THE IMPACT OF VERTEBRATE PESTS ON ANIMAL PRODUCTION PARTICULARLY IN NEW SOUTH WALES

INTRODUCTION

G.E. ROBARDS*

Of the many factors which affect animal production, wildlife is one of the few which has rarely been considered by the Australian Society of Animal Production. A variety of non-domesticated mammals are closely associated with the livestock industries and those which cause production losses are referred to as vertebrate pests in this contract. In some States this definition is carried further by the legislative declaration of pest status. For example, in N.S.W. rabbits, feral pigs and wild dogs are proclaimed as Noxious Animals under the Pastures Protection Act, 1934 and the legislation requires landholders to thoroughly suppress and destroy them at all times. Similar laws apply in other States.

In addition to the deleterious effect which vertebrate pests have on lambing percentages, pasture condition, fencing and watering facilities, some pose a major threat as potential reservoirs and vectors of exotic disease. Research has generally been aimed at greater understanding of the biology of vertebrate pests with a view to the development and testing of better control methods.

The following papers review the current state of knowledge, and make particular reference to the New South Wales Department of Agriculture's current research programmes on feral pigs, rabbits, wild dogs and the testing of contingency plans for the control of vertebrate pests in the event of an outbreak of exotic disease.

THE IMPACT OF FERAL PIGS ON LIVESTOCK PRODUCTION AND RECENT DEVELOPMENTS IN CONTROL

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Feral pigs are simultaneously perceived as a potential national disaster (in terms of exotic disease) by some and as an export commodity and hunting asset by others. Somewhere in between, they are viewed as an important vertebrate pest which reduces the profitability of agriculture. Reconciling these diverse values and the conflicts which inevitably ensue is a complex problem - one which emphasizes the need to evaluate the feral pig in specific situations, and to avoid the appealing, but misleading, tendency to generalise.

At worst, the damage caused by feral pigs and the cost of control can make specific livestock enterprises uneconomical. For example, lamb predation by feral pigs has been a major factor in enterprise substitution from sheep to cattle in areas adjoining the Macquarie Marshes in New South Wales. On a smaller scale, 'pig problem areas' on many properties are relegated to low risk or low value production.

HOW FERAL PIGS LIMIT PRODUCTION

Feral pigs limit animal production in a number of ways (Table 1). Where possible these losses have been quantified, although the figures may represent extreme values (high and low) and be specific to the location evaluated. Never-

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theless, it is clear that feral pigs have a range of effects on animal production and the cost of damage can sometimes be extremely high. Further, the overall extent of losses may be underestimated, particularly those associated with lamb predation. Because feral pigs are crepuscular or nocturnal in their activity (Giles 1980; Pavlov and Hone 1982), diurnal observations of pigs or predatory activity are relatively rare, and landholders are likely to underestimate the number of animals present. Further, feral pigs consume nearly all of the carcase of lambs killed (Pavlov and Hone 1982), so there is usually little direct evidence of predation.

Table 1 A summary of damage and losses caused to livestock production in Australia by feral pigs

Damage (Location)	Extent	Source
Lamb predation/injury (Goodooga, N.S.W.)	Lamb marking reduced from 117% (pigs absent) to 80% (pigs present)	Plant et al. 1978.
(Nyngan, N.S.W.)	Reduction in lamb marking varied between years - from nil to 38%	Pavlov et al. 1981.
Predation on lambing ewes/weak sheep	No conclusive evidence	Pullar 1953; Tisdell 1982.
Pasture damage (Tenterfield, N.S.W.)	Standing green grass matter reduced 74% (introduced pasture), 98% (native pasture)	Hone 1980.
Flock harassment (Nyngan, N.S.W.)	Pigs less than 100m from flock caused disturbance on 78% of observations	Pavlov and Hone 1982.
Endemic disease transmission (Ayr, Qld)	Brucella suis : 34% of animals tested	Keast et al. 1963; Norton and Thomas 1976.
	Leptospirosis, Tuberculosis, Sparganosis	Pullar 1950; Letts 1964; Keast et al. 1963; Murray and Snowdon 1976.
Damage; forage crops; watering facilities; fences		Tisdell 1982.
Exotic disease: potential cost; research costs ; cost of preparedness		Pullar 1950; Murray and Snowdon 1976; Geering 1981; Hone and Bryant1981.

In addition to the direct losses associated with predation, there are indirect losses to the producer including decreased production as a result of harassment, increased incidence of mismothering and a decreased rate of genetic gain. Sheep management can also be complicated by the need to select locations for lambing with a low risk of predation by feral pigs, and by variable predation hampering the identification of unrelated fertility problems.

The identification of economic losses in animal production does not necessarily mean that these losses can be economically reduced. First, spillovers from other activities may change the net value of the feral pig in specific situations (Tisdell 1982). For example, even where feral pigs can be practically controlled, the net value of capturing and selling feral pigs may exceed the difference between the cost of control and damage saved. Second, where losses are marginal or the cost of control is relatively high, damage control may be uneconomical. Management policies recognizing this problem have recently been suggested for parts of New South Wales (Bryant et al. 1984).

BIOLOGY AND BEHAVIOUR RELEVANT TO CONTROL

Feral pigs require adequate cover and water. Given these minimal requirements, they are dietary and habitat opportunists, with a potential rate of increase which is uncharacteristically high for an ungulate. In addition, feral pigs are highly mobile and non-territorial. These attributes are central to their success as feral animals and impact as vertebrate pests.

Feral pigs occur throughout New South Wales, Queensland and the Northern Territory, and are most abundant in areas of dense cover, permanent water and low human population density. Fewer animals occur in other States, where pig populations tend to be restricted to specific areas. The movement and dispersal patterns of feral pigs are critical behavioural components of effective control. Limited Australian data (Giles 1980) support observations from elsewhere that feral pigs are relatively sedentary, and have large home ranges which overlap extensively. Together with demographic data, information on the rates of dispersal and re-colonisation of feral pigs following control is needed to specify the most effective frequency and intensity for control programmes.

RECENT DEVELOPMENTS IN RESEARCH AND CONTROL

On the bases of economy, efficiency and accessibility, poisoning is a widely used means of feral pig control in Australia. Compound 1080 (sodium monofluoroacetate) is the only toxin recommended for use against feral pigs by the N.S.W. Department of Agriculture, and is the agent most widely used on a State and national basis. However, 1080 has some disadvantages: it has no antidote; is highly toxic to canids; is relatively quick acting and may result in bait shyness; and causes frequent vomiting in feral pigs (McIlroy 1981; 1983). Equally importantly, mortality after poisoning has been unacceptably low in some field situations (Hone and Pedersen 1980) and under experimental conditions (Hone and Kleba 1984). Recent experimental evidence indicates that the feral pig may be much less sensitive to 1080 than previously believed, with a calculated LD_{50} under unstressed, unfasted conditions of 4.36 mg/kg (95% confidence limits; 2.01-7.43 mg/kg n=60) (P. O'Brien and B. Lukins unpublished data). Further, the response of feral pigs to specific doses of 1080 is highly variable.

In response to these factors, alternatives to 1080 for feral pig control are being evaluated. Hone and Kleba (1984) have demonstrated that the anticoagulant, warfarin, has potential in this role. It is both highly toxic andacceptable to feral pigs, is relatively slow acting, and has an effective antidote. Recently developed anticoagulants have proven even more toxic to feral pigs in preliminary evaluation (P. O'Brien and B. Lukins unpublished data). These agents show considerable promise as safe and effective alternatives to 1080.

Where feral pigs occur in high density in relatively open, but inaccessible habitats, shooting from helicopters is becoming established as an effective means of control. Extensive riverine flood plains and marsh systems, such as the Macquarie Marshes, are particularly suitable sites for aerial control. During the past five years, regular shoots have been undertaken in the Macquarie Marshes, combined with habitat modification and more conventional forms of control. 'Catch per unit effort' data suggest a consistent decline in feral pig numbers as a result of this strategy (Fig. 1). The optimum frequency of control using helicopters and its cost relative to alternatives has not yet been assessed.

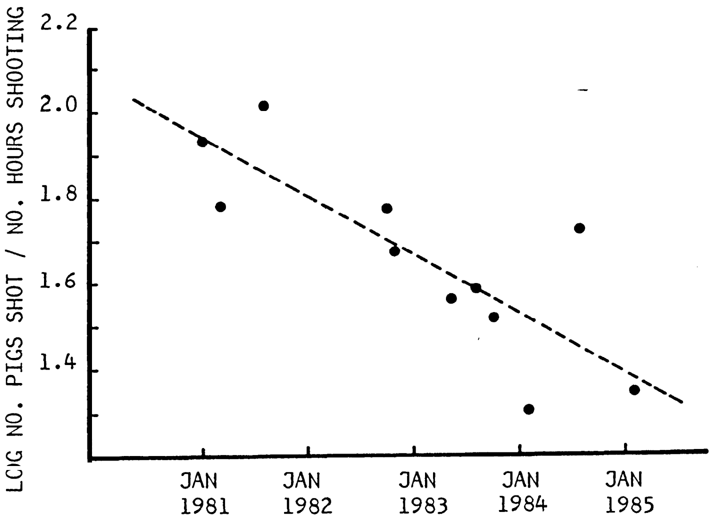

Figure 1 Effect of repeated helicopter shooting of feral pigs in the Macquarie Marshes. (Data includes all flights > 3 hours duration). (R. Hosie and T. Korn, pers. comm.).

Feral pigs are highly regarded as game meat in European markets, particularly West Germany, and the commercial harvesting of feral pigs for export has developed rapidly in Queensland and New South Wales over the past two years. Proponents of commercial harvesting argue that it is a valuable adjunct to commercial control and has effectively reduced feral pig density in many areas. The latter notion is supported by the fact that 107,715 feral pigs were processed at packaging plants in Sydney and Brisbane between 1.7.84 and 31.12.84 (T. Korn, pers. comm.). Critics of the industry argue that it is dependent on pig numbers and therefore there is a vested interest in maintaining supplies, that harvesting places practical and legal constraints on conventional control efforts, and that only large animals are taken.

Two factors caution against any dependence on harvesting achieving long-term control. First, similar ventures have floundered in the past when drought has compromised the quantity and quality of animals that could be obtained (M. Sheehan, pers.comm.). Second, the industry is relatively unstable, with uncertain continuity of demand, and suppliers responding opportunistically to market forces.

CONCLUSIONS

National estimates of the actual potential impact of feral pigs on animal production may be intuitively and politically satisfying, but they are unlikely to be accurate and rarely have either biological or operational relevance. This is a consequence of sparse data and the complex way in which the net value of feral pigs varies with time, place and observer. The need for caution in interpreting large-scale estimates of damage by feral pigs is generally recognized by those who make the estimates (Benson 1980; Tisdell 1982), but rarely by those who use them.

Although I have resisted the reviewer's temptation to generalise feral pig impact from the property to the nation, it is apparent that this animal is an important and underestimated liability to livestock production in Australia. In the event of exotic disease being transmitted by, or established in feral pig populations, national estimates of losses wil1 be appropriate.

The present distribution and abundance of feral pigs, combined with their adaptability and the costs of control, militate against eradication as a management option. Instead, safe, effective and economic control of this pest is an attainable objective in most situations. The means by which this is achieved need to accommodate the problems of specific areas, and are likely to become increasingly refined as new and improved techniques are developed.

THE IMPACT OF RABBITS ON LIVESTOCK PRODUCTION

3. D. CROFT*

The deliberate release of European wild rabbits near Geelong (Victoria) in 1859 and their subsequent spread was a disastrous event for the grazing industries. Within 40 years rabbits had become established throughout the continent, mostly south of the Tropic of Capricorn, and now inhabit approximately four million square kilometres. Rabbits range from subalpine areas to stoney deserts, and subtropical grasslands and wet coastal plains, preferring mediterranean-type climates (Myers 1970).

CSIRO and to a lesser degree State organisations, have extensively studied the biology, ecology, distribution and behaviour of rabbits. Most studies have been directed towards devising effective techniques to reduce rabbit numbers. There is little quantitative information on the effect of rabbits on agricultural production in Australia.

Estimates of economic losses have been derived by comparing returns with and without rabbits present or before and after the advent of myxomatosis (Thompson 1951; Fennessy 1962; Bromell 1972). Even in the absence of quantitative data any competition for pasture imposed by rabbits must be considered detrimental to livestock production.

RABBIT CONTROL MEASURES

For the past 125 years, the control of rabbits has been the responsibility of the farmer and each State Government. In this time rabbit populations have been subject to natural control mechanisms such as predation (cats, foxes, raptors), climatic factors (drought and flood), disease (Coccidiosis), and most importantly, biological control by myxomatosis. Even with the addition of sophisticated methods of poisoning, fumigation, harbour destruction and the rabbit flea as a vector, some landholders have been unable to reduce rabbit populations to an acceptably low level. It is difficult to determine whether this is due to the hardy nature of the animal, the cost of control, or farmer apathy.

Prior to 1950, arsenic and strychnine poisons, trapping and digging out were the major control techniques used against rabbits. Because of the labour intensive nature of these techniques it is understandable that the advent of myxomatosis in the 1950's was considered a major breakthrough. This killed over 99 percent of rabbits infected, causing a major reduction in rabbit populations. However, the disease has become steadily less effective due to viral attenuation and the genetic resistance of rabbits. The reducing effectiveness of myxomatosis has lead

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to greater use of poisons (particularly 1080) and techniques such as fumigation and warren ripping, either as individual programmes or in combination.

While most Australian graziers are aware that rabbits at high densities cause pasture degradation over time and possible loss of livestock production, many consider that controlling rabbits at moderate to low densities is not a viable proposition. In a Western Australian survey of farmers attitudes towards the control of rabbits and weeds, over half (58.7%) stated that more effort should be put into rabbit control, yet one third (30.9%) felt the main responsibility lay with local and State governments (Sexton 1975). This attitude is likely to remain until a monetary value can be placed on the impact of rabbits onlivestock enterprises.

RABBITS AND PASTURE DEGRADATION

Rabbits compete with sheep for available pasture, and when they co-exist, pastures degenerate and soil erosion can occur (Cannon et al. 1973). There is well documented evidence by British workers (Fenton 1940; Phillips 1953; Watt 1957, 1981) that rabbits damage pasture both quantitatively and qualitatively. For example, Thompson and Worden (1956) showed that rabbits depressed ryegrass and clover swards, allowing weeds to invade. A similar study in Australia by Myers and Poole (1963) found that a relatively low to moderate rabbit density (25-50 per hectare) depressed total yield by as much as 25%. They further stated that rabbits were more competent than sheep in selecting seedlings, seed and roots - items which are intimately related to pasture stability. Wood (1984) has pointed out the insidious nature of rabbit damage even at low densities in the Australian arid zone, and that complacency and inaction will produce continual depradation.

In Western Australia, Gooding (1955) found that a light rabbit infestation could cause losses of 10%, but heavy infestations could cause 100% loss. He also noted that species composition changed with the most succulent and nutritious plants disappearing first. Using biomass estimates, B. Cooke (pers.comm.) suggested that large rabbit populations can account for about 60% of the totalgrazing pressure in the pastoral lands of South Australia. He also estimated that even when there were only two rabbits per warren the grazing pressure was about 30% on these pastures.

Costin and Moore (1960) found that the instability of a slope could be amplified by burrowing which led to landslips and the stripping of vegetation. Myers and Pool (1963) also found that rabbits left soil bare by removing large amounts of vegetation and scratching for clover burr. Not only did this allow soil erosion to occur but on bare areas undesirable species such as Patterson's Curse (Echium plantagineum) became dominant.

RABBITS AND LOSS OF ANIMAL PRODUCTION

A major consequence of pasture damage caused by rabbits is a reduction of carrying capacity and loss of animal production. The ratio of rabbits per sheep equivalent has been estimated as between 6 and 15 (Munro and Wright 1933;Wodzicki 1948; Thompson 1951). Overall, I have found a ratio of 9:1 the most realistic and acceptable.

Fennessy (1962) reported that 45 million rabbits were harvested in Australia during 1955-56, which is equivalent to 5 million sheep using the 9:1 ratio. This harvest was probably only a small percentage of the actual rabbit population at that time. In moderate to low rainfall areas where sheep rely on natural pasture, and often browse salt-bush and small shrubs, grazing by rabbits led to a much reduced carrying capacity.

While there is little documented evidence of the loss to the sheep industry caused by rabbits, even less is available to substantiate losses in the cattle industry. There are anatomical differences and variations in vegetation preferences between sheep, cattle and rabbits. Myers and Bults (1977) state that "irrespective of where they live rabbits prefer soft, low-fibre, highly nutritious annual grasses, legumes and herbs". Cattle, on the other hand prefer longer and/or stalkier grasses and have limited ability to forage on clover burr or grass seed which can be utilized by rabbits or sheep. Cole (1973) considered rabbits a grazing competitor with cattle particularly because of their ring-barking of shrubs.

Where rabbit densities are not manipulated prior to a drought, the amount of available feed is further limited by the rabbit population. The control of rabbits prior to a drought may mean the difference between a grazier maintaining stock or losing them through starvation or forced sale. Martin and Atkinson (1978) considered that the probability of a grazier surviving a drought with minimum loss of productivity is inversely related to the rabbit density at the start of the drought.

CURRENT RESEARCH IN N.S.W.

The New South Wales Department of Agriculture is quantifying the effects that rabbits at medium and low densities have on sheep liveweight and wool production. Using four different rabbit densities on uniform pastures, sixteen 0.25 ha plots are stocked with two sheep (equivalent to the district average) and with rabbits at either 0, 6, 12 or 18 per plot. Data are being collected every six weeks on sheep (liveweight, fat depth and wool production), rabbits (weight, breeding condition and reproductive rate) and pasture (composition, heights and vegetation change).

Preliminary results show a trend of improved sheep liveweight and fat depth in plots without rabbits. In other groups there are indications of an inverse relationship between rabbit numbers and factors such as liveweight and fat depth (Table 1).

Table 1 Mean sheep liveweights and fat depths for each of four rabbit densities after six months

Rabbits/ .25 ha	Sheep liveweights (kg)	Fat depths (mm)
0	44.9	1.7
6	45.4	1.8
12	42.0	1.2
18	41.6	0.8

THE IMPACT OF WILD DOGS ON LIVESTOCK PRODUCTION

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Wild dogs (dingoes, feral dogs and hybrids between the two) have been implicated as predators of livestock in Australia since the early development of the grazing industries. They are widely distributed throughout eastern New South Wales and Victoria, particularly in the ranges; in all except the central and central-southern areas of Queensland; and throughout the Northern Territory and much of Western Australia, particularly in the Kimberleys and Fortescue River/Pilbara regions, and northern South Australia.

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In Queensland and South Australia areas 'outside' the dingo barrier fence have the highest densities of wild dogs. In New South Wales, Victoria and the Pilbara region wild dog predation occurs in sheep country adjacent to well-timbered unimproved or crown lands, while in central and northern Australia calves are the most commonly attacked livestock. Poultry and goats are-also subject to predation in closely settled areas.

EFFECTS ON LIVESTOCK PRODUCTION

Macropods are dominant in the diet of wild dogs, domestic livestock comprising only a small proportion of their food intake (Coman 1972; Whitehouse 1977; Newsome et al. 1983). However, the activities of wild dogs in grazing areas are not restricted to killing to satiate hunger and most stock kills are not consumed (Thomson 1984a). Additionally, large losses of livestock can often be attributed to a single animal.

Various studies dealing with the total number of livestock killed by wild dogs identify sheep as the most adversely affected species. From 1958 to 1962, an estimated 21,567 sheep were lost to wild dog predation from 212 properties in the New England region of New South Wales (Wright et al. 1963). A second survey of 600 landholders in north eastern New South Wales showed that losses were small on average but could be severe in individual cases. Seven percent of sheep properties experienced annual losses of 5% or greater, and 84% suffered only occasional killings or none at all (Fennessy 1966). Other direct costs of predation by wild dogs include dog-proof fence erection and maintenance, veterinary costs for injured stock, and control costs, particularly labour. Saunders and Korn (this contract) have dealt more fully with the costs of wild dog control.

There are also indirect costs associated with the presence of wild dogs. Some landholders change their livestock enterprises by reducing sheep numbers, increasing the proportion of cattle or change to cattle only, leading to a loss of profitability in some cases. Estimates by Wright et al. (1963) indicated that landholders in wild dog areas could increase their sheep numbers by 37% if wild dogs were not present. Harassment by wild dogs also may lead to mismothering and production losses. Land values can be affected by proximity to wild dog inhabited lands and development curtailed.

Wild dogs are implicated in the spread of certain diseases. Coman (1972) and Durie and Riek (1952) suggest that a wild dog-macropod sylvatic cycle maintains a high incidence of helminth parasites, particularly hydatids (Echinococcus granulosus) in domestic cattle. Wild dogs could also be important reservoirs of infection for the rabies virus if the disease becomes established in Australia (Murray and Snowdon 1976).

Some livestock producers consider wild dogs to be beneficial as wild dog predation may control macropod populations (Caughley et al. 1980; Shepherd 1981) and hence reduce competition for herbage between macropods and cattle. However, it would appear that owing to overlapping but generally different food preferences competition between domestic grazing animals and macropods is unlikely, except under drought conditions (Dawson et al. 1975).

Feral pigs are a serious agricultural pest (Hone et al. 1981) and a potential reservoir for exotic diseases (Murray and Snowdon 1976). On the basis of a survey of bounty data, Woodall (1983) concluded that dingo predation had a significant effect on feral pig populations in Queensland. However, if wild dog numbers were sufficient to control feral pigs, one would intuitively assume this benefit to be more than offset by predation of livestock, particularly in sheep grazing areas.

WILD DOG CONTROL MEASURES

Graziers rely on four methods of control; exclusion fencing (netting and/or electrified), poison baiting, trapping and shooting. Dog-proof fences, maintained by government and landholder contributions, extend for many hundreds of kilometres along the north western boundaries in New South Wales and across central South Australia and Queensland. In other areas exclusion fences, erected and maintained by graziers, separate grazing areas from wild dog inhabited land.

Two poisons are in use to control wild dog populations, sodium monofluoracetate (1080) and strychnine (not permitted in some States including New South Wales). Poisoned meat baits are either placed by hand where wild dogs are likely to locate them or dropped from aircraft into inaccessible, wild dog inhabited terrain. In New South Wales aerial bait is restricted to areas where hand baiting is impracticable, and is strictly controlled by the Department of Agriculture.

The aim of wild dog control is to prevent livestock losses rather than eliminate all dingoes. By creating a wild dog-free zone between grazing land and wild dog populations the chance of contact between dogs and stock is limited. Research in Western Australia (Thomson 1984b) has shown the "buffer zone" strategy to be effective. A 15 to 20 km wide area, outside stock boundaries, was almost cleared of wild dogs by aerial baiting programmes. Dingo groups slowly became re-established into these zones but it took two years for wild dogs to cross the buffer into sheep country.

The steel-jawed leg trap is another common method of reducing wild dog numbers, particularly when dealing with dogs which will not take baits and in areas where 1080 baiting is prohibited. Shooting is usually opportunist, although ambushes are sometimes set. Drives, where beaters frighten wild dogs towards a line of shooters, are also used to remove troublesome dogs.

FURTHER IMPACT EVALUATIONS

In New South Wales the Department of Agriculture is conducting two surveys throughout the coast and tablelands. One is a continuing survey of the locations of wild dog attacks and the numbers of livestock killed or mauled (Table 1). Predictably, sheep are the most vulnerable of livestock.

Table 1 Reported livestock losses due to wild dog predation for 26 eastern NSW Pastures Protection Boards for the period January, 1982 to March, 1985

Livestock species	Total No. killed	Total No. mauled
Sheep	16,196	3,269
Cattle	481	184
Goats	300	35
Poultry	238	87
Other/Unspecified	87	59

The aim of the second survey is to estimate the economic impact of wild dog predation. From July 1984 to January 1985 six of 91 randomly selected graziers in north eastern New South Wales suffered sheep losses to wild dogs and 13 experienced predation of calves. Nine percent (188 head) of all sheep deaths and 10% (59 head) of all cattle deaths were attributable to wild dogs. A total of 409 man days were spent in wild dog control and prevention activities. Research by government institutions throughout Australia includes: studies of the interaction of sheep and dingoes; testing the buffer zone concept; the development of a humane leg trap;

improvement of control techniques such as fencing and baiting: taxonomic investigations; development of attractants; non-target effects of baiting and trapping; and population biology and general ecology of wild dogs.

A number of ecological and social issues complicate-the central task of developing cost-effective methods of reducing wild dog predation. These issues include the conservation of pure dingoes and non-target wildlife species; problems associated with hybridization; conflicts of interest caused by proximity of agricultural land to National Parks and vacant crown land; and organizational difficulties between wild dog control bodies.

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THE COST AND IMPLICATIONS OF VERTEBRATE PEST CONTROL TO LIVESTOCK INDUSTRIES

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INTRODUCTION

It is extremely difficult to quantify the cost of livestock productionlosses through vertebrate pests due to the nature of their behaviour and the type of damage they cause. In some areas these losses are not always identified and are simply included as part of the overall environmental limitations on the obtainable level of livestock production. We suggest that this occurs because the rural community is not aware that a problem exists and is unwilling to initiate control unless the damage is perceived to be economically important. There is also a related lack of knowledge of control techniques or strategies and how to implement them. These problems are also identified by Swanson (1976), Appleton (1982) and Grant (1982).

In this paper we discuss the cost and effectiveness of vertebrate pest control. More specific information on impact is considered in the previous papers of this contract. In light of this impact we also discuss the necessity for a greater awareness of vertebrate pest problems and the need for a sustained and co-ordinated control effort.

COSTS OF VERTEBRATE PEST CONTROL

As an example of the levels of expenditure on vertebrate pest control we consider the State of New South Wales. All rural landholders in the State contribute to the cost of vertebrate pest control through various taxes and levies. State and Federal taxes fund Government bodies involved in land management which in turn allocate funds for expenditure on vertebrate pest control. The principal Government bodies involved are the Department of Agriculture, National Parks and Wildlife Service and Forestry Commission.

In 1984 the Department of Agriculture's allocation to the regulation, extension and research of vertebrate pest control was approximately $430,000. Various industry and Federal bodies contributed $100,000 for research and control purposes. An additional $140,000 was allocated to subsidise wild dog control and a further $12,000 for the control of vertebrate pests on unoccupied crown lands. The National Parks and Wildlife Service and Forestry Commission estimates their expenditure in

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1984 on vertebrate pest control to be in the order of $500,000 and $140,000 respectively. The total Government expenditure on vertebrate pest control in N.S.W. was thus about $1.3m in 1984.

The Pastures Protection Board System in N.S.W. has legislative responsibility for the organisation of vertebrate pest control. This system is funded through landholder levies which are in part used to employ vertebrate pest control officers. In 1984, the cost of employing these officers was $1,739,000. An additional levy of $693,000 was collected for the specific purpose of wild dog control, the majority of which is spent on the maintenance of the wild dog fence in the north west of the State.

In 1984, 1080 poisoning by landholders involved 3725 man days and $309,000 in costs of bait and materials for rabbit control, 428 man days and $35,000 for feral pig control and 695 man days and $28,000 for wild dog control. This gives a total of 4848 man days and $372,000. Other known expenditure by landholders involves the hire of helicopters and use of ammunition for feral pig control. In 1984 this amounted to $80,000.

Because of the variety of alternative control strategies which are equally as expensive and labour intensive as 1080, the above figures could conservatively be doubled to estimate the total cost of landholder initiated vertebrate pest control. This would provide a figure in the order of $1m and 10,000 man days per annum.

In summary, the total expenditure on vertebrate pest control in N.S.W. for the year 1984 is estimated to be of the order of $4m not including landholder labour costs.

EFFECTIVENESS OF CONTROL

Despite the annual commitments made for control, Croft (1983) reported that the majority of N.S.W. was affected by one or more vertebrate pests (Table 1).

Table 1 Percentage of N.S.W. affected by low, medium or high densities of vertebrate pests

Vertebrate Pest	High	Medium	Low	Total
Rabbits	4.2	11.0	68.8	84.0
Feral Pigs	8.5	20.0	18.2	46.7
Wild Dogs	0.6	3.2	10.0	13.8

It cannot be inferred that increased funding would improve the cost of efficiency of control. Changes in the nature of the vertebrate pest problem (for example, expansion of the distribution and impact of feral pigs in Tableland areas) may also require the adoption of new or modified control techniques. However, examples exist where significant results have been achieved in reducing long term cost of control and population levels through a recognition of the existence and extent of a vertebrate pest problem and by co-ordinating available resources to solve that problem. The effectiveness of this approach is supported by Appleton (1982) who surveyed landholders and concluded that feral pig control required an organised strategy involving producers, local authorities and relevant state government departments to achieve effective, long term damage reduction.

A co-ordinated strategy was the basis of a pilot scheme to control feral pigs in north-west N.S.W. Where implemented this approach produced significant results

(Bryant et al. 1984). This has been particularly evident in 18,000 ha of the Macquarie Marshes where the combination of poisoning followed by helicopter shooting over a period of four years has produced a consistent decline in feral pig numbers (see above).

A similar success was achieved with rabbit control on 179 properties at Rankin Springs in N.S.W., covering 248,500 ha plus 19,000 ha of Crownland (Table2).

Table 2 Rankin Springs rabbit control programme (R. Hosie, personal communication)

Year	Rabbit Infestation Level (No. of properties)				Control Inputs	
	High	Medium	Low	Free	Bait (kg)	1080 (g)
1976	50	46	62	21	56,322	6,913
77	12	19	92	56	24,675	5,641
78	2	12	102	63	19,641	2,294
79	5	6	71	87	10,937	1,354
80	3	10	81	80	16,647	3,147
81	0	12	77	90	6,210	789
82	0	0	75	104	4,935	520
83	0	0	78	101	360	40
84	0	4	82	93	2,414	246

EXOTIC DISEASE IMPLICATIONS

So far in this paper we have considered the need to control vertebrate pests to reduce immediate costs to livestock production. Perhaps of equal importance as motivation for improved control, are the implications of exotic disease. The feral pig has been identified as the species of highest priority for control because of its potential role as a reservoir and spreader of exotic animal diseases. These might include Foot and Mouth, African Swine Fever, Rinderpest, Swine Vesicular Disease and Vesicular Stomatitis.

The greatest loss as a result of an exotic animal disease outbreak would be associated with the closure of export markets. Doyle (1980) suggested that in the event of Foot and Mouth Disease, the reduction in the first year alone in rural production would be in the order of $2,500 million. The actual magnitude of this loss would be dependent on the time taken to establish that the disease was completely eliminated. Procedures for quarantine, destruction of infected stock and vaccination, can be readily implemented in the case of domestic stock as detailed in various contingency plans adopted by State and Federal authorities.

Feral pigs, on the other hand, are difficult to contain within defined boundaries, and are difficult to eradicate quickly over large areas. Should an exotic disease become established in a feral pig population, the time taken to eliminate the disease and hence the cost to livestock industries, could be substantial. The cost of feral pig eradication under these circumstances would also be significant.

As distinct from our knowledge of suitable control techniques for vertebrate pests in normal agricultural situations, there are acute deficiencies in preparedness to control or eradicate feral pigs in an exotic disease emergency. For this reason the N.S.W. Department of Agriculture in conjunction with the Commonwealth and Queensland Departments is developing contingency plans and appropriate control strategies for implementation in such an emergency.

CONCLUSION

Vertebrate pests are a significant problem to the livestock industries. The objective of their control should be to maintain densities-at the level where economic losses do not exceed the cost of effective ongoing control. This cannot be achieved merely by reactive control strategies. Fennessy (1966) refers to these as the traditional "fly-swat type of pest control" which simply reduces symptoms. Significant results require a recognition or awareness of the problem, careful planning, a co-ordinated approach, and maintenance of control effort.

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