CHAPTER 9: THE BEHAVIOUR AND MANAGEMENT OF PEST SPECIES

Before we can discuss the behaviour and management of pest species, we must formulate a definition of 'pest'. A pest is a troublesome or destructive animal; so a pest species can be defined as any animal that causes destruction or is a problem in an area.

Different species have very different potentials as pests. Some may become:
1. widespread, e.g., rabbit
2. localised, e.g., dingo, emu, donkeys, goats, pigs, various kangaroo species.

Often the pest species is a feral animal. Currently there is no standard definition that is accepted by all parties who are interested in this subject (Report on Feral Animals in the Northern Territory, referred to in this chapter as F.A.N.T., 1979). Feral means 'wild, untamed, uncultivated' (Oxford). Taken literally, feral animals would include:
1. native fauna, e.g., dingoes
2. introduced wild animals, e.g., rabbit, fox
3. feral livestock, e.g., buffalo, pigs, cattle, horses (brumbies) donkeys, camels, goats, cats, dogs.

In some states there is legislative declaration of pest status. For example, in NSW rabbits, feral pigs and wild dogs are proclaimed as Noxious Animals under the Pastures Protection Act, 1934, and the legislation requires landholders to control and destroy such pests. (Robards, 1986).

Recently, some writers have narrowed the term 'feral' to include only feral livestock. In certain localities any of the animals in the above three categories can be a pest.

Pests have a direct effect on man and his domestic animals. They can:

a. compete with domestic livestock for food and water;

b. carry exotic diseases. Also, the control of any introduced diseases could be hampered by wild herds or groups, acting as reservoirs for disease, e.g., foot and mouth, blue tongue, rinderpest;

c. damage man's crops (e.g., wild pigs) and fences;

d. contaminate water needed for stock;

e. have a deleterious effect on lambing percentages.

Management and control of pest species

There are several ways to control pest species. Reduction, control and elimination where possible, are the key factors, although elimination may be almost impossible. During the process of reduction and control of pest species they should be utilised to the maximum extent by:

1. bringing them back under domestication, if possible;

2. harvesting and converting them to useful products, unless this is quite impractical.

At the moment, the usual ways of attempts at control are being used: shooting, trapping, poisoning and fencing, but commercialisation has begun in some species, e.g., pigs, camels, kangaroos, goats. C.S.I.R.O. (Commonwealth Scientific Industrial Research Organisation) has an incentive scheme for export development and the Northern Territory is fostering an ox and buffalo market in S.E. Asia and the Middle East.

However, once a pest species is a commercial asset, it becomes 'farmed' and will not be eradicated. There are many factors to consider in the harvesting and using of wild animals:

1. moral aspects of the conservationist, who fears extinction of native species;

2. aesthetic aspects - people do not like seeing animals hunted, e.g. deer, rabbits, and kangaroos. Cultural traditions provide each society with a set 'table of animal values' and in our society snakes, wolves, foxes and bats are judged to be ferocious, cunning and dangerous. On the other hand, deer, rabbits and seals are spoken of as gentle and sweet. Like all prejudices, fixed ideas about animals tend to be accepted as truth (Cohen, 1978).

3. sporting aspect - the hunting and trapping of animals for sport is opposed by some groups of people;

4. commercial aspect.

Before effective control measures can be taken of any pest species, an estimation of population size and localities where they are found to be causing problems is needed. The localities of the Australian pest species have been mapped but an accurate estimation of population is more difficult.

Population size depends on:

a. births and deaths;

b. immigration and emigration.

There are several methods used to estimate the population, and these include:
1. a direct count of all animals present in an area. This is very difficult, especially in a wooded area.
2. sample counts, which can be done by aerial counts or shooters' counts. This can be done at different times of the year but is expensive and inaccurate.
3. indirect counting. This can include counting faecal pellets in an area and estimating the number of pellets per animal. The number of pellets produced by any animal can be influenced by age, sex and diet, so it is an inaccurate method. Another method is to count the number of animal calls (e.g., bird calls) within a certain locality.
4. trapping. Animals can be trapped, counted and marked, then released and later retrapped.
Using the formula:

$$\frac{\text{number of marked animals trapped}}{\text{total number trapped}} = \frac{\text{total marked}}{\text{population size (N)}}$$

$$\text{e.g.} \quad \frac{5}{35} = \frac{20}{N}$$

Therefore, N = 140 = population size. However, there

are several problems using this method:
1. one must assume all animals are equally trappable;
2. one can get animals that are 'trap-happy' and get caught many times, or the animals that learn to avoid traps.

It can be seen that estimation of a population is a difficult problem. Apart from the estimation of population, an understanding of the pest animal's behaviour (which includes reproductive behaviour) is needed before effective controls can be implemented.

The National Feral Animal Control Program (NFACP) is a program put in place by the Commonwealth Government with the specific aim of reducing the impact of feral animals. It is funded by the National Heritage Trust program and managed by Environment Australia and the Bureau of Rural Sciences. The program aims to develop and implement projects to reduce the impact of feral animal pests on native species and the natural environment. It also deals with agricultural damage caused by feral animals. (Environment Australia 5/9/2001a)

BEHAVIOUR OF PEST SPECIES AND SOME CONTROL METHODS

The following pest species will be discussed:

1. Feral pigs
2. Dingoes and feral dogs
3. Feral goats
4. Feral donkeys
5. Kangaroo species
6. Rabbits

FERAL PIGS

Feral pigs (***Sus scrofa***) are now in such numbers, and are creating such havoc in the rural industry that they rival dingoes as a major pest. In Queensland alone the population is estimated to be between 1.6 million and 2.3 million (Courier Mail Report 4.3.82).

More recent estimates put the probable population size in Australia between 3.5 and 25 million (Mason and Fleming, 1999).

They are found through Queensland, New South Wales, the Northern Territory and parts of Western Australia, usually along the watercourses. The colonies derive from domesticated stock brought in as a food source for settlers. Some of these subsequently escaped or were deliberately let go (F.A.N.T., 1979).

There are two types of feral pigs derived from European breeds, e.g. Saddlebacks, Tamworths and Large Whites, and the Chinese or Asian type, with horizontal stripes and a ruff on the neck. The total number of feral pigs is unknown throughout Australia and there is a need for an accurate estimate.

Feral pigs are found from western Victoria, through New South Wales into Queensland; and across northern Australia from Cape York in the east to the Kimberley region in the west (Environment Australia. www.ea,gov.au/biodiversitv)

Feral pigs are simultaneously perceived as a vector of diseases that could cause a potential national disaster (*In terms of exotic disease) by some, and as an export commodity and hunting asset by others (O'Brien, 1996).

Habitat

Generally pigs tend to concentrate near watercourses and billabongs, but during the wet season they range further through the open forest country. Because they are water-dependent there can be huge die-offs in time of drought (Squires, 1981).

Feral pigs are highly mobile and non-territorial. (O'Brien 1986).

Behaviour

1. The pig is omnivorous, with a diet ranging from roots, grass and the shoots and leaves of edible species such as Pandanus palm, to the dead carcasses of animals. It predates on fauna when the opportunity arises (F.A.N.T. 1979).

2. Its rooting habits can cause holes which provide hazards to vehicles and horsemen, as well as destroying whole pastures. The pig's habit of wallowing and rooting around the edges of watercourses and swamps destroys the vegetation that prevents erosion and provides food and nesting sites for native wildlife. (Environment Australia 5/9/2001b)

3. Breeding - pigs are prolific breeders capable of two litters per year so that they can rapidly colonise an area, even after partial eradication. A four-year study showed there was no seasonal pattern of breeding (Giles, 1978a). Young sows commence breeding at between 6-12 months of age, providing live weight exceeds about 30 kg. Mean litter size of sows shot in New South Wales, who were eight months or older, was 6.29 (Giles, 1978b). Sows often exhibit an infertile oestrus after farrowing, but lactating sows can be successfully rebred. A fertile heat occurs after weaning (Graves 1984). Several males may mate with one female. This may play a large factor in genetic variability of pigs, especially when oestrus is synchronised (Delcroix, Mauget and Signoret, 1990).

4. The feral pig has learnt to stand still and drop into the grass, making it difficult to see. It moves and feeds in the evening and early morning which adds to the difficulties of control.

5. Problems caused by pigs include damage to fences, bores, roads, pastures; the killing of lambs and predation on fauna. Wilson and O'Brien (1989) suggested that in the event of Foot and Mouth Disease epizootic in Australia, feral pigs may act as a major amplifying host for the disease. In its initial year, a Foot and Mouth Disease outbreak could cost Australia about $5 billion in lost export revenue.

Piglets are prone to a high mortality rate, depending on food supplies and weather conditions.

Sows (female pigs) will aggressively protect their young from any threat.

Feral pigs are highly mobile and non-territorial (O'Brien, 1986).

Feral pigs kill and eat up to 40 per cent of lambs born in some areas, costing the sheep industry millions of dollars each year (Environment Australia, www.ea.gov.au/biodiversity

In addition to the direct losses associated with predation, there are indirect losses to sheep farmers, including decreased production as a result of harassment, increased of mis-mothering, and a decreased rate of genetic gain (O'Brien, 1986).

Control measures

• The dependence of the feral pig on water means some control measures will succeed by poisoning around water holes.

• Poisoning is most commonly carried out by the compound 1080 (sodium monofluroacetate) in grain. It is the only toxin recommended for use by the NSW Department of Agriculture. There are some disadvantages of this compound: it is highly toxic to canids; there is no antidote; and it is relatively quick acting and may result in bait shyness. It causes frequent vomiting in feral pigs. Equally important, mortality after poisoning has been unacceptably low in some field situations (O'Brien 1986).

• Alternatives may include anticoagulants, for example Warfarin, which is highly toxic and acceptable to feral pigs, relatively slow acting and there is an effective antidote (O'Brien 1986).

• When accessibility is limited, poisoning may be possible by utilizing aircraft to distribute the baits (Mitchell 1998).

• Trapping, shooting and baiting pressures could be increased in known problem areas.

• More intensive campaigns, of say 2 months' duration, towards the end of each dry season, involve station cooperation and all available techniques (F.A.N.T., 1979).

• Commercialisation, to sell feral pig meat to the European market has already commenced in Queensland.

• In 1990, Australia exported in excess of 1500 tonnes of wild pig meat to European countries (Environment Australia 5/9/2001b).

• Hunting dogs were successful on 88% of occasions of catching and cornering solitary pigs when encountered (Caley and Ottley 1995).

• The 'Judas goat' method can be adapted for use with pigs (McIlroy and Gifford 1997).

Control is an enormous problem which involves high cost and is likely to need very well organised campaigns as feral pig populations can increase at 80 to 110 per cent per annum, depending on the area and seasonal conditions. (Environment Australia 5/9/2001b)

DINGOES AND WILD DOGS

The dingo (***Canis familiaris dingo***) is the main carnivorous species affecting sheep and cattle. Many are hybrids with red kelpie and blue heeler. The dingo population extends over very wide areas; in Victoria and New South Wales it is confined to the eastern portion of the states; and in Queensland dingoes occur towards the periphery of the sheep country that extends in a broad tongue up through the centre of the state. In South Australia, Western Australia and the Northern Territory dingoes occur throughout the low-rainfall country, and they extend into the high-rainfall country in the north (Fennessy, 1970). In Queensland and South Australia, areas 'outside' the dingo barrier fence have the highest densities of wild dogs/dingoes (Fleming and Robinson, 1986).

Behaviour

1. Carnivorous, and will gang up to kill calves, sheep and kangaroos. The type of prey available, the relative abundance of the various species of prey and the nature of the environment (stable and fluctuating) influence the foraging strategies of dingoes (Thomson, P.C. 1992b).

2. Breeding. There is a well-defined seasonal reproductive cycle in both male and female dingoes. Bitches breed once a year and mating takes place between April and June;e males produce very few sperm in summer (Newsome et al., 1973). Gestation is about 63 days and there may be four to six pups in a litter. They can live for eight to 10 years but many die younger. Alloparental behaviour is exhibited in which both parents regurgitate food for pups. Pack members may also provide for bitches confined to the den with very young pups. (Thomson, P.C. 1992a)

In undisturbed social groups usually only the dominant female's pups are raised each year. When group hierarchies are disrupted, for example, by control measures, more females raise litters, leading to increased numbers of juvenile dingoes (Thomson, 2000).

3. Movements are generally quite localised, within a 7 km range, with the furthest observed about 34 km (Newsome et al., 1973). There are two patterns of movement: a reconnaissance pattern, which takes in visits to scent posts, and maintains communication between animals; and a hunting pattern, which is a zigzag pattern (Figure 9.1, Sheehan, personal communication). Dingoes are equally active day and night, spending about nine hours resting and 15 hours active. Packs will move within their territories in response to movements of their prey (Ballard et al. 1987).

4. Problems caused by dingoes include: damage to sheep, cattle and other fauna, carrying disease (especially distemper and an array of parasites e.g. hydatids).

5. Some livestock producers consider wild dogs to be beneficial as wild dog predation may control macropod populations and hence reduce competition for herbage between macropods and cattle (Fleming and Robinson 1986).

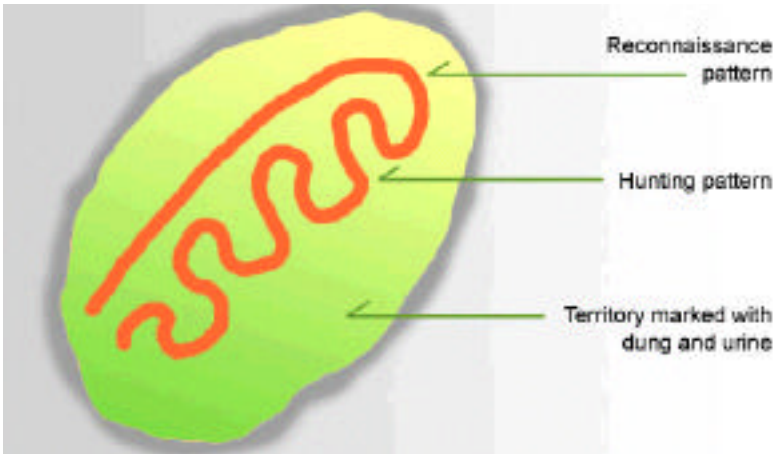

Figure 9.1: Patterns of movement of a dingo in Queensland.

6. Dingo predation has had a significant effect on feral pig populations in Queensland (Woodall 1983).

Macropods are dominant in the diet of dingoes, domestic livestock comprising only a small proportion of their food intake. However, the activities of wild dogs/dingoes are not restricted to killing to satiate hunger and most stock kills are not consumed (Flemning and Robinson, 1986).

Stomach analyses of dingoes have revealed diets containing insects, carrion, rabbits and some relatively rare native species (Thomson. 2000)

Other direct costs of predation by dingoes include dog-proof fence erection and maintenance, veterinary costs for injured stock, and control costs, particularly labour (Fleming and Robinson, 1986).

Dingoes are highly sociable animals. They live in a well-defined home range in groups of 2–10 or more, but members of the group are seldom seen together at any one time. Most of the time they form small, flexible sub-groups (Thomson, 2000).

Dingoes usually attack rams from the rear, most probably to avoid the ram's horns, which are used for defence. Sometimes the testicles are bitten off live rams (Thomson, 2000).

Control measures

• With poison, using the sodium salt 1080.

• Shooting and trapping.

In the regions of Australia where eradication has been accomplished, this has been primarily due to the pressure of settlement and has first involved erecting a dog-proof fence and then killing the dingoes inside the fence by trapping, shooting or poisoning. In 1954, a dingo fence was built in Queensland, 6,000 km long and 1.85 m (6 ft) high, around the sheep area but it is costly to maintain.

The steel-jawed leg trap is also used, especially when dealing with dogs that will not take baits and in areas in which baits are not permitted (Fleming and Robinson 1986).

A number of ecological and social issues complicate the task of dingo control, including the conservation of pure dingoes and non-target wildlife species, problems associated with hybridisation, and conflicts of interest caused by the proximity of agricultural land to National Parks and vacant Crown land (Fleming and Robinson, 1986). The aim of dingo control is to prevent livestock losses rather than to eliminate all dingoes. This can be achieved by creating a dingo-free 'buffer' zone between grazing land and dingo populations (Fleming and Robinson, 1986).

FERAL GOATS

The goat (***Capra hircus***) was introduced to arid areas as a source of fresh milk and meat in homesteads and mining camps. Feral herds are now established in Western Australia, Queensland and western New South Wales and in the Flinders Ranges of South Australia. There are no permanent colonies in the Northern Territory mainland but some of the off-shore islands have colonies.

Behaviour

1. Animals graze off green shoots and most non-woody dry material for about 1.5 m (5 ft) above ground level. They are selective grazers.

2. Breeding. The female feral goat gives birth in isolation in a secluded spot, selected before parturition. Twinning is common (52%) but 1-5 kids may be born. Breeding occurs throughout the year providing that favourable nutritional conditions prevail. Male goats exhibit urine marking, resulting in the synchronising of oestrus among females. Males court females with a series of increasing contact patterns culminating in copulation. Dominance relationships between males are strongly exhibited in the wild, where an individual's social rank is determined by horn size, age, weight and behaviour (Shackleton and Shank 1984).

3. Feral goats show a strong inclination to home range, with males moving over several home ranges of the more restricted female. Female kids tend to adopt the home range of their mothers but males move away at weaning (Harrington, 1982). Furthermore, studies of movements showed that feral goats would move out of their home range, sometimes by over 100 km, and while this seemed to be prompted by low nutrition or lack of water in some cases, in others the reason was not apparent.

These characteristics make feral goats almost impossible to control because it is considered uneconomical to maintain the standard of fences required to restrain them or to keep out wild bucks (Harrington, 1982).

4. Problems caused by feral goats include a disease risk, damage to vegetation, competition for food with sheep and cattle, competition with native animals for food and shelter, and accelerated soil erosion.

Australia has an estimated 2.6 million feral goats, distributed in all states and territories, except the Northern Territory (Parkes, Henzell and Pickles, 1996).

Estimates of goat densities range from two (average density in all states during the early 1990s) to five (estimate in more preferred habitats) per square kilometre. At these densities feral goats would be contributing from 10% to 25% of the total pressure on sustainable grazing (Parkes el al., 1996).

Feral goat populations survived and proliferated in many environments for reasons such as high levels of fecundity, lack of predators, freedom from disease, high mobility, and diverse diet (Henzell, 1992).

Feral goats could facilitate the spread of exotic diseases (such as foot-and-mouth disease) should such diseases enter Australia.

Feral goats can carry many internal and external parasites, some of which (e.g., foot rot) can affect sheep.

Goats become sexually mature at an early age and have a gestation period of 150 days, so feral goats are able to produce up to two litters per year.

Control measures

• Shooting is the main means of control.

• Commercialisation has the potential for up-grading feral goats to become good cashmere producers. Also, female feral goats are greatly in demand for up-grading to Angora bucks. However, the bulk of feral goats are exported as carcasses.

• Trappers operate by erecting traps around the watering points that are used when mustering the animals (Axford, G 1/8/2001).

• The dingo can adequately control feral goats in some areas. In the eastern rangelands, goats can shelter around steep rocky outcrops giving them protection from dingo attack. In pastoral regions, dingoes are heavily controlled by pastoralists or have been removed (Environment Australia 5/9/2001c).

The feral goat has not been eradicated from any extensive mainland environment in Australia. Eradication from island habitats, however, has been successfully achieved in Australia (Allen and Lee, 1995).

Complete removal or feral goats from Australia is well beyond the capacity of available techniques and resources because the species is well-established across a vast area (Environment Australia, 1999a).

Although mustering feral goats for slaughter or live sale is labour-intensive and limited to relatively flat terrain, it is worthwhile, especially when goat densities are high (Harrington, 1982b).

The success of mustering in reducing the population can vary greatly, with reduction rates of 26% to 80% having been reported (Henzell, 1984).

Trapping groups of goats around watering, points can be an effective and efficient control technique and is most effective during dry periods when goats are obliged to find water and there is limited access to alternative water sources (Harrington, 1982b). However, some-concerns have been expressed about the use of traps at water points and the potential deleterious impacts on non-target species and animal welfare (Environment Australia, 1999a).

Fences will not permanently stop the movement of all goats and should, therefore, be used only as a tactical technique in a management program (Parkes, 1990). Fencing is also expensive to establish.

Ground-based shooting is not commonly used as a control strategy for feral goats in the pastoral areas of Australia due to its labour-intensity and its variable efficiency. However, volunteer shooters have been successfully used to conduct ground shooting (Environment Australia, 1999a).

Aerial shootings are used to control inaccessible populations, manage low-density populations or remove survivors from other control campaigns (Parkes et al., 1996). This method is costly, but allows difficult terrain to be covered quickly and gives culling rates far in excess of other control methods (Lim, Sheppard, Smith and Smith, 1992).

The 'Judas goat' technique involves attaching a radio collar to a feral goat and releasing it in the expectation that it willl meet up with other goats. The goat is then tracked down and the herd it has joined is killed. 'Judas goats' are generally used where there is a low-density population or to locate survivors of other control programs. However, this technique is expensive as it requires costly equipment and skilled staff (Parkes et al., 1996).

The only poison that has been trialed for feral goat control is 1080 (sodium monofluoroacetate). The main risk of this technique is the consumption of baits by non-target species.

Three baiting techniques have been reported: pelletised grain bait (Forsyth and Parkes, 1995); foliage baiting (Parkes., 1983); and poisoning of a water supply (Norbury, 1993). The poisoning of the water supply was the only technique that was successful in Australia.

FERAL DONKEYS

NB These animals are no longer regarded as pests

Feral donkeys were introduced for draught animals during the early exploration and settlement of much of inland Australia and in the Northern Territory.

Habitat

They favour river frontages, where forage types are more varied and water is more often available. However, to avoid man who is their only predator, donkeys often retreat to broken, rocky hill country (F.A.N.T., 1979).

Behaviour

1. Donkeys are gregarious and tend to cluster in large

mobs. They are adept at digging for soakage water in dry stream beds and will apparently drink saltier water than horses or cattle.

2. They eat any plant that grows.

3. A study of the Victoria River, Kimberley area (McCoot et al., 1981) it was noted that donkeys walk along well-defined pads radiating from waterholes. When shot at, they flee along these pads.

4. Jennies (females) were found in groups of up to 15, accompanied by their foals and a mature jack (male). Most males were found in bachelor groups of up to 10 but a few were solitary. The family group male was the leader of the group and if the jennies were shot, the jack brayed toward the shooters and then led the remnants of the group away.

5 Breeding has a marked seasonality and over 50% of conceptions occurred before the onset of the wet season. Reproductive rate was high.

Control measures

The economics of harvesting donkeys for pet-meat are tenuous due to the rugged country causing extensive damage and limited access to freezer facilities (McCoot et al., 1981). It is suggested that Northern Territory pastoralists be granted a subsidy on ammunition used in the control of feral animals. Optimal impact would be achieved by ammunition provision accompanied by organised 'donkey drives' over large areas, perhaps using helicopters. Water-traps can also be useful in less-favoured areas (McCoot et al., 1981).

KANGAROOS

There are four major kangaroo species in the inland that might become problems in areas at some times. These are the grey kangaroo (two species eastern and western greys), the red kangaroo and the hill kangaroo or euro (Squires, 1981). There are conflicting views about kangaroos; many farmers regard them as direct and serious competitors with their stock and insist that numbers be reduced. Some people feel they should be harvested for meat and furs, and others feel they should be protected because they are unique to Australia. Discussions on these views are complicated by there being several species of kangaroos (Fennessy, 1970).

*Euro (***Macropus robustus*)

The euro occurs in pest numbers in the north-west of Western Australia. They are found in rocky hills and ranges and, being sedentary, are vulnerable to shooting. Studies have shown that they are not in direct competition with stock all the time, and in areas where the euro population increased it was due to the sheep eating out the original pasture and it being replaced by spinifex species which euros eat but sheep find unpalatable (Fennessy, 1970).

*Red Kangaroo (***Megalteia rufa*)

This kangaroo lives in the open plains, grassland and lightly timbered country, characteristic of the arid and semi-arid regions. It is the most mobile of the species and is in some danger of extinction as it is easy to shoot in its open habitat. It inhabits much of the inland sheep area and competes with sheep for living space and food in some areas of western New South Wales and south-west Queensland (Fennessy, 1970; Squires, 1981).

Grey Kangaroo (eastern grey, **Macropus giganteus***; western grey,* **M. fuliginosus***)*

There are two species, one in eastern Australia and the other throughout southern to western Australia. Their distributions overlap in western Victoria and southwestern New South Wales, and they are regarded as pests in Queensland, and are locally troublesome in New South Wales, Victoria and Western Australia. Grey kangaroos favour coastal forests and denser inland scrubs; they feed on open plains within range of suitable forest shelter (Fennessy, 1970).

Problems

The most important factor is the possible competition between livestock and kangaroos grazing the same area. When food is readily available they rarely compete directly, because although sheep and kangaroos eat the same classes of plants, they often prefer different species in different proportions.

Control measures

In the areas where the kangaroo is thought to be a pest, shooting is the usual control method used. Commercialisation of kangaroo meat and the skin industry has absorbed at least one million animals each year, in recent years. The kangaroos, almost entirely red and grey, were collected mainly in western New South Wales and southwestern Queensland (Fennessy, 1970).

The potential supply of kangaroo meat in Australia is 57,000 t/year. The total national production of regular meat (eg beef, lamb) in 1992–93, totalled 2,807,000 t. Therefore, the potential kangaroo meat supply amounts to only 4% of the total current red meat production (Hardman, 1996).

At a retail price of $6.00/kg, the potential value of kangaroo meat is approximately $340 million per year (Hardman, 1996).

The current situation in Queensland and most other states is that 75% of kangaroos are shot for their skin only, (carcases not utilised). The remaining 25% are shot mainly for pet food at a retail price of $0.85–$l.05/kg (Hardman, 1996).

RABBITS

Rabbits are found in the southern half of Australia and have never extended far north of the Tropic of Capricorn or to the subtropical coastal belt receiving summer rainfall. The mainland populations originated from a small shipment liberated in Victoria in the 1850s. The rapid spread and growth of the rabbit population caused per-

manent degradation of pastures, erosion and a marked reduction in stock-carrying capacity. Rabbits also ringbark and kill trees and dump subsoil on the surface.

One rabbit can consume 200-500g of vegetation nightly causing serious loss of ground cover, which leads to erosion as well as the loss of stock feed and seed supplies for future years. (Croft, D. 1/8/1998)

Damage by wild rabbits in Australia, including the annual cost of control and production losses, has been estimated at $600 million (Environment Australia 5/9/2001d).

The introduced European rabbit (***Oryctolagus cuniculus***) is one of the most widely distributed mammals in Australia. and, except for the house mouse, the most abundant (Williams, Parer, Coman, Burley and Braysher, 1995).

It is estimated that rabbits now inhabit an area of 4.5 million square kilometres or about 60% of Australia.

Rabbits breed in response to a combination of environmental factors, including an increase of green grass in their diet and cool temperatures.

Female rabbits become sexually mature at three to four months and can produce litters of four or five young every month.

The impact of rabbits on native animals and plants is becoming increasingly recognised and includes competition with many native animals for food and shelter, and damage to native vegetation through ringbarking, grazing and browsing.

The decline and extinction of many of Australia's terrestrial mammals that weigh between 35 and 5500 grams, particularly in the arid and semi-arid zones, was associated with the introduction of the rabbit (Calaby, 1969).

Rabbits/0.25ha	Sheep live-weights (kg)	Fat depths (mm)
0	44.9	1.7
6	45.4	1.8
12	42.0	1.2
18	41.6	0.8

Table 9.1: Mean sheep liveweights and fat depths for each of four rabbit densities (Croft, 1986).

Agricultural production losses due to rabbits in South Australia alone are estimated to be around $20 million each year (Environment Australia, 1999b).

The key to the success of the rabbit in Australia is the ‘warren’, which provides protection from weather and predators and enables rabbits to inhabit semi-arid and arid country (Williams et al., 1995).

There are indications of an inverse relationship between rabbit numbers and factors such as liveweight and fat depth of sheep (see Table 9.1).

Control measures

A combination of methods is used to control the rabbit:

• destroying warrens through ripping, ploughing, blasting and fumigating;

• poison baiting;

• shooting and hunting with dogs;

• releasing predators, for example, cats and foxes;

• rabbit-proof fencing;

• biological control, for example, myxomatosis and rabbit fleas (CSIRO 17/9/1996).

Myxomatosis was introduced in late 1950 after a long series of field trials, and was spread rapidly through the rabbit population by mosquitoes and sand flies. Within three years the population was reduced to 10-20% of its level before the spread of the disease (Fennessy, 1970). Poisoning, fumigation of burrows and destruction of warrens by ripping them up, and the use of steel traps and dogs are all control methods used to keep down the surviving rabbit population, which has become increasingly resistant to the myxoma virus.

The kill rate today is often less than 50 per cent, as rabbits have gained increasing resistance to the myxoma virus (CSIRO 17/9/1996).

In 1990 a team from the South Australian Animal and Plant Control Commission imported a new species of rabbit flea from Spain. The flea has been released into rangelands in South Australia, New South Wales, Queensland and the Northern Territory. The Commission anticipates that the flea will assist the spread of the myxoma virus in drier areas of the continent where mosquitoes are not present (CSIRO 17/9/1996).

Scientists believe that it is now possible to modify the myxoma virus to include genes that will prevent conception in rabbits. (CSIRO 17/9/1996)

Initial results of Myxomatosis were promising, with mortality rates well over 90% in rabbits that contracted the disease. Because some rabbits developed limited resistance to the disease, the virus currently affects no more than 60% of rabbits exposed (Environment Australia 1999b).

Eradication of rabbits on the mainland is not possible but there are effective ways to reduce rabbit numbers and to lessen the impacts of competition and land degradation on wildlife in significant areas (Environment Australia, 1999b).

Schedule 3 of the Commonwealth Endangered Species Protection Act 1992 requires the preparation and implementation of a threat abatement plan, and this was conducted in June 1999 by Environment Australia under the National Heritage Trust.

Rabbit Calicivirus Disease (RCD) was first noticed in China in 1984. In March 1995 field investigations began on Wardang Island, South Australia. In October 1995 the virus escaped onto the mainland, possibly as a result of windborne vectors (Cooke, 1996). It spreads through direct contact with other rabbits and does not need an insect to spread it (Environment Australia 5/9/2001d).

The rapid spread of RCD in Australia, more than 400 kilometers per month, suggests that windborne insect vectors may play an important role in its transmission in Australia (Cooke, 1996)

Little information has been published on mortality rates in wild rabbits, however, in South Australia mortal-

ity rates exceeding 95% were observed in populations not previously exposed to RCD (Cooke, 1996).

The Cooperative Research Centre for the Biological Control of Vertebrate Pest Populations is researching a method, called immunocontraception, to suppress the fertility of rabbits. It is possible that the contraceptive agent will eventually be spread using a genetically altered form of the Myxoma virus (Environment Australia, 1999b).

It appears that 60 to 80% of female rabbits would need to be prevented from breeding to achieve a sustained reduction in rabbit numbers (Williams and Twigg, 1996).

Control of pest species: Research

Apart from the control measures already mentioned, research is progressing on methods of biological control for various pest species.

1. Pest repellents and attractants: the use of pheromones as an attractant for insects has been successfully used. They are lured by the pheromone to mate with sterile insects.

2. Use of naturally occurring plants: for example, if wild ginger is ground and mixed with food, elk and captive deer reject it. By trial and error, plants can be extracted and tested with various species.

3. Introduction of a virus or bacterium that will affect only the pest species: this is how myxomatosis was used on the rabbit population, and while it was very successful in the early stages, gradually immunity towards the virus developed. It is also a method which requires exhaustive testing as it must be pest-specific.

4. Closer study of the target animal's life cycle and behaviour to find at which point control is maximised.

The control of pest species has great importance not only for individual farmers, but also for the economy of the country's primary industries.

REFERENCES

Allen, L.R. & Lee, J.M. (1995) The management of feral goat impact on Townsend Island. Progress report to the Department of Defence, Queensland Department of Lands.

Axford 13/9/2001. Fact sheet: Improving vegetation conservation and management through goat control. www.affa.gov.au/content/butput.cfm?

Ballard, Whitman and Gardener (1987). Ecology of an exploited wolf population in South central Alaska. Wildlife monographs. 98:1–54

Bureau of Rural Sciences: www.affa.gov.au/rura1_science_pests

Caley and Ottley, 1995. The effectiveness of hunting dogs for removing feral pigs. Wildlife Research. 22:149–54.

Choquenot, D., McIlroy, J. & Korn, T. (1996) Managing Vertebrate Pests: Feral Pigs. Australian Government Publishing Service, Canberra.

Cohen, I.E. 1978. The predators. G.P. Putnam's Sons. N.Y. p.138.

Cooke, B.D. (1996) Analysis of the Spread of Rabbit Calicivirus from Wardang Island through Mainland Australia. A report prepared for the Meat Research Corporation, October 1996. Project CS.236.

Croft, J.D. (1986) The impacts of rabbits on livestock production pp. 82-84, in Proc. Aust. Soc. Anim. Prod Vol 16, Pergamon Press (Aust) Pty Ltd, Sydney

CROFT. 1/8/1998. Fact Sheet: Rabbit control benefits from combining methods-AFFA. www.affa.gov.au/content/output.cfm?

CSIRO 17/9/1996. Controlling wild rabbits – need for integrated control strategy. Australia and New Zealand Colicivirus Disease Program. www.csiro.au/communication/rabbits/qa1.htm

Delcroix, Mauget and Signoret, 1990. Existence of synchronization of reproduction at the level of the social group of the European wild boar. Journal of Reproductive Fertility. Vol 39:613–67

Environment Australia 5/9/2001a. Why control of feral animals is important. www.ea.gov.au/biodiversity/invasive/pests/index.html#why

Environment Australia 5/9/2001b. Feral Pigs –Sus scrofa. Invasive species – Feral Pigs. www.ea.gov.au/biodiversity/invasive/pests/pig.htm

Environment Australia 5/9/2001c. Feral Goats – Capra hircus. Invasive species – Goats. www.ea.gov.au/biodiversity/invasive/pests/goat.htm

Environment Australia 5/9/2001d. European Rabbit – Oryctolagus cuniculus. Invasive species – Feral Rabbits. www.ea.gov.au/biodiversity/invasive/pests/rabbit.htm

Environment Australia: www.ea.gov.au/biodiversity/invasive/pests

Environment Australia (1999a) Threat Abatement Plan for Competition and Land Degradation by Feral Goats. Under the Natural Heritage Trust.

Environment Australia (1999b) Threat Abatement Plan for Competition and Land Degradation by Feral Rabbits. Under the Natural Heritage Trust.

Fennessy, B.V. 1970. Native Fauna. In the Australian Environment.

Ed. G.W. Leeper. C.S.I.R.O. Melbourne University Press.
Feral Animals in the Northern Territory 1979. Report of the Board of Inquiry. Chairman, Dr. G.A. Letts. Pub. Dept. Primary Production, N.T. Gove.
Fleming and Robinson, 1986. The impact of wild dogs on livestock production. Animal Production in Australia. Vol 16.
Forsyth, D.M. & Parkes, J.P. (1995) Suitability of aerially sown artificial baits as a technique for poisoning feral goats. NZ J. Ecol. 19, 73–76.
Giles, J.R. 1978a. Feral pigs in New South Wales. AMRC Review No. 35.
Giles, J.R. 1978b. Feral pigs, goats, water buffalo and donkeys. Proceedings No. 36 of Course for Veterinarians, Fauna Part B. The Post-Graduate Committee in Veterinary Science. Feb. 6–10, 1978 p.631–39.
Graves, 1984. Behavior and ecology of wild and feral swine. Journal of Animal Science. Vol 58. No. 2
Hardman, J.R. (1996) The Wild Harvest and Marketing of Kangaroos: A case study of the profitability of Kangaroos compared with sheep/beef in Queensland. Department of Primary Industries, Queensland.
Harrington, G.N. 1982. Grazing behaviour of the goat. Proceedings of 3rd International Conference on Goat Production and Disease. Arizona U.S.A. 398–403.
Harrington, G.N. (1982b) The feral goat. In: P.J. Holst, Goats for meat and fibre in Australia, 3–73. Standing Committee on Agriculture Technical Report Series No. 11, CSIRO, Canberra.
Henzell, R.P. (1984) Methods of controlling feral goats. Department of Agriculture South Australia. Fact Sheet No. 20/84
Henzell, R.P. (1992) The ecology of feral goats. In D.Freudenberger (ed), Proceedings of the National Workshop on Feral Goat Management, 13–20. Bureau of Resource Sciences, Canberra
Lim, L., Sheppard, N., Smith, P. & Smith, J. (1992) The biology and management of the yellow-footed rock wallabies, ***Petrogale xanthopus***, in NSW. New South Wales National Parks and Wildlife Service Species Management Report 10, Sydney
Mason and Fleming, 1999. Australian hunters and the surveillance of feral pigs for exotic diseases. Wildlife Society Bulletin 1999. Vol 27.
McCoot, C.J., Pollitt, C.C., Fallon, G.R. & Turner, A.F. 1981. Studies of feral donkeys in the Victoria River - Kimberleys Area. Aust. Vet. J. 57: 444–49.
McIlroy and Gifford, 1997. The 'Judas' Pig Method: a method that could enhance control programs against feral pigs. Wildlife Research. 24:483–91
Mitchell, 1998. The effectiveness of aerial baiting for the control of feral pigs in North Queensland. Wildlife Research. 25:297–303
Newsome, A.E., Corbett, L.K., Best, L.W. and Green, B. 1973. The dingo. AMRC Review.
Squires, V. 1981. Livestock Management in the Arid Zone. Inkata Press. Melbourne, Sydney and London.
Norbury, G. (1993) The use of 1080 to control feral goats in Western Australia. Appendix 3 in The proposed use of 1080 to control feral goats in Western Australia. Public Environmental Review EPA Assessment No. 752. Agricultural Protection Board of Western Australia.
O'Brien, P. 1986. The impact of feral pigs on livestock production and recent developments in control. Animal
O'Brien, P.H. (1986) The impact of feral pigs on livestock production and recent developments in control. In Proc. Aust. Soc. Anim. Prod., Vol 16, 78–82, Pergamon Press (Aust) Pty Ltd., Sydney.
Parkes, J.P. (1983) Control of feral goats by poisoning with compound 1080 on natural vegetation baits and by shooting. NZ. J. For. Sci. 13: 373–85.
Parkes, J.P. (1990) Feral goat control in New Zealand. Biol. Conserv. 54: 335–48.
Parkes, J.P., Henzell, R.P. and Pickles, G. (1996) Managing Vertebrate Pests: Feral Goats. Australian Government Publishing Service, Canberra.
Production in Australia. Vol 16 Pegamon Press
Robards, 1986. The impact of vertebrate pests on animal production particularly in NSW. Animal Production in Australia. Vol 16 Pegamon Press
Shackleton and Shank. 1984. A Review of the social behaviour of feral and wild sheep and goats. Journal of Animal Science. Vol 58. No 2.
Thomson, P.C. 1992a. The behavioural ecology of Dingoes in North-West Australia III. Hunting and Feeding Behaviour and diet. Wildlife Research. Vol 19.
Thomson, P.C. 1992b. The behavioural ecology of Dingoes in North-West Australia II. Activity Patterns, Breeding Season and Pup rearing. Wildlife Research. Vol 19.
Thomson, P. (2000) Dingo. Department of Agriculture—Western Australia, Farmnote 133/2000.
Williams, C.K., Parer, I., Coman, B., Burley, J. and Braysher, M. (1995) Managing Vertebrate Pests: Rabbits. Australian Government Publishing Service, Canberra.
Williams, C.K. and Twigg, L.E. (1996) Responses of wild rabbit populations to imposed sterility. In R.B. Floyd, A.W. Sheppard and P.J. De Barro (eds) Frontiers of Population Biology, pp.532–47. CSIRO Publishing, Melbourne.
Wilson and O'Brien, 1989. Wildlife and exotic animal disease emergencies in Australia: Planning an effective response to an outbreak. Disaster Management 1:30–35