on sheep and beef cattle production in Queensland.

Materials and methods

The data examined in this review were principally from five sources. Sheep and cattle numbers for local government areas were from the Australian Bureau of Statistics (consecutive years 1970–89) and Commonwealth Bureau of Census and Statistics (CBCS), Queensland (unpublished data from 1990 to 1994, CBCS, Brisbane). Sheep and cattle numbers for Queensland were extracted from the Australian Bureau of Statistics (consecutive years 1945–83) and National Farmers' Federation (1995–96). Sheep numbers included adult sheep and lambs, while the cattle numbers were for beef cattle only.

Data on the amount of strychnine and 1080 used in Queensland and the number of dingo trappers employed by local governments were extracted from annual reports (Land Administration Commission consecutive years 1960–78; Stock Routes and Rural Lands Protection Board 1979–83). The use of strychnine powder and baits prior to 1960 was not collated as much of its use was unrecorded. Historical evidence suggests, however, that the practice of using strychnine to control dingoes existed prior to their declaration in 1885 (Gordon 1880).

The number of dingo bounties 1945–83 were obtained from Stock Routes and Rural Lands Protection Board (1983–84) and the Department of Lands (Land Protection Branch, unpublished archives for years 1984–95; S. Adie, Land Protection Branch, personal communication 1996).

DINGO BOUNTIES

Subsequent to the declaration of dingoes as pests in 1885, the principal method of controlling dingo populations in Queensland was through trapping and shooting by the provision of a state bounty system. Government agencies that administered the various Acts controlling pest animals promoted bounties for a wide variety of 'pest species'. These included various species of kangaroos and wallabies (Macropodidae), pademelons, rat kangaroos (Potoroidae), bandicoots (Peramelidae) (Hrdina 1997), 'eagle hawks' and their eggs (probably *Aquila audax*) and the introduced European hare *Lepus europaeus*, red fox *Vulpes vulpes* and pig *Sus scrofa* Stock Routes and Rural Lands Protection Board (1983–84). Hundreds of thousands of native and introduced animals were destroyed over the years and millions of dollars were exhausted in the schemes (Hrdina 1997). Gradually government-subsidized bounties were discontinued, and in Queensland today only the bounty of 10 dollars per dingo scalp remains.

Smith (1990) described a positive trend in bounty figures that reflected sheep numbers. Subsequently, the statistical relationship of 50 years of bounty payments (1945–95) and sheep and beef cattle numbers in Queensland was examined.

STRYCHNINE AND 1080 BAITING

Strychnine was used widely for at least a century to control dingoes prior to 1968, when 1080 was first tested as a predator control agent. The Queensland government conducted extensive aerial baiting campaigns, dropping approximately one million strychnine baits per year in the pastoral region. They also facilitated ground baiting by graziers from 1947 to the early 1970s (Land Administration Commission consecutive years 1960–78; Kerr 1991). In evaluating this dingo control strategy, the impact that 1080 introduction had on the use of strychnine and how dingo populations were affected during the transition was examined.

In this analysis the total number of strychnine baits and the total amount of strychnine powder sold or distributed by the Government pest agency was compared with the quantity of 1080-impregnated meat distributed for dingo control in state co-ordinated campaigns from 1960 to 1994. The number of dingo trappers employed by local government agencies and the number of scalps presented state-wide for this same period during which 1080 baiting campaigns first commenced was also assessed.

As no objective measure of dingo abundance was available, the number of dingo trappers employed by local authorities and the annual number of dingo bounties were used as indicators of relative dingo abundance. Both Woodall (1983) and Jarman & Johnson (1977) have used dingo bounties in this way.

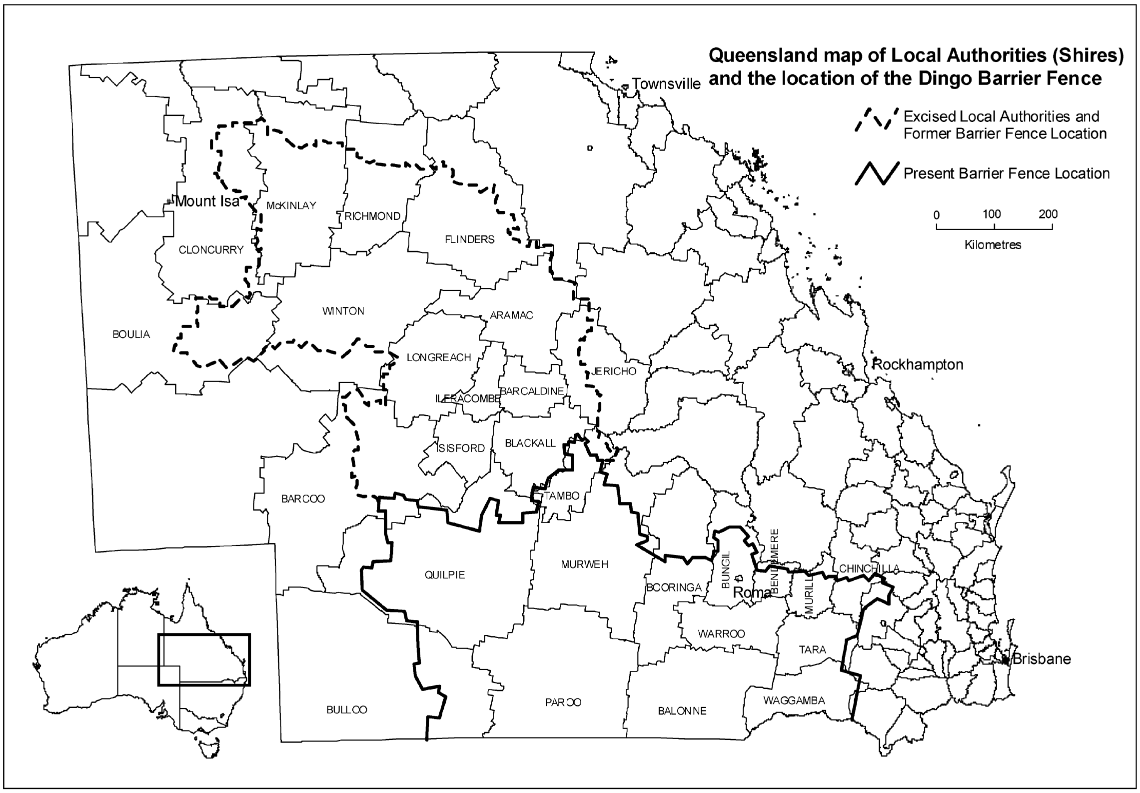

Fig. 1. Present and former location of Queensland's dingo barrier fence in relation to local government areas.

COMPARISON OF DINGO BARRIER FENCES AND CHEMICAL BUFFERS

Alignment and cost of barrier fences

Probably one of the most controversial of all dingo control strategies, at least in the last two decades, has been the maintenance of the Queensland section of the DBF. The DBF is a 2·0-m high wire-netting fence, first erected around 1945, primarily to prevent the movement of dingoes into sheep-producing areas. The Queensland section of the DBF connects with the New South Wales 'border fence' in south-west Queensland. The border fence, so named because it literally follows the New South Wales–Queensland and South Australian border, turns south-west across South Australia eventually terminating in the Great Australian Bight. The protected area inside the DBF includes most of Australia's sheep-producing areas. Some sheep-production areas lie outside the fenced area. To be viable these producers rely heavily on poisoning programmes and buffer areas to control dingo-predation losses. Beyond the sheep-producing areas beef cattle production predominates and dingo densities are highest.

The current DBF, however, is only a fraction of its original extent. From 1945 to 1981 the DBF in Queensland was 5631 km in length (Fig. 1). A decline in the state's sheep numbers during the 1960s and 1970s and a corresponding expansion in cattle production, coupled with economic recession, led to degradation of sections of the DBF. The high cost of maintaining a 2·0-m high, dingo-proof, netting boundary fence as opposed to a four-strand barbed wire fence, which is all that cattle require, resulted in sections of the DBF falling into disrepair. After lengthy negotiations with industry and local government, the Queensland government decided to upgrade and realign the DBF, effectively excising about half of the state's sheep-production areas.

The controversy of the DBF relates more to its cost and who pays rather than its ecological impact or practical effectiveness, although that too has been questioned. In 1996–97 the cost of maintaining the 2560-km realigned section of the Queensland DBF was Aust$1·26 million (T. Dunne, Department of Natural Resources, personal communication 1997). Approximately half of this amount was taxpayer funded and the remainder levied from local governments and based on the number of domestic livestock 'protected' by the DBF.

Baiting practices

Baiting campaigns across Queensland are co-ordinated by government-employed operators licensed to use 1080. Co-operation and participation, however, are not assured without the goodwill of individual graziers. Many graziers along the boundary between sheep and beef production areas, particularly the western boundary, are formally or loosely organized into dingo control syndicates. These groups co-operatively bait contiguous properties at least annually and establish 'dingo-free' buffers similar to those described by Thomson (1987), with the objective of keeping dingoes out of sheep-production areas. However, some beef producers view dingoes favourably, believing they control pest populations of feral pigs, rabbits, kangaroos and wallabies. Therefore some producers elect not to bait and colleagues bait only occasionally.

Effectiveness of physical and chemical barriers

To evaluate the effectiveness of the DBF and chemical buffers as dingo control strategies, changes in the numbers of sheep and cattle in local government areas inside and outside the DBF in the decade following 1981 were examined. Changes in sheep and cattle numbers were calculated from the mean of 1981–83 and 1988–90, for each of the 28 local authorities enclosed or bisected by the former DBF. The change in sheep and beef cattle numbers in each local authority was compared to identify common trends. All the data post-1990–91 were excluded to avoid the influence of a major drought (1991–96) and the effect that a sell-off of the Australian wool stockpile had on prices and sheep numbers. Between 1990–91 and 1994–95 there was a 33·8% reduction in total sheep numbers across all local authorities in Queensland. The reduction was more severe south (38·9%) compared with north of the DBF (26%).

Each local government area differed in size, shape and relative distance to the DBF or buffer. Hence, each local government area's relative exposure to dingo predation losses was calculated as an interface index (the percentage of each local government area's sheep production that is > 50 km from the DBF or buffer boundary). A local government area's sheep-production area is the percentage area inside the former or current DBF. The value of 50 km was arbitrary but considered to separate the local government areas most likely to be exposed to predation losses should dingoes successfully breach the DBF or chemical buffer from those areas where sheep production is distant from potential dingo attacks. The interface index was plotted against change in sheep numbers for each local government area.

STATISTICAL ANALYSIS

The null hypothesis was that there was no difference in percentage change in sheep numbers with interface index across Queensland. Theoretically, if dingo predation was not a significant factor the percentage change in sheep numbers would be similar irrespective of distance from beef-production areas. If there was a difference and chemical buffers and the DBF were equally effective at mitigating dingo predation losses, then trends in percentage change in sheep numbers and interface index would be no different between local government areas.

Compiled data were subject to regression analysis for determining apportioned variance (Systat 7.01), analysis of variance (Excel 5.0) and regression tree analysis (Systat 7.01) (Breiman *et al.* 1984; Wilkinson 1997). Similar in effect to cluster analysis and referred to initially as 'automatic interaction detection', regression tree analysis grouped similar local government areas based on the smallest sum of squares with the splitting criteria defined by least significant difference calculations. Additionally, Systat 7.01 regression tree mobiles have the advantage that they identify, measure and illustrate graphically the degree of fit of those characteristics with the largest discriminating influence, and can use continuous, discrete and categorical data. (Mobiles are the graphical output produced by regression tree analysis.)

Change in sheep numbers was used as the dependent variable. Interface index, the position of the local government area relative to the DBF (fence category; Table 1) and latitude were used as independent variables to discriminate local government areas.

Climate, a colinear variate of latitude, has been shown to be an important factor affecting the productivity of sheep in Australia (Brown & Williams 1970). Reduced wool growth and lambing rates occur in northern Australia compared with southern Australia. Thus, sheep production in the far north of Queensland is significantly less profitable. Within Queensland these differences should not be great. But, as the DBF traverses the state in an east–west direction, the northern chemical buffer areas are potentially less profitable than the sheep-producing areas protected by the DBF in the south. By including latitude as a variable in the regression trees analysis, the influence of decreasing sheep productivity with latitude could be evaluated in relation to percentage change in sheep numbers.

Table 1. Fence categories: location of sheep-producing local government areas in Queensland in relation to whether they are 'inside' or 'outside' the current dingo barrier fence (DBF) and whether the local government area is divided between sheep and beef production

Category†			
1	2	3	4
Bendemere	Balonne	Barcoo	Aramac
Booringa	Paroo	Boulia	Barcaldine
Bungil	Tara*	Cloncurry	Blackall
Bulloo	Warroo	Flinders	Ilfracombe
Chinchilla	Waggamba*	Jericho	Isisford
Murilla		McKinlay	Longreach*
Murweh		Richmond	
Tambo		Winton	
Quilpie			

*Local government areas with < 1% of properties outside DBF.
†Category 1, a portion of the local government area is inside but is dissected by the current DBF. Category 2, the local government area is entirely enclosed by the current DBF. Category 3, the local government area lies outside the current DBF but was previously dissected by the fence, i.e. excised category 1. Category 4, the local government area now lies outside the DBF and was not dissected by the former fence, i.e. excised category 2.

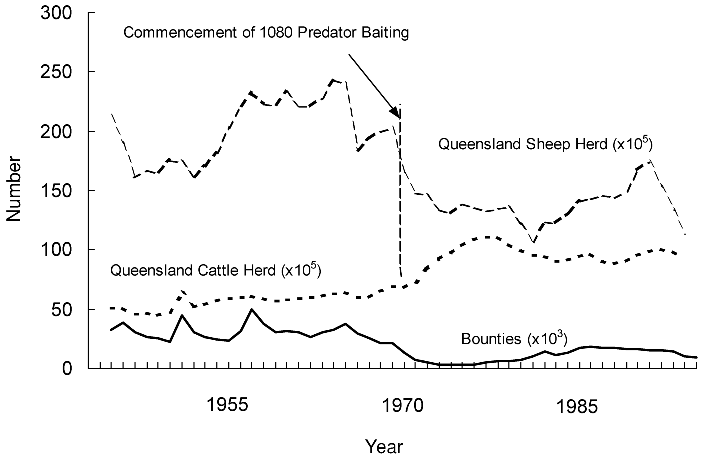

Fig. 2. Queensland's sheep and beef cattle numbers in relation to dingo bounties 1945–96.

Table 2. Correlation and significance of the relationship between sheep and beef cattle numbers, 1080 use, and bounty payments in Queensland

Description	Correlation coefficient	F	P
Total sheep/bounty payments 1945–95	0·80	86·8	< 0·01
Total sheep/1080 use 1970–95	0·19	1·02	0·32(NS)
Total beef cattle/bounty payments 1945–95	−0·80	84·5	< 0·01
Total beef cattle/1080 use 1970–95	−0·52	8·4	< 0·01
Total sheep/total beef cattle 1945–95	−0·72	51·5	< 0·01
Bounty payments/1080 use 1970–95	0·64	16·7	< 0·01

Results

DINGO BOUNTIES

Over 1·5 million dingo scalps have been presented for bounty payment in Queensland since declaration in 1885. The number presented each year has varied from almost 50 000 scalps in 1957–58 to 2689 in 1975–76 (Fig. 2). Correlation and regression analysis (Table 2) demonstrated that bounty payments increased significantly with Queensland's sheep numbers. When beef cattle numbers and dingo bounties were compared over the same period, there was significant negative correlation. Similarly, there was a significant negative correlation between sheep and cattle numbers over the 50 years we compared, suggesting substitution between these two grazing activities.

STRYCHNINE AND 1080 CAMPAIGNS

For the 9 years (1960–68) prior to the introduction of 1080, a total of 8·89 million strychnine baits was dropped by aircraft on cattle properties around the perimeter of the sheep-production areas. DC3 aircraft, loaded with strychnine-impregnated, paper-wrapped, tallow baits, flew 236 600 km in baiting campaigns during this 9-year period. This was the Queensland government's contribution to the poisoning effort. Over this same period the government sold an additional 2·68 million strychnine baits and 414·8 kg (17 427 one-ounce bottles) of strychnine powder to graziers for baiting dingoes on private property.

The impact 1080 baiting had on dingo populations and Queensland government policy was profound and immediate (Figs 3 and 4). Within 4 years of 1080 predator baiting commencing in Queensland 'numerous unsolicited reports … from graziers [reported] a total absence of dingoes and dingo tracks on their properties since the baits were laid' (Land Administration Commission 1970–71).

The 1080 campaigns commenced concurrently with a massive decline in the wool industry and some of the reductions attributed to 1080 here may be exaggerated by reduced sheep numbers and corresponding reduction in dingo control effort (see the Discussion on dingo bounties). Historical records show, however, that by 1969 government-initiated aerial baiting campaigns with strychnine had discontinued. By 1973 strychnine baits were no longer available because of limited demand, and by 1976 Queensland's Stock Routes and Rural Lands Protection Board discontinued the practice of supplying strychnine to graziers (Fig. 3). Over the decade following 1968, the number of local government-employed dingo trappers dwindled from 57 in 1968 to five in 1976 (Fig. 4). From 1977 no further mention of them is made in annual reports. Furthermore, the 1970s had the lowest number of dingo scalps for several decades (5400 pa 1970–79 compared with 25 200–32 000 pa for the decades 1940–69).

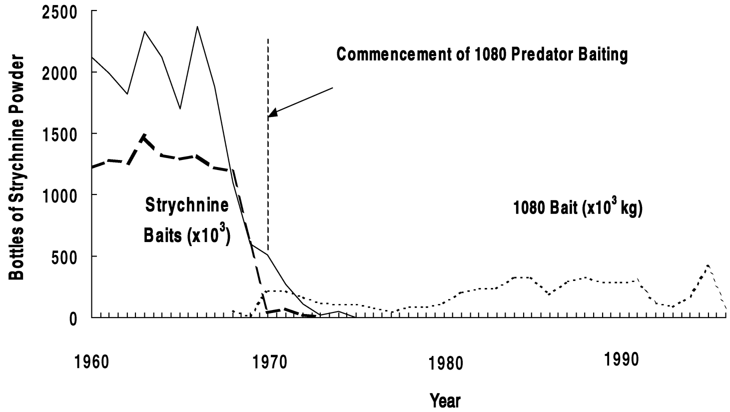

Fig. 3. The amount of strychnine powder sold and poisoned baits distributed in Queensland to control dingoes from 1960 to 95.

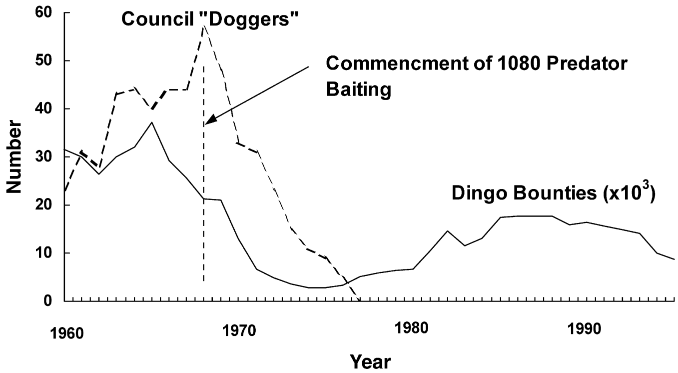

Fig. 4. The effect of 1080 introduction in 1968 on dingo populations in Queensland as measured by the number of local government-employed dingo trappers and dingo bounties 1960–95.

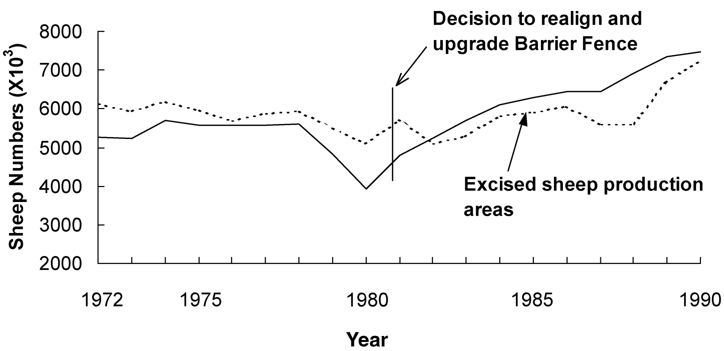

Fig. 5. Sheep numbers in local government areas prior to, and following, the realignment of the Queensland dingo barrier fence 1972–90. The fence was realigned and upgraded in 1981 and half the formerly protected area was excised.

In 1981 the value of the bounty increased from Aust.$2 to $5, and later in 1983 from $5 to its present value of $10 (Stock Routes and Rural Lands Protection Board 1988–89). However, like Jarman & Johnson (1977) discovered, the fivefold increase in value made no significant difference to the number of bounties presented in the long term (Fig. 4). During the late 1980s and early 1990s the number of dingo scalps gradually increased yet not to the threefold increase that would be needed to restore figures to pre-1080 levels. We assume that bounties increased during this period because sheep numbers increased and there was a corresponding increase in dingo control effort (Fig. 2).

COMPARISON OF THE DINGO BARRIER FENCE AND POISON BUFFERS

Data over the years 1972–90 show that there was a general decline in sheep numbers over the decade prior to 1981 (Fig. 5). In the decade following the realignment and improved maintenance of the DBF, sheep numbers increased in most local government areas. However,

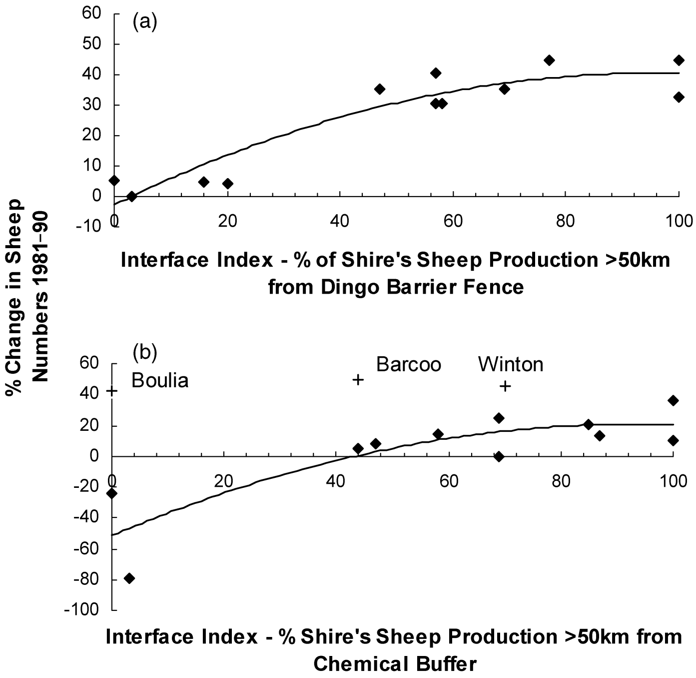

Fig. 6. Change in sheep numbers 1981–90 in local government areas (shires) protected by the dingo barrier fence (a) or chemical buffers (b) in Queensland. The three outliers (+) were dropped in the analysis but are shown as a separate series for illustration.

there were significant differences in the demographic pattern of these changes, showing a significant positive relationship between the relative increase in sheep numbers and interface index ($F = 7{\cdot}0$, $P = 0{\cdot}01$, $n = 28$). Presumably this pattern reflected each local government area's relative degree of exposure to predation and the dingo control strategies used. Trend lines demonstrated that the DBF restricted the impact of dingo predation more in the vicinity of the DBF (Fig. 6a) than buffers had done (Fig. 6b). The trend lines had the same non-linear trajectory but were significantly different with respect to linearity and where they crossed the y-axis. Line one representing local government areas protected by the DBF $y = 50{\cdot}19 - 47{\cdot}38 \times 0{\cdot}9813^x$, which is significantly distinct from the line representing local government areas protected by chemical buffers $y = 37{\cdot}63 - 88{\cdot}13 \times 0{\cdot}9813^x$.

The strongest increase in sheep numbers occurred in those local government areas that had no or little interface with the DBF or buffer boundary. The exceptions were the shires of Barcoo, Winton and Boulia, three local government areas along the western boundary of the buffer. All three share a distinctive dingo control strategy. Uniquely, they achieve a large-scale co-ordinated baiting campaign along 600 km of their western boundary. These three shires had similar increases in sheep numbers to local government areas protected by and greater than 50 km from the DBF (Fig. 6b). Latitude effects on sheep productivity is recognized as a potential factor explaining the difference between the trend lines. However, the relative increase in sheep numbers in Barcoo, Winton and Boulia showed that the trend line differences were not caused by latitude effects or decreasing suitability of properties across the boundary of the sheep areas. We attributed the differences in trend lines to the effects of dingo predation and differences between buffers and the DBF.

With Barcoo, Winton and Boulia omitted from analysis, regression analysis of sheep-production trends showed a stronger positive relationship between increased sheep numbers and interface index whether protected by a chemical buffer area ($R^2 = 64{\cdot}9$, $P = < 0{\cdot}01$, $n = 11$) or the DBF ($R^2 = 55{\cdot}8$, $P = < 0{\cdot}01$, $n = 14$). These demo-graphic effects are specific to sheep because no correlation exists between beef cattle numbers and interface index.

With the same three local government areas removed from the data set, regression tree analysis identified the interface index, latitude and fence category as significant interactive characteristics for discriminating local government groupings (Table 3). The analysis aligned local government areas into four distinct groups with a high predictive value (0·706) achieved for the model. Discriminated on the basis of interface index (0·411) was the most important split because it separated the main body of cases. (Splits are a process of case segregation parallel to the standard graphical axes). The analysis separated out seven local government areas where > 53% of their sheep production was within 50 km from the DBF or chemical buffer boundary.

The local government area of Bendemere also showed an unusually high increase in sheep numbers (17%) inconsistent with its closeness to the DBF. This was caused by Bendemere's record sheep numbers in 1988, the highest for a decade. If this year is ignored and the mean of 1989–90 is substituted, Bendemere had almost no change over the decade 1981–90. This figure (–0·04%) was used subsequently in analyses.

Table 3. Local authority groupings identified by the regression trees analysis, their characteristics and mean change in sheep numbers 1981–90

Local authorities where > 53% of the shire's sheep production < 50 km from cattle/sheep interface (Splitting criteria: interface index)		Local authorities where > 46% of the shire's sheep production is > 50 km from the cattle/sheep interface (Splitting criteria: interface index)	
Sheep protected by chemical buffers (Splitting criteria: fence category > 2)	Sheep protected by barrier fence (Splitting criteria: fence category < 3)	Sheep produced in north and central Queensland (Splitting criteria: latitude < 24·9°)	Sheep produced in southern Queensland (Splitting criteria: latitude > 24·8°)
Group 1	Group 2	Group 3	Group 4
Cloncurry	Bendemere	Aramac	Balonne
Jericho	Bungil	Barcaldine	Booringa
McKinlay	Chinchilla	Blackall	Murweh
	Murilla	Flinders	Paroo
		Ilfracombe	Quilpie
		Isisford	Tambo
		Longreach	Tara
		Richmond	Waggamba
			Warroo
			Bulloo
Mean change in sheep numbers	Mean change in sheep numbers	Mean change in sheep numbers	Mean change in sheep numbers
–32·4%	8·05%	15·9%	40·1%
SD 42·6	SD 6·5	SD 11·2	SD 9·1

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The second split separated the remaining 18 local government areas on the basis of latitude. This split improved the model by 0·142. The final split accounted for an improvement in the predictive model of 0·153. This split was on the basis of fence category and further divided the seven local government areas with regard to whether they were protected by the DBF or chemical buffer (Table 3).

The predictor fence category (Table 1) in the regression tree was degraded by sharing variance in the regression model with the constant. This has been shown to cause the assessed variance to be confounded and overstated in models (Kirby 1993). Subsequent centring and back-stepped regression demonstrated that fence category variance had been apportioned incorrectly. Therefore, because of this shared variance, the interface index was a primary predictor in the model whose variance proportion best expressed the relationship between change in sheep numbers and distance from the boundary with beef production.

This analysis demonstrated that, in spite of underlying latitude effects, the relative exposure sheep had to beef production areas had a significant influence on change in sheep numbers over the decade examined irrespective of whether they were protected by the DBF or chemical buffer. This result highlights the potential impact dingo predation has on sheep production in Queensland. In comparison, the DBF confined dingo impacts closer to the sheep/cattle interface than poison buffers (Fig. 6). This resulted in a stronger mean increase in sheep numbers in group two (8·05%, SD 6·52) compared with group one (–32·4%, SD 42·6; Table 3).

Inside the DBF (Fig. 1), sheep numbers had increased in all local government areas, even in those local governments where 80–100% of their sheep-production area was within 50 km of the DBF. In local government areas protected by a chemical buffer, however, and with the exception of Boulia, sheep numbers had declined where > 70% of the local government area's sheep-production area was within 50 km of the buffer boundary. Where > 50% of the local government area's sheep-production area was over 50 km from the cattle/sheep boundary, chemical buffer-protected areas were comparable to DBF-protected areas.

Discussion

DINGO BOUNTIES AND ABUNDANCE INDICES

Jarman & Johnson (1977) and Woodall (1983) both used bounties as an index of dingo abundance. Jarman & Johnson (1977) found that changes in the value of the bounty did not affect the number of scalps presented and concluded that bounties represent a constant killing effort and hence crudely reflected dingo abundance. Harden & Robertshaw (1987) examined 25 years of dingo bounty figures for the mid-north coast of New South Wales and concluded that a decline in dingo scalps during this period was directly related to a reduction in hunters, not a decline in dingo abundance. These data show that bounties were not sensitive to a fivefold increase in the value of the scalp and support the conclusions of Harden & Robertshaw (1987) and Jarman & Johnson (1977), where sheep numbers remained constant.

Use of bounties to reflect dingo abundance is cautioned. Bounties should not be used to reflect relative dingo abundance across both sheep and cattle production areas as the control techniques and control effort are so vastly different. Historical data should also be examined in the context of trends in sheep production over the same time frame as this is a major indicator of relative control effort. Woodall (1983), for example, used feral pig and dingo bounties between 1945 and 1950 and 1971–76 to evaluate the distribution and population dynamics of these two species across Queensland. Using bounty data, he concluded that feral pigs increased in Queensland, subsequent to the introduction of 1080 and a decline in dingo abundance, and that feral pig mortality was significantly related to dingo predation and rainfall. However, over those same years there was a 48% reduction in Queensland's sheep flock from an average of 17·9 million in 1945–50 to 9·3 million in 1971–76. The positive relationship between sheep numbers and dingo bounties over the 50 years examined in Queensland reflects the close interconnection between sheep numbers, the total area producing sheep, the market value of sheep, and the subsequent control effort employed by sheep producers to reduce their predation losses. Thus this change in sheep numbers would have radically reduced the properties over which dingoes were trapped, the manpower involved in dingo control and consequently the number of dingo scalps presented for bounties.

DINGO CONTROL AND BEEF PRODUCTION

A significant negative relationship was found between beef cattle and bounties ($r^2 = -0{\cdot}80$, $F = 84{\cdot}5$, $P = 0{\cdot}01$) and between beef cattle numbers and 1080 use ($r^2 = -0{\cdot}52$, $F = 8{\cdot}4$, $P = < 0{\cdot}01$), showing that a dissimilar relationship towards dingoes exists between beef and sheep producers. Two factors are believed responsible for this. First, many beef producers do not perceive dingoes to be a significant economic problem, and secondly, beef producers use alternative control techniques that yield relatively few scalps.

Historically, beef producers in Queensland have expressed mixed perceptions towards dingoes (Hrdina 1997). The apparent difference between beef and sheep production and grazier participation in dingo control is caused by a basic incompatibility between sheep production and dingoes, which does not occur, or is not perceived to occur, between beef production and dingoes.

Thomson (1992) reported that sheep were 'easy' prey and dingoes killed sheep in excess of their needs for food. Further, co-operative effort was not required for dingoes to catch or kill sheep whereas groups were more successful than solitary dingoes in killing calves. Beef producers are most likely to control dingo numbers when they see evidence of predation. This basic difference requires sheep producers to keep constant vigilance against dingoes and results in comparatively more effort put into dingo control by sheep producers compared with beef producers.

Another significant factor is that, in order to obtain a dingo scalp, traps rather than poisons must be employed because fresh poisoned animals are seldom discovered. Harden & Robertshaw (1987) found that 87% of the 18 614 dingo scalps presented for bounties in their study were either trapped (50%) or opportunistically shot (37%). Trapping is particularly labour intensive yet suited to dingo control in sheep areas. The reasons for this are varied. First, sheep producers rely heavily on working dogs for mustering and handling sheep, and poison baits place unacceptable risks to these animals. Secondly, baiting dingoes in sheep areas is less effective because of the greater abundance of medium-sized prey animals (sheep, kangaroos, rabbits, feral goats and pigs) available to dingoes compared with beef production areas (Mitchell, Merrell & Allen 1982; Corbett 1995).

There is also a significant social bias. As dingoes focus the sheep-producing community's attention towards a common threat, there is a personal satisfaction and social reward at physically capturing and scalping a dingo that is not experienced from a successful baiting programme. Sheep properties are, on average, much smaller than cattle stations, at 4000 ha compared with 20 000 ha, respectively (Australian Bureau of Statistics). Consequently, communities in sheep-production areas are geographically closer and communication with neighbours conceivably more frequent. Discussions regarding dingo problems and capture successes are topics of great community interest. A practical reality of the two dingo control strategies is that, unlike trapping, dingo remains are rarely discovered after baiting and the only practical indication of a successful poison campaign is the disappearance of dingo tracks and cessation of livestock attacks.

On cattle stations, working dogs are used less frequently and can be managed around mustering and baiting programmes because the properties are comparatively larger and the perceived objective of dingo control is not eradication. Consequently, beef producers opt for baiting and opportunistic shooting, rather than trapping, to reduce dingo populations. Even though dingo densities are much higher in beef areas (Mitchell, Merrell & Allen 1982) the time and manpower resources given to dingo control is comparatively less.

The observed trends in Fig. 2 can be interpreted thus. The perception of a predation problem, the techniques used and the degree of effort expended by sheep producers to control dingoes, produces a significant positive relationship between sheep numbers and dingo bounties, but as producers substitute beef cattle for sheep, a different perception of predation impact follows. This change in perception results in reduced control effort and use of techniques that produce few scalps, producing a strong negative correlation with beef numbers.

STRYCHNINE AND 1080 BAITING CAMPAIGNS

1080 had, and continues to have, a significant impact on dingo management in Queensland (Figs 3 and 4). However, there were significant yet negative relationships between cattle numbers and 1080 use. Contributing to this negative correlation is the perception that dingo predation increases with the onset of drought conditions. Corbett & Newsome (1987), Thomson (1992) Corbett (1995) and have demonstrated that dingoes substitute prey of increasing body size and lesser profitability (rabbits to kangaroos to cattle, for example) as drought and food availability worsens. Simultaneously, this may result in increased dingo control in response to producers observing more mauled or predated calves and a decline in cattle numbers as a consequence of destocking and reduced production during drought.

BARRIER FENCES AND CHEMICAL BUFFERS

Undoubtedly there may be several factors contributing to a general increase in sheep numbers over the decades 1970–90 (Fig. 5), for example change in sheep and beef prices driven by domestic demand and the export market, in addition to population increases, changes in eating patterns, improved cultural practices, droughts and the greater ease of maintaining cattle in drought-prone areas. By using the percentage change in sheep numbers rather than raw sheep numbers as an independent variable, the relative productivity between local government areas was standardized. What is important to this analysis of dingo control strategy is the demographic pattern associated with this relative increase in sheep numbers.

During the 1970s when some sections of the original DBF were abandoned, dingoes invaded many sheep properties that were previously 'clean' and it was years before they were brought under control. The most critical area identified inside the realigned DBF was the area between Murilla and Tambo Shires, a distance of 400 km (Stock Routes and Rural Lands Protection Board 1984).

In a 1982 report to this Board, it was noted that in the local government area of Jericho (in the excised area of the former DBF) a general apathy to be involved in baiting campaigns existed amongst beef producers and effectively no chemical buffer existed. This same report claimed that the neighbouring local government areas of Aramac and Barcaldine were already (1982) experiencing increased problems with dingoes in their sheep areas (Stock Routes and Rural Lands Protection Board 1982). These data show that over the decade 1981–90 sheep numbers declined by 23·8% in the local government area of Jericho and 0·6% in Aramac against the trend of a 15·9% increase for those neighbouring, yet more distant, local government areas protected by a chemical buffer.

This analysis shows that the degree of closeness to beef cattle-production areas, whether protected by a DBF or chemical buffer, had a significant negative influence on change in sheep numbers over the decade examined. We conclude, however, that the impact of dingoes on sheep numbers is largely indirect. The perception that dingoes are a significant practical, if not economic, problem is a primary consideration for sheep producers along the cattle/sheep interface. Proximity to dingo-infested areas and a judgement of potential risks associated with producing sheep and controlling predation loss cause many producers to take alternative options, such as substituting beef cattle instead of increasing sheep numbers. An equally valid alternative interpretation of this analysis is that we have measured sheep producer's confidence in the dingo control strategy used across Queensland and detected a significant level of caution amongst those graziers close to the cattle/sheep interface. Overall, where sheep production is within 50 km of the cattle/sheep interface, graziers have greater confidence in physical barriers than chemical buffers.

While generally there was a significant positive relationship between increased sheep numbers and distance from the cattle/sheep interface, the local government areas of Barcoo, Winton and Boulia were exceptions. These 'outliers' were important to the evaluation. The effectiveness of, or confidence in, highly organized and co-operative dingo destruction syndicates is reflected in the increased sheep numbers between 1981 and 1990 of 49·5%, 45% and 42·6% for Barcoo, Winton and Boulia, respectively.

In contrast, the northern and eastern chemical buffer has been less effective. This area is characterized by less organized control syndicates, a more individual and piecemeal approach to baiting and often smaller holdings in a rougher and more dissected landscape.

RECOMMENDATIONS FOR MANAGEMENT

The role of bounties in dingo control has been shown to be ineffective (Rolls 1969; Harden & Robertshaw 1987; Smith 1990). Strong recommendations have been made for abolishing Queensland's bounty system (Smith 1990; see also the Smith Report 1976) yet strong grazier support for its continuation still exists (Allen 1990). Apparently, the perceived threat of predation and the intangible social and psychological rewards of a bounty outweigh their practical and economic failure. While trapping is an important control technique to the sheep industry, this analysis support the view of Smith (1990) that bounties have no worthwhile role in controlling dingo populations at a state level. In beef production areas in particular, trapping harvests an expendable surplus of dingoes and does not contribute to their effective management.

It is concluded from this analysis that, in terms of managing dingoes, the following principles apply to the use of dingo barrier fences vs. chemical buffers. (i) Where holdings are large, in semi-arid and open landscapes, and there is strong grazier support for co-ordinated dingo-baiting campaigns, chemical buffers are equally as effective as a physical dingo barrier fence in preventing the ingress of dingoes into sheep-production areas. (ii) Where properties are smaller, in rough, forested terrain, where alternative prey species are more abundant, where there is mixed support for co-ordinated baiting campaigns, or where a contiguous buffer cannot be maintained, a physical barrier is more effective than a chemical buffer for protecting sheep.

The DBF apparently provides a valuable role in reducing sheep losses. Thus, there is some justification in extending the DBF to encompass those excised shires where sheep production is still a major source of income for the district and where buffers are less effective. From the position of equity and cost sharing, this analysis suggests those sheep producers > 50 km from a fence or buffer boundary are being protected by the efforts of the unfortunate few who bare the dingo control costs. Where there is no system to share the cost of dingo control, co-ordination and effectiveness of control methods are compromised to the extent that sheep production contracts.

Looking to the future, it is not unreasonable to predict that unless there is a significant improvement in the economics of sheep production, sheep numbers in Queensland will continue to decline in the excised area contracting from the north and east. Animal welfare concerns and poor sheep and wool prices coupled with reduced experience and skill in trapping techniques will probably result in declining use of this control method. Perceptions of the impact of dingoes have on cattle and macropods has changed little since 1880. Subsequent research has demonstrated that even solitary dingoes can easily outpace and kill sheep, leading to surplus killing (Thomson 1992), yet curiously, no research has documented a significant impact on beef cattle. In fact, there is more evidence to suggest that dingoes have a greater positive role in controlling potential pests (Corbett & Newsome 1987; Caughley *et al.* 1980; Thomson 1992; Hrdina 1997) than a negative impact on calf production (Allen & Gonzalez 1998). Without a change in perception and attitude, however, we believe 1080 baiting will probably continue to be used in the coming decades in both sheep and beef areas, although with increasing restrictions on where poison baits might be used.

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