25. Livestock guardian dog/wild dog (*Canis lupus familiaris* and *C. l. dingo*) interaction study

Project dates

May 2009 – December 2011

Project leader

Dr Lee Allen
Robert Wicks Pest Animal Research Centre
Tel: (07) 4688 1397
Email: lee.allen@deedi.qld.gov.au

Objectives

- Investigate the spatial and temporal movements of guardian dogs in relation to sheep and adjacent wild dogs, in particular the degree to which guardian dogs and wild dogs intermix.
- Evaluate mesopredator and native wildlife responses to the presence of livestock guardian dogs.
- Assess whether there is any interbreeding between guardian dogs and wild dogs.
- Develop and disseminate recommendations for best practice guardian dog management.

Rationale

Wild dogs (*Canis lupus familiaris* and *C. l. dingo*) include dingoes as well as hybrids of dingoes and domestic dogs. It is believed that they deliver biodiversity benefits by suppressing mesopredators (foxes and feral cats) and preying on overabundant large macropod species. However, they are also a threat to sheep and goat production—past satellite tracking of wild dogs shows that 25% of males disperse more than 100 km and up to 500 km from their natal areas. The frequency and magnitude of these movements make it unrealistic to establish buffers to protect sheep and goat producers from livestock predation.

Livestock guardian dogs can be considered 'placebo wild dogs' in a sheep production environment. The initial study site, Dunluce Station, near Hughenden, runs 20 000 sheep with minimal annual predation loss, yet is surrounded by beef cattle properties with known wild dog populations and predation losses. Prior to using guardian dogs in 2001, land managers regularly baited with 1080 (sodium fluoroacetate) and shot wild dogs, yet suffered 15% annual loss of sheep to wild dog attacks.

Given such apparent benefits, guardian animals could prove to be a future management imperative for protecting sheep and goats from the ingress of dispersing wild dogs. Although guardian dogs are increasingly used by graziers, there is currently very little known about how guardian dogs 'work' in Australia—particularly in extensive grazing systems—and even less about their night-time movements and interaction with wild dogs. Anecdotal accounts suggest some guardian dogs are effective at preventing wild dogs from attacking livestock, while others have been seen associating with wild dog packs.

A critical management concern is the potential for guardian dogs to interbreed with wild dogs, producing larger, more aggressive and destructive hybrids. In this study, we investigate interbreeding on two properties with different approaches to the management of guardian dogs. On Dunluce Station, all working dogs are desexed according to best practice guidelines. On the second study site—Stratford Station, a beef cattle property south of Jericho in central western Queensland—guardian dogs are not desexed, are not bonded to the cattle and return to the homestead each morning.

Methods

Spatial and temporal movements

We place global positioning system (GPS) collars on maremma guardian dogs to record half-hourly locations for over 12 months (downloaded quarterly), monitoring their daily movement patterns and annual seasonal changes in activity. We are particularly interested in activity pattern differences between individual guardian dogs in relation to their gender and social status (as seen in wild dogs and reported by guardian dog owners) and how sheep paddocks and adjacent paddocks are patrolled. Concurrently, we capture wild dogs in adjoining paddocks (< 5 km from sheep) and fit them with GPS/Argos transmitters recording hourly locations.

We overlay GPS location data for wild dogs and maremmas on satellite imagery of the properties using geographical information systems to identify any overlap of movements and territory boundaries. If any overlap exists, we investigate the temporal relationships between guardian dogs and wild dogs.

Interbreeding

DNA is collected from tissue samples or blood at the time of collaring and from dogs shot or trapped locally. It is analysed for genetic evidence of interbreeding.

Biodiversity impacts

Simultaneously, we monitor the activity (a measure of relative abundance) of wild dogs, guardian dogs (much greater foot length), macropods, foxes and feral cats within and outside the protected paddocks from spoors at tracking stations, using activity index methodology (Allen et al. 1996). Tracking stations 1 km apart are monitored for three consecutive days.

Progress in 2010–11

Spatial and temporal movements

We monitored half-hourly locations of eight maremmas and hourly locations of six wild dogs on Dunluce Station for six months. Collars were recovered and downloaded in October 2010. For five of the six wild dogs, 864 hourly locations were recorded within the sheep paddocks or adjacent paddocks where one or more guardian dogs patrolled (Figure 25.1).

While many wild dog forays into sheep paddocks occurred overnight (twice as many night-time locations as day-time locations), and came from refuge areas on the Flinders River 20 km away, some stayed in the open grazing paddocks for up to two days (Figure 25.2).

During these intrusions, guardian dogs appeared to remain more or less stationary, closely associated with the sheep, and showed no obvious pursuit of wild dogs. At times wild dogs circled the maremma locations or camped during the middle of the day in paddocks containing sheep, yet remarkably no sheep were attacked (Figure 25.3).

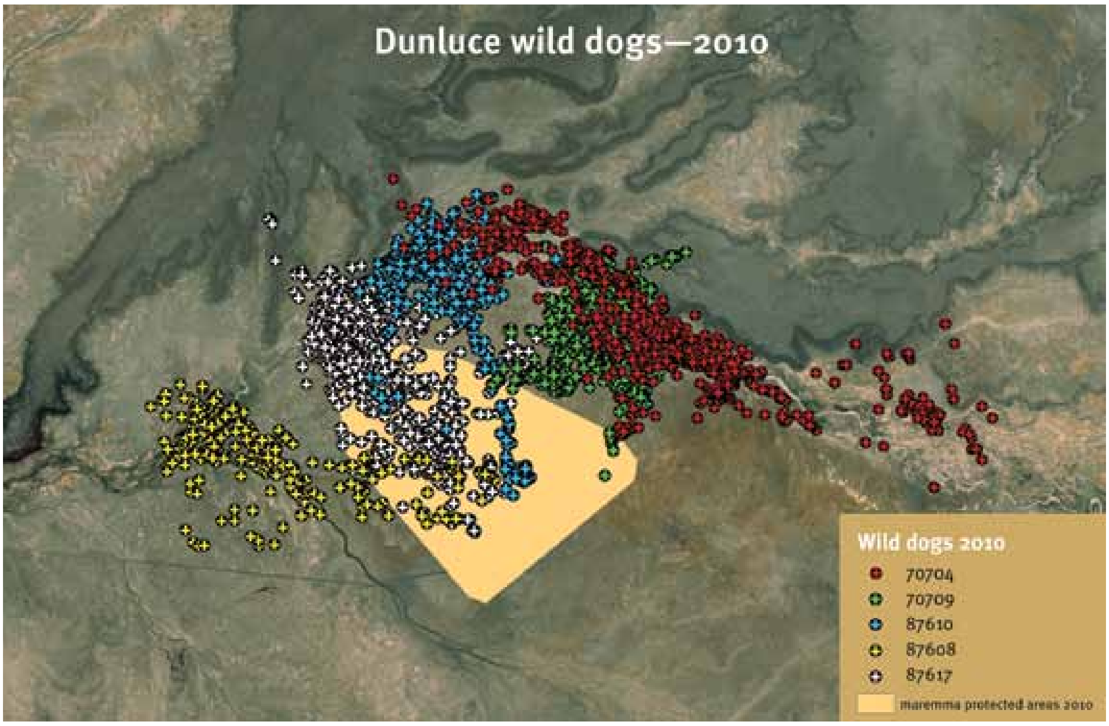

Figure 25.1 Wild dog GPS locations—up to 20% were in sheep paddocks or adjacent paddocks patrolled by maremmas

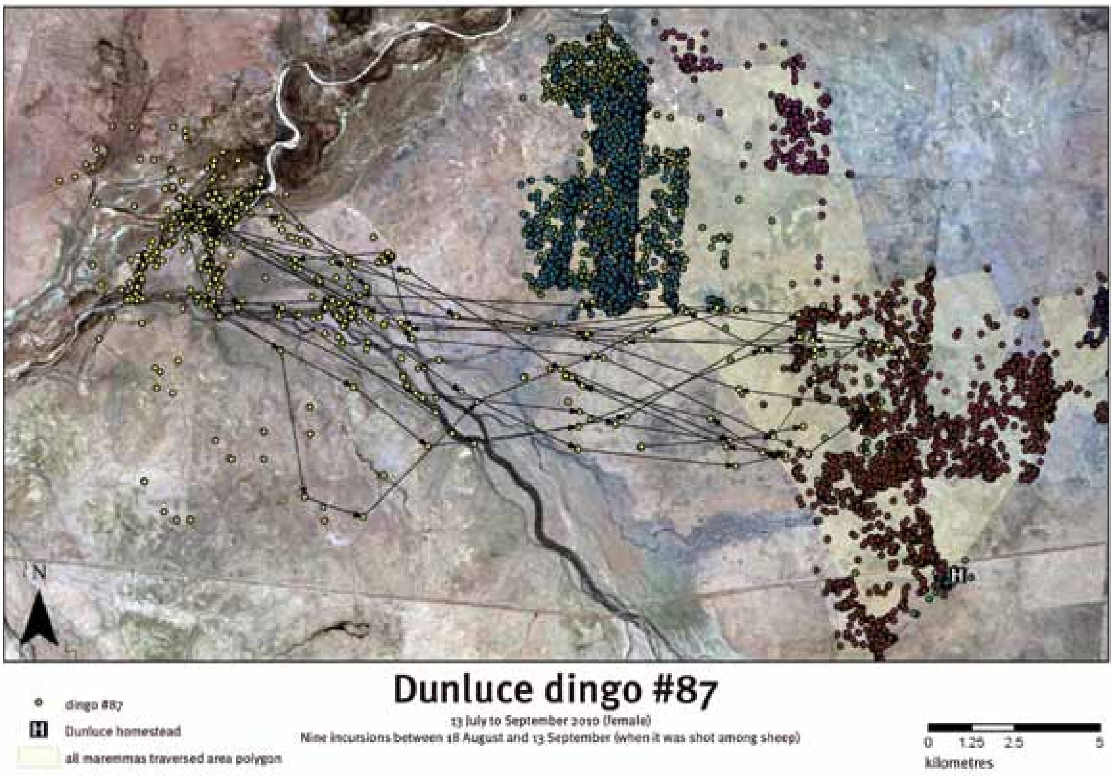

Figure 25.2 Wild dog forays of more than 20 km from refuge areas on the Flinders River to sheep paddocks

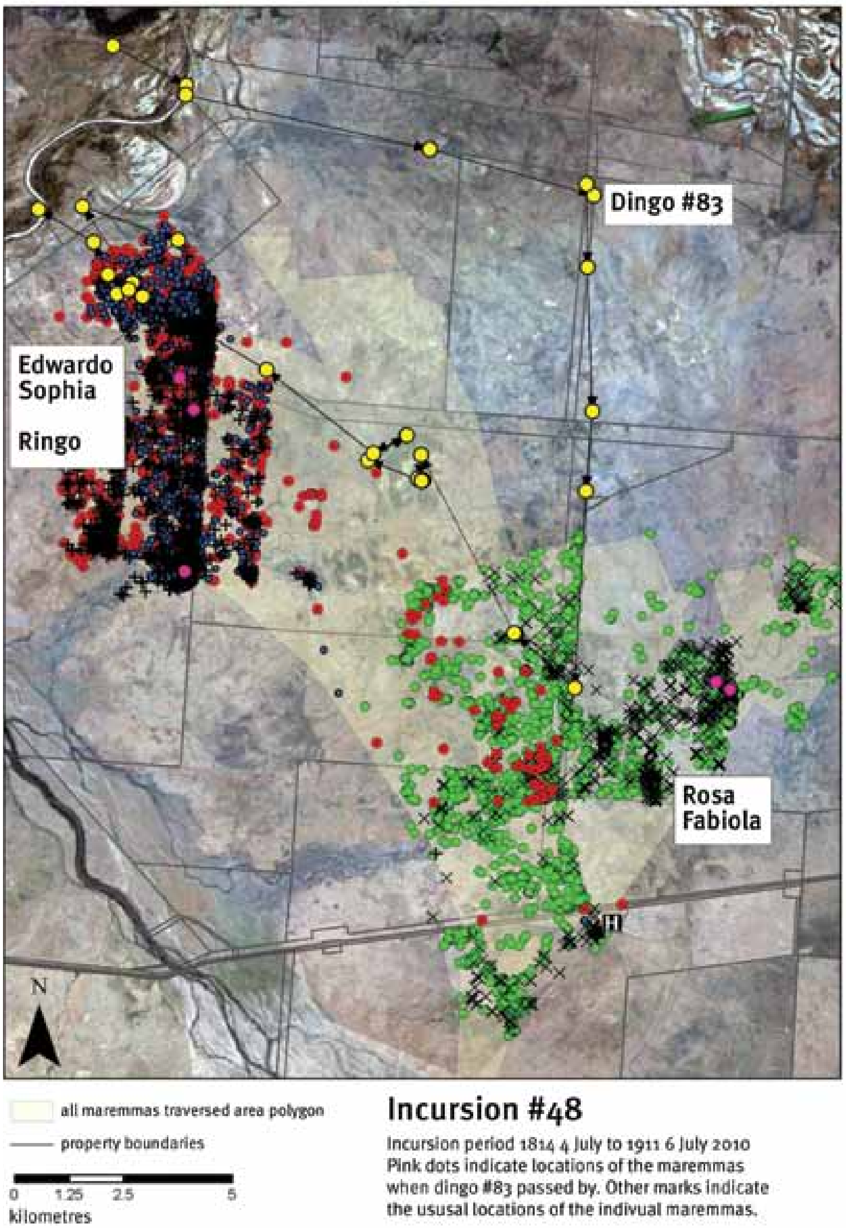

Figure 25.3 Locations of five maremmas (highlighted in pink) when a wild dog foraged in their sheep paddock

Interbreeding

DNA analysis of blood samples taken from wild dogs showed no evidence of interbreeding between maremmas and wild dogs on Dunluce Station. However, all working maremmas on Dunluce Station are desexed or treated to prevent interbreeding.

Biodiversity impacts

The activity of rodents and birds (likely prey for feral cats and foxes) was similar for both sheep and cattle paddocks and was independent of the activity of foxes, maremmas and wild dogs. Fox and wild dog activity fluctuated between surveys, but these animals were mostly detected in the sheep–maremma paddocks rather than the cattle paddocks. No wild dogs were detected during the July survey (at whelping), yet tracking showed they were still making incursions into the area at this time.

In April 2011, we captured and collared eight wild dogs and six maremmas on Stratford Station. We will conduct wildlife surveys and DNA analysis of wild dogs similar to those on Dunluce Station.

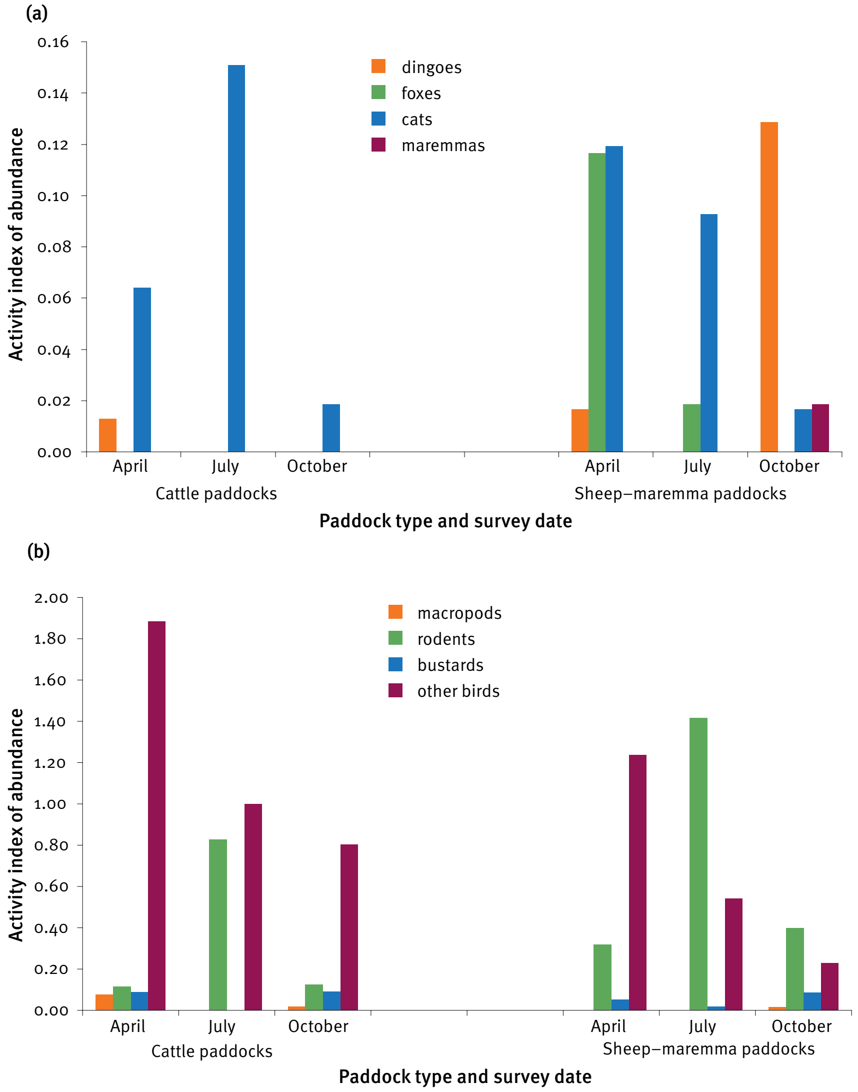

Figure 25.4 The activity of (a) predators and (b) wildlife at Dunluce Station in the sheep–maremma paddocks compared to the cattle-only paddocks as detected during surveys in April, July and October 2010

Funding in 2010–11

- Australian Pest Animal Research Program, Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) ($30 000)
- Queensland Government

Collaborators

- Ninian Stewart-Moore (Dunluce owner, Leading Sheep North and Central West regional committee member)
- Robyn and Terry Brennan (Stratford Station owners, Desert Channels Queensland)

More information

Key publication

Allen, L & Byrne, D 2011, 'How do guardian dogs "work"?', in G Saunders & C Lane (eds), *Proceedings of the 15th Australasian Vertebrate Pest Conference*, Invasive Animals Cooperative Research Centre, Sydney, p.158.

For further information on this research project and access to key publications, visit the invasive plant and animal science pages on the Biosecurity Queensland website at www.biosecurity.qld.gov.au

26. Assessing the role of harvesting in feral pig (*Sus scrofa*) management

Project dates

January 2007 – December 2010 (completed)

Project leader

Dr Matt Gentle
Robert Wicks Pest Animal Research Centre
Tel: (07) 4688 1033
Email: matthew.gentle@deedi.qld.gov.au

Other staff in 2010–11

James Speed and David Aster

Objectives

- Survey landholders in the western Darling Downs to determine the distribution of pig damage, its perceived cost and the control methods employed.
- Estimate the density–impact relationship for pigs damaging grain crops.
- Quantify the effectiveness of commercial and recreational harvesting for managing feral pig populations.

Rationale

Pest managers often encourage commercial and recreational harvesting of feral pigs (*Sus scrofa*) because this is considered essentially a 'free' reduction in pest density. However, little is known about the effectiveness of such an approach in managing pig populations. Also, it is questionable whether Australian governments should remain passive observers in the commercial use of pest animals or pursue markets more actively and subsidise harvests in unprofitable areas or at unprofitable times.

This project is a critical component of an ongoing program by the Queensland Murray–Darling Committee (QMDC) to coordinate the control of feral pigs, foxes and feral cats in the region. By evaluating the impacts of commercial and recreational pig harvesting compared to a coordinated control program, particularly in relation to crop damage, the project helps determine the optimum mix of harvesting and conventional control (i.e. baiting) and guides decision-making by pest managers.

Methods

We survey landholders throughout the QMDC area (the Border Rivers Maranoa–Balonne Natural Resource Management Region) using a combination of telephone and postal surveys. In addition to identifying hot spots of damage and areas with little control, the survey facilitates the selection of study sites for more intensive assessments of damage and density. Importantly, these surveys also raise awareness of the project throughout the rural community.

On six study sites, which encompass a range of pig densities, we then estimate both pig density and lost grain production using a combination of helicopter surveys and ground assessments. Study sites are predominantly grain-cropping properties, which are monitored twice during the maturation of the crop—early (post-emergence) and at harvest. The aerial pig-density surveys are conducted using a four-seater helicopter (Robinson-44™) flying along predetermined transects through each study area.

We assess pig damage by estimating the density of damage patches through line transect techniques and visually estimating the level of damage by comparing the yield within each damaged patch to the yield in an adjacent, undamaged crop area.

To monitor feral pig harvesting, we collate data from five wild-boar processing companies on the number of pigs harvested locally from our study sites and regionally across Queensland. Processing companies record the number of pigs harvested from each of the 215 field chiller locations throughout Queensland, which allows an investigation of the spatial patterns in harvesting. We also collate aerial survey data collected as part of the annual macropod monitoring program (courtesy of DERM) to calculate feral pig densities at each of the Queensland survey blocks. We can then compare densities with the numbers harvested to estimate harvest rates across survey blocks. This requires the cooperation of individual harvesters, the game industry and Safe Food Queensland. We also monitor other control activities undertaken at each site through discussions with landholders.

This research is conducted under an animal ethics permit, CA 2007/09/211.

Findings

Pig damage is common throughout the QMDC area, with 63% of survey respondents reporting losses. Commodities reported as damaged include cereals, vegetables, legume crops, and lambs (by predation). Cereal crops in particular suffered considerable damage; these included sorghum (8.3%), wheat (3.3%) and barley (13.4%). Lamb predation was also high (16.1%). However, damage figures calculated from field assessments (sorghum 1.3% and wheat < 0.4%) appear low relative to both landholder perceptions and previous studies. Caley (1993) reported 40% damage to sorghum crops and Pavlov (1980) found 4–7% damage in wheat crops. These results may reflect seasonal conditions at study sites or pig densities at the time of assessments. Nevertheless, assuming that the conservative field estimates are representative of feral pig damage throughout the QMDC area, the mean annual loss per sorghum producer is $843 and per wheat producer is $448. Awareness of this impact will help to justify and promote feral pig control measures.

Results from aerial surveys on the study sites (conducted from November 2007 to April 2010) and the macropod monitoring program (conducted annually from 1991 to 2010) demonstrate that feral pig populations are both widespread and persistent throughout Queensland, reaching high densities when conditions are favourable. Populations in the QMDC area can reach high densities—4.4 pigs km^{-2} were recorded at Southwood in March 2008 (Figure 26.1) and historical records show densities of 6.3 pigs km^{-2} at Westmar in 1999. Predominant land management practices in the region offer fragmented landscapes with vast cropping and grazing areas, natural watercourses and stock waters, which provide pigs access to water, shelter and sufficient food to maintain relatively high densities.

Feral pigs have long been established throughout the region and should have reached a long-term equilibrium abundance. This equilibrium is dynamic and is best considered as an average density around which the population fluctuates, but with no long-term trend. The survey data provides additional empirical evidence that the density of feral pigs is not constant but fluctuates from year to year, most likely as determined by environmental influences.

In an effort to reduce abundance and associated damage, landholders commonly control feral pig populations through poisoning, trapping and harvesting. However, to maintain reduced densities of feral pigs, higher rates of population growth following control must be stopped. On all QMDC study sites, regardless of harvesting and control activities, the rate of population growth was not significantly different from zero, indicating that populations were stable—although fluctuating—during the course of the study. There was no clear decline in abundance. Control activities had, at best, been able to suppress growth.

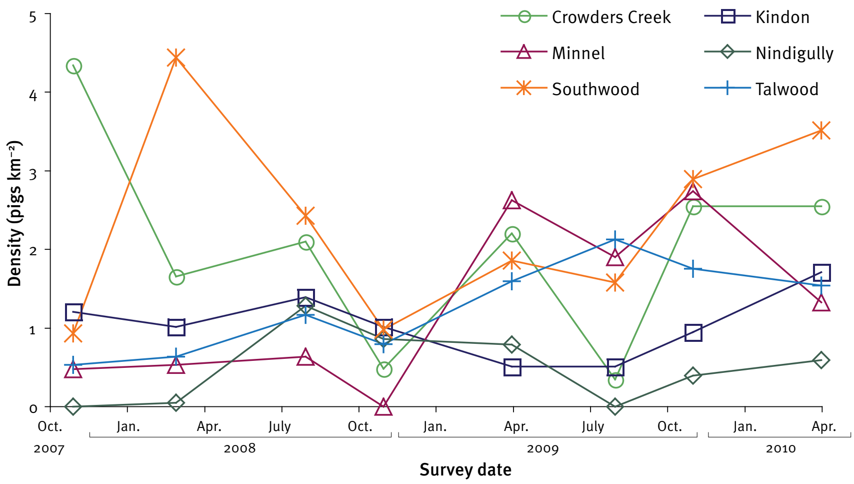

Figure 26.1 Feral pig density on the six study sites, calculated from aerial surveys

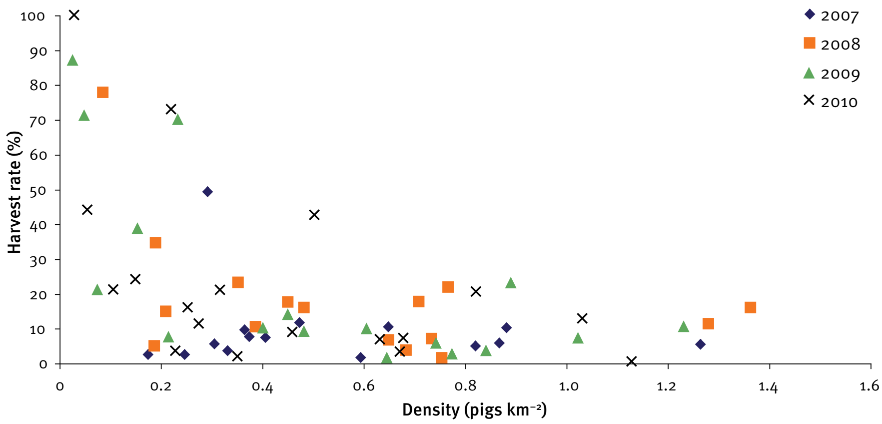

Figure 26.2 Commercial harvesting rate and feral pig density for Queensland macropod survey blocks, 2007–2010 (excluding blocks where no feral pigs were observed during surveys)

The ineffectiveness of commercial harvesting is not surprising, considering the low harvest rates relative to the maximum rate of population growth (r_{max}) that can be achieved under ideal environmental conditions. For a feral pig population growing at r_{max}, between 60 and 70% of the population needs to be removed each year to keep it stable. Harvest rates only occasionally exceeded r_{max} and such occurrences were not maintained across sites and years (Figure 26.2). Moreover, harvest rates were elevated only at low densities. This indicates that while harvest rates may be sufficiently high to hold populations at low densities, the population is likely to recover following an increase in food supply or a reduction in harvest effort.

References

Caley, P 1993, *The ecology and management of feral pigs in the wet-dry tropics of the Northern Territory*, MAppSc Thesis, University of Canberra, Canberra.

Pavlov, PM 1980, *The diet and general ecology of the feral pig (*Sus scrofa*) at Girilambone, NSW*, MSc Thesis, Monash University, Melbourne.

Funding in 2010–11

- QMDC ($51 000)
- Queensland Government

Collaborators

- QMDC
- Safe Food Queensland
- Australian Quarantine and Inspection Service
- Game and meat processors

More information

Key publication

Gentle, M, Pople, T, Speed, J & Aster, D 2011, *Assessing the role of harvesting in feral pig (*Sus scrofa*) management*, Final report to the Queensland Murray–Darling Committee, Toowoomba.

For further information on this research project and access to key publications, visit the invasive plant and animal science pages on the Biosecurity Queensland website at www.biosecurity.qld.gov.au

27. Assessing feral pig (*Sus scrofa*) damage to crops using remote sensing

Project dates

February 2009 – December 2010 (completed)

Project leader

Dr Matt Gentle
Robert Wicks Pest Animal Research Centre
Tel: (07) 4688 1033
Email: matthew.gentle@deedi.qld.gov.au

Other staff in 2010–11

James Speed

Objectives

Assess the use of satellite imagery and geographical information systems to measure feral pig damage to grain crops. Key objectives are:

- Undertake field assessments of crops to identify and map areas of pig damage.
- Investigate methods for using satellite imagery and/or aerial photography to determine the extent of pig damage in grain crops.
- Given the success of objective 2, construct and validate a model to define pig damage from all available field data sets.

Rationale

Current methods of determining levels of feral pig (*Sus scrofa*) damage rely on landholder surveys or intensive and costly field assessments. Surveys of landholders usually indicate the level of damage perceived by landholders rather than actual measurements. The relationship between this subjective (and usually qualitative) measure and actual damage is unknown. However, quantitative assessments are very labour-intensive and not practical for broadscale assessments of damage.

An earlier study by Caley (1993) investigated feral pig damage to sorghum and maize crops in the Northern Territory by using a combination of exclosures and visual assessments. Although these techniques were suitable for assessing damage to grain crops, Caley (1993) recommended that future studies should use aerial photography to quantify pig damage in sorghum crops. The use of satellite imagery is a logical extension of this recommendation. Satellite imagery offers the potential of determining the nature, extent and location of damage and its relationship with aspects of the environment.

Methods

Wheat crops in the Moonie–Goondiwindi area of southern Queensland are field surveyed for feral pig damage. Targeted crop types and paddock locations include those known to have historically suffered high levels of damage. We record the location of trampled patches (using a GPS), area damaged and intensity of damage within this area (e.g. 80% loss), along with species responsible for the damage.

We use the data to establish characteristics of feral pig damage in crops, including the location and typical areal extent of pig damage. Using this information, we specify a minimum mapping unit and image pixel size suitable for mapping pig damage. This allows us to select suitable image data, including government archive SPOT (satellite pour l'observation de la terre), Ikonos, Quickbird and Geoeye.

Then we analyse imagery (recorded at the same time as field data) to determine unique characteristics of feral pig damage that could be used to develop a suitable mapping approach. Once a suitable approach is developed, we apply it to other current and archival imagery to identify areas of pig damage.

Findings

We were able to identify many patches of feral pig damage in field assessments and successfully captured suitable Quickbird imagery. However, we were unsuccessful in using satellite imagery to identify feral pig damage in wheat crops. Despite several attempts using visual or pixel-based approaches, there was no apparent match between field survey points and evident damage in the images.

Firstly, patches of feral pig damage recorded during field assessments were typically small, often only marginally larger than a single pixel in the image. However, even the numerous large patches of feral pig damage recorded (e.g. an area of close to 70 m × 70 m at Southwood) could not be successfully distinguished in the imagery.

Secondly, regardless of the size of the damaged area, the characteristics of pig damage were difficult to distinguish from underlying damage associated with dryland cropping systems, including damage from poor crop establishment, wind and scalding. For example, gilgais (soil depressions) are common in the study area and typically fill with water during wet periods. These and other variations in soil conditions are responsible for significant natural variation in crop establishment and yield, which could easily be mistaken for feral pig damage on imagery. Additionally, wheat crops have a relatively open canopy, particularly as the crop matures and approaches ripening (grain-fill), which further complicates differentiation from damaged areas.

Thirdly, determining the cause of crop damage during field assessments is not straightforward. Some interpretation by the observer is usually required through inspecting field signs either on the ground or on damaged plants. Some ground-truthing of crop damage identified on satellite imagery would always be required to establish the species responsible.

Furthermore, the capture process associated with Quickbird images can prove problematic. Factors impeding successful image capture include the size and shape of the capture area (areas > 18 km wide need to be captured in at least two passes), significant cloud cover at the time of pass and the priority of other pending image capture requests.

Those results, when combined with the cost, analytical difficulties, practicalities and logistical issues with data collection, indicate that using satellite imagery for assessing feral pig damage to grain crops currently has serious deficiencies. Further studies should only be considered if new advances in image capture (e.g. inclusion of middle-infrared bands) or analysis have been made.

Reference

Caley, P 1993, *The ecology and management of feral pigs in the wet-dry tropics of the Northern Territory*, MAppSc Thesis, University of Canberra, Canberra.

Funding in 2010–11

- Australian Pest Animal Research Program, DAFF ($22 000)
- Queensland Government

Collaborator

Prof. Stuart Phinn (Centre for Spatial Environmental Research, The University of Queensland)

More information

Key publication

Gentle, M, Phinn, S & Speed, J 2011, *Assessing pig damage in agricultural crops with remote sensing*, Final report to the Australian Government Department of Agriculture, Fisheries and Forestry, Canberra.

For further information on this research project and access to key publications, visit the invasive plant and animal science pages on the Biosecurity Queensland website at www.biosecurity.qld.gov.au

28. Non-target impacts of 1080 meat baits for feral pigs (*Sus scrofa*)

Project dates

June 2010 – June 2012

Project leader

Dr Matt Gentle
Robert Wicks Pest Animal Research Centre
Tel: (07) 4688 1033
Email: matthew.gentle@deedi.qld.gov.au

Other staff in 2010–11

James Speed, Tony Pople and Michael Brennan

Objective

Quantify the population-level impact on non-target species, specifically birds, from 1080 meat baiting practices used for feral pig control.

Rationale

Bait containing 1080 (sodium fluoroacetate) is widely used for the routine control of feral pigs in Queensland. Meat baits are popular in western and northern pastoral areas since they can be distributed aerially. Although much research has assessed the effectiveness of baiting practices, little is known about the long-term impact of such practices on other species.

The APVMA conducted a review into the use of 1080 meat baits for feral pig control. This review indicated that the practice may be harmful to a range of non-target animals, largely because of species' sensitivity to 1080 (i.e. the toxicity of 1080). These concerns are supported by field observations from south-western and northern Queensland indicating some bait uptake by non-target species. Species observed include corvid and raptor species such as the Australian raven (*Corvus coronoides*), Australian magpie (*Gymnorhina tibicen*), whistling kite (*Haliastur sphenurus*), black kite (*Milvus migrans*) and wedge-tailed eagle (*Aquila audax*), and varanid species such as Gould's goanna (*Varanus gouldii*) and the lace monitor (*Varanus varius)*.

Published susceptibility data indicates that many of these species are (theoretically) at risk through primary poisoning from 1080 meat baits. For example, for an average adult Australian raven (of body weight 585 g), about 3 mg of 1080 (less than 5% of the 1080 content in one bait) would be a lethal dose. However, it is not certain that this **theoretical** risk translates into a **real** impact. Occasionally, bird carcasses (primarily raptors) have been found following baiting operations and, in some cases, laboratory analyses have confirmed 1080 poisoning as the cause of death. Yet we are unsure whether these cases represent a level of mortality that could threaten species' population viability or disrupt some ecological function performed by these species. No trial to date has demonstrated any **population** impact on non-target species. By examining such impacts, this project helps ensure that baiting operations are acceptably target-specific, and that 1080 use is responsible and ecologically sustainable.

Methods

Population counts

To detect any changes in the abundance of non-target species following standard aerial baiting operations, we count birds (targeting raptor and corvid species) before and after baiting on treatment sites and on control sites not exposed to baiting. These counts occur along driven transects for up to 10 days in each period. All data is recorded using distance-sampling techniques to provide density estimates and is analysed using the computer program Distance 6.0.

Monitoring of individual birds

We also monitor individual birds of a susceptible non-target species during a 1080 baiting campaign to determine levels of mortality due to baiting. Up to 15 individual Australian ravens are trapped and fitted with radio transmitters via elasticised harnesses on each treatment site and a control site. We then monitor their mortality for 2–6 weeks post-baiting, depending on the level of harness/transmitter failure.

Monitoring of bait uptake and carcass searches

During baiting, we further monitor a sample of bait stations (up to 40) daily via remote photography or soil plots to determine the proportion of baits removed and the identity of species removing baits. All monitored baits have radio transmitters incorporated to report the fate of removed baits, for example moved (transmitter found within bait) or consumed (transmitter found without bait).

We also search and collect carcasses of non-target species for toxicological analyses to confirm the cause of death.

This research is conducted under an animal ethics permit, CA 2009-06-360.

Progress in 2010–11

We completed a preliminary population count trial at Culgoa Floodplain National Park and three nearby properties (Kulki, North Kulki and Tambingey) south of Bollon, south-western Queensland, in May–June 2011. Culgoa Floodplain National Park was aerially baited for feral pigs as part of routine management and served as the treatment site; Kulki, North Kulk and Tambingey served as control sites.

Density estimates were calculated for species where a sufficient number of sightings were recorded in the pre-baiting period. Initially, separate detection functions were calculated for each site/species combination, but some were subsequently pooled (to obtain a global detection function) where they were not significantly different.

Photo 28.1 An Australian raven inspecting a goat carcass at an unset bait station near Culgoa Floodplain National Park, south-western Queensland

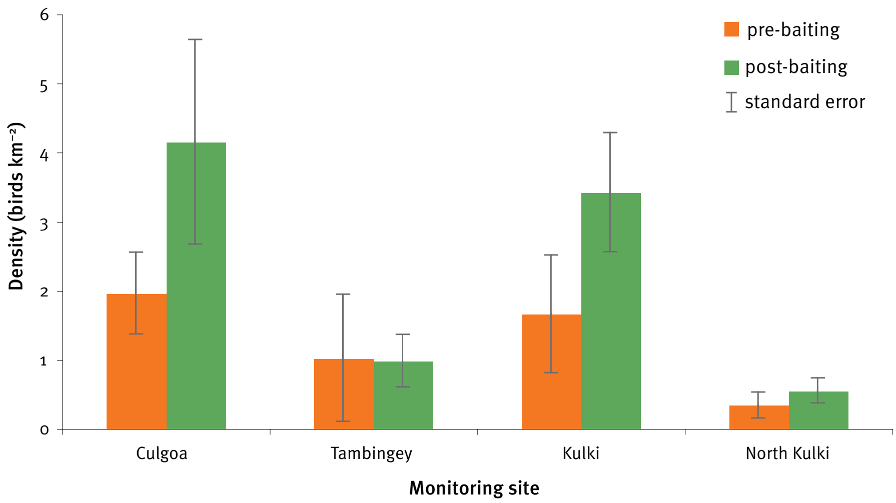

Figure 28.1 Pre-baiting and post-baiting densities of Australian raven at four monitoring sites in south-western Queensland

Densities of the Australian magpie, pied butcherbird and wedge-tailed eagle were not significantly different pre-baiting and post-baiting at Culgoa Floodplain National Park or the control sites. The abundance of Australian ravens, however, significantly increased—effectively doubled—following baiting at Culgoa Floodplain National Park (Figure 28.1). Raven densities also appeared to increase at Kulki and North Kulki post-baiting, but these differences were not statistically significant. Densities on Tambingey were stable during the same period.

While results to date suggest minimal, if any, impact on susceptible bird species, further monitoring is required to investigate effects on long-term abundance. Further replication during the October–November 2011 baiting period will also help account for any confounding effects from bird movements (emigration or immigration) and bait distribution (e.g. increased food availability).

Funding in 2010–11

Queensland Government

Collaborators

- DERM
- The University of Queensland

More information

Key publication

Gentle, M 2010, 'What gets killed by meat baits for feral pigs?', in *Proceedings of the 3rd Queensland Pest Animal Symposium*, Gladstone, Queensland.

For further information on this research project and access to key publications, visit the invasive plant and animal science pages on the Biosecurity Queensland website at www.biosecurity.qld.gov.au

29. Feral pig (*Sus scrofa*) best practice research in northern Queensland

Project dates

July 2009 – June 2012

Project leader

Dr Jim Mitchell
Tropical Weeds Research Centre
Tel: (07) 4761 5734
Email: jim.mitchell@deedi.qld.gov.au

Other staff in 2010–11

Brian Ross

Objective

Improve feral pig management in the dry tropics of northern Queensland.

Rationale

Large numbers of feral pigs continue to cause environmental and economic impacts in the dry tropics of northern Queensland. While there are several control techniques available for feral pigs, refinement of these is important to improve efficacy and minimise non-target impacts. For broadscale control, ground and aerial baiting are two of the most practical and efficient options, but these need to be timely and strategic. Research over several years has focused on establishing appropriate baiting densities and practices (e.g. strategic versus blanket baiting). The next step is to determine whether concentrated repeat baiting can offer better control than a one-off baiting program.

Methods

Along the frontage of the Burdekin and Star rivers (north of Charters Towers), we establish nine experimental areas (10 × 1 km) in blocks of three. Within each block we randomly assign experimental areas to one of three treatments: nil treatment (no baiting), standard baiting (once only) or pulse baiting (baiting at monthly intervals for three consecutive months).

We distribute the standard 1080 pig-strength formulation (72 mg in each 500 g meat bait) from an aircraft at a density of 12 baits km^{-2}. Following baiting, we monitor population knockdown through activity transects and camera-capture sampling.

Progress in 2010–11

In September 2010, we undertook initial aerial baiting for both the standard (one-off) and pulse baiting treatments. This was followed by further baiting in the pulse baiting treatment areas in October and November 2010. Monitoring revealed no significant differences in the feral pig populations before and after treatments. This was most likely associated with prolonged rainfall during 2010, which created an abundance of waterholes and allowed pigs to remain widely dispersed. Normally during the dry season feral pigs tend to concentrate around remaining permanent waterbodies, which allows control activities to be targeted to these areas. Because baiting was concentrated in strips along the edges of the rivers, a number of feral pigs may not have come in contact with the baits. A repeat of this project will be considered if additional external funding becomes available.

Funding in 2010–11

- Land Protection Fund ($128 000)
- Queensland Government

More information

For further information on this research project, visit the invasive plant and animal science pages on the Biosecurity Queensland website at **www.biosecurity.qld.gov.au**

30. Adaptive management of rabbits (*Oryctolagus cuniculus*) in south-eastern Queensland

Project dates

2000–2012

Project leader

Dr David Berman
Robert Wicks Pest Animal Research Centre
Tel: (07) 4688 1294
Email: david.berman@deedi.qld.gov.au

Other staff in 2010–11

Michael Brennan

Objectives

Establish landholder-driven, scientifically monitored rabbit-control programs in the Darling Downs – Moreton Rabbit Board (DDMRB) area to:

- measure the benefits of rabbit control to biodiversity, agriculture and pastoralism
- demonstrate the importance of targeting control activities in key breeding places (sources)
- refine control strategies and methods to reduce cost and increase effectiveness
- measure the cost of eradicating small, isolated rabbit populations.

Rationale

In south-eastern Queensland, a rabbit-proof fence maintained by the DDMRB has protected large areas from rabbits since 1906. This area is unique because it is highly suitable for rabbits, yet has never experienced the damage caused by plagues of uncontrolled rabbits as seen in adjacent areas not protected by the rabbit-proof fence. This situation is ideal for measuring the benefits of effective rabbit control to biodiversity and agriculture. Measuring these benefits and demonstrating control methods are essential to justify the expense of controlling rabbits and to encourage landholders to control this pest.

Rabbit incursions into the DDMRB area have occurred for many years and appear to be more frequent recently, although rabbits generally have not yet established permanent warren systems within this area. Genetic studies comparing rabbit populations inside and outside the DDMRB area can help identify the source of these rabbit incursions. Targeting these source areas could help prevent further incursions into the DDMRB area; it could also help minimise the cost and maximise the long-term effectiveness of rabbit control in south-eastern Queensland.

Methods

Benefits of rabbit control

In the study site at Cottonvale, south of Warwick, we mark all warrens and log piles with steel posts and record the number of active and inactive burrows. We also establish rabbit-proof and cattle-proof (with rabbit access) exclosures to identify the impacts of rabbits and separate these from impacts caused by cattle. To monitor rabbit and wildlife activity, we distribute sand tracking plots and also install movement-sensing cameras. Once we have measured the differences between lightly infested and heavily infested areas, we destroy warrens by ripping. Then we measure the effectiveness of this method for rabbit control as well as the associated rate and extent of recovery of pasture and biodiversity.

Genetic studies

We also obtain ear-tissue samples from rabbits at 19 locations both inside and outside the DDMRB area. Susan Fuller from the Queensland University of Technology conducts genetic analyses on extracted rabbit DNA.

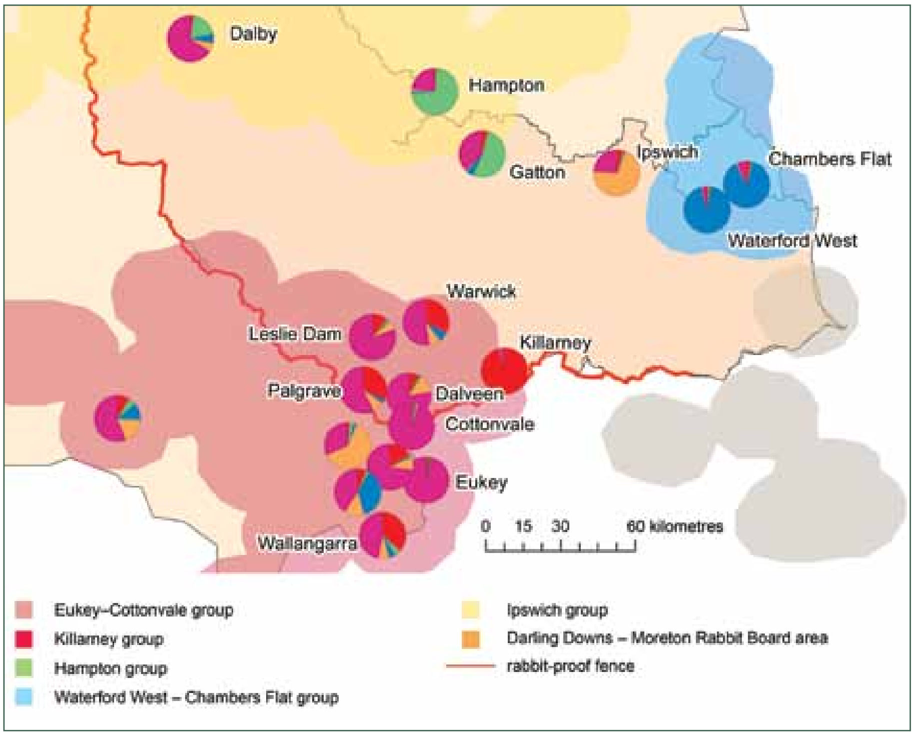

Figure 30.1 The genetic make-up of rabbit populations at 18 locations in south-eastern Queensland

Progress in 2010–11

Benefits of rabbit control

Research to date suggests that native plants and animals benefit significantly from low rabbit densities achieved by the rabbit-proof fence and other control activities. The benefit to agricultural production is also significant but requires further quantification.

Genetic studies

Total DNA was extracted from ear-tissue samples obtained from 2007 to 2010 and nine loci were analysed. The analysis indicated five genetically distinct populations: Killarney, Hampton, Ipswich, Waterford West – Chambers Flat and Eukey–Cottonvale (Figure 30.1).

The pie charts in Figure 30.1 show the proportion of sampled rabbits in each of these populations. Larger coloured areas are threatened by dispersing rabbits (i.e. are within 20 km of warrens reported via RabbitScan). There is likely to be limited rabbit movement between green, pink and blue areas.

Rabbits within each site are highly genetically related, but gene flow (dispersal) between sites appears to be restricted. Cottonvale and Eukey rabbits showed a high degree of genetic similarity. Dalveen and Leslie Dam populations were also quite similar to the Eukey–Cottonvale populations, indicating that some restricted gene flow has occurred among these sites in the past.

Rabbits from the clean and dirty side of the fence at Cottonvale were genetically very similar, suggesting a shared ancestry. Geographically, the closest site to Cottonvale was Dalveen, and this site was composed of individuals that shared 78% ancestry with the Eukey–Cottonvale populations. Therefore, rabbits that have recently invaded the clean side of the fence at Cottonvale and Dalveen are likely to have originated from the dirty side of the fence at Cottonvale, probably via occasional holes in the fence. Since, for rabbits, Eukey appears to be a more productive area than Cottonvale, it is likely that Eukey is the original source of rabbits. Eukey–Cottonvale is also the likely source of rabbit populations at Leslie Dam. Rabbits from Palgrave and Warwick display mixed ancestry. Rabbit populations in these areas are likely to have been founded by a combination of migrants from Eukey–Cottonvale and Wallangarra. The rabbit population at Killarney was most likely founded by rabbits from Warwick.

These results suggest that it is important not only to eradicate populations within the DDMRB area but also to control rabbits at Cottonvale, Eukey and Wallangarra to reduce the chance of further invasions. These areas are the sources of rabbits invading at least the southern part of the DDMRB area.

Therefore, control of rabbits in these areas has the potential to reduce rabbit numbers over a much larger surrounding area. Warren ripping at Cottonvale and Eukey (coordinated and partly funded by the QMDC) has significantly reduced rabbit populations to the extent that they may no longer be sources of rabbits for surrounding areas. Further work is required to ensure there are no large warren systems remaining, while ripping is also required at Wallangarra.

Rabbits from Dalby, Gatton and Hampton displayed similar ancestry, but the sources of these populations are unknown. The sources of the Chambers Flat – Waterford West and Ipswich populations are also unknown. Additional tissue samples need to be collected from areas to the north of the DDMRB and the Tweed Heads area to identify possible sources of these rabbits.

Funding in 2010–11

Land Protection Fund ($20 000)

Collaborators

- Susan Fuller (Queensland University of Technology)
- Mark Ridge (DDMRB)
- Shane Cartwright (Queensland Murray–Darling Committee)
- Harley West (Granite Borders Landcare)

More information

Key publications

Berman, D, Brennan, M & Elsworth, P 2011, 'How can warren destruction by ripping control European wild rabbits (*Oryctolagus cuniculus*) on large properties in the Australian arid zone?', *Wildlife Research* 38(1): 77–88.

Brennan, M & Berman, D 2008, 'The value of having no rabbits in South East Queensland', in G Saunders & C Lane (eds), *Proceedings of the 14th Australasian Vertebrate Pest Conference*, The Vertebrate Pests Committee and the Invasive Animals Cooperative Research Centre, Canberra, p. 102.

Scanlan, JC, Berman, DM & Grant, WE 2006, 'Population dynamics of the European rabbit (*Oryctolagus cuniculus*) in north-eastern Australia: simulated responses to control', *Ecological Modelling* 196(1–2): 221–36.

For further information on this research project and access to key publications, visit the invasive plant and animal science pages on the Biosecurity Queensland website at www.biosecurity.qld.gov.au

31. Mapping the distribution and density of rabbits (*Oryctolagus cuniculus*) in Australia

Project dates

July 2008 – August 2012

Project leader

Dr David Berman
Robert Wicks Pest Animal Research Centre
Tel: (07) 4688 1294
Email: david.berman@deedi.qld.gov.au

Other staff in 2010–11

Michael Brennan

Objectives

- Improve the understanding of the distribution and abundance of rabbits in Australia.
- Produce a map of the distribution and abundance of rabbits that is suitable for:
  - estimating the extent of damage caused
  - efficiently planning control programs
  - monitoring the success of rabbit control at the regional, state and national levels.

Rationale

From an initial release in Victoria in 1859, European rabbits (*Oryctolagus cuniculus*) have spread across the country and are viewed as Australia's most serious vertebrate pest. During the past 60 years, rabbit populations have been suppressed significantly by the biological control agents myxoma virus and rabbit haemorrhagic disease virus (RHDV), and (in places) by conventional control. Yet it is difficult to measure the benefit of these control efforts because our knowledge of rabbit distribution and abundance Australia-wide has been inadequate.

A map prepared as part of the National Land and Water Resources Audit 2007 was based on predominantly qualitative information obtained from local experts, which makes comparisons between regions difficult.

A map prepared for Queensland using Spanish rabbit flea release sites and soil type (Berman et al. 1998) proved a good representation of rabbit density and distribution, but its extension to the whole of Australia was compromised by data restricted largely to arid areas.

To collect recent rabbit distribution and abundance data across Australia, the Rabbit Management Advisory Group initiated RabbitScan in May 2009. RabbitScan gives all Australians a means to map rabbits using Google Earth® technology. It is designed to allow community and school groups to report rabbit abundance. Records collected by RabbitScan, combined with existing records, will provide an improved understanding of rabbit distribution in Australia. RabbitScan has now given rise to FeralScan (www.feralscan.org.au), through which other pest animals are also mapped.

Methods

We provide scientific support for RabbitScan, promote the collection of data via RabbitScan and search for published and unpublished historical records of rabbit occurrence and density. Using all available records of rabbits (historical and RabbitScan), we determine the density of rabbit sites across various soil landscapes (as classified in the *Atlas of Australian soils* mapping units). This enables us to produce a map showing the relative suitability of areas for rabbits.

We also attempt to identify key areas requiring priority treatment, which may be the sources of rabbits for surrounding areas. First, we overlay historical and RabbitScan data points (including a 20 km buffer representing the area immediately threatened by dispersing rabbits). The area of overlap most likely represents the area where rabbit populations have been most stable. We then examine the proportion of RabbitScan points with highest warren density within the area of overlap. These areas are likely to be the most productive breeding places for rabbits. We expect the highest warren densities to be located mainly in the area of overlap.

We further investigate whether the density scores reported by RabbitScan respondents are correlated with latitude, which is known to have a major influence on rabbit distribution and abundance. We expect the density of rabbits to be, on average, higher in the south than in the north.

Progress in 2010–11

From RabbitScan and other sources, we have obtained coordinates for a total of 9901 points where rabbits occur or have occurred in Australia. The area exposed to the impact of rabbits in Australia is at least 2 213 598 km^2 or 29% of the continent. The area within 20 km of RabbitScan points with the highest warren density is 84 021 km^2 or 4% of the total area exposed to the impact of rabbits (Figure 31.1). Interestingly, 82 of 111 points (74%) with the highest warren density were in the area of overlap between historical and RabbitScan points.

Rabbit density as reported by RabbitScan respondents decreased with latitude (Figure 31.2), matching expectations from conventional scientific knowledge. This suggests that respondents are reliably reporting density estimates and that RabbitScan can be useful for monitoring trends within selected areas (catchments or council areas) of Australia.

This work highlights the importance of mapping the distribution and abundance of rabbits for identifying areas that require increased control efforts. The full value of RabbitScan will be realised once a few years of data have been collected and we can monitor the effects of control activities.

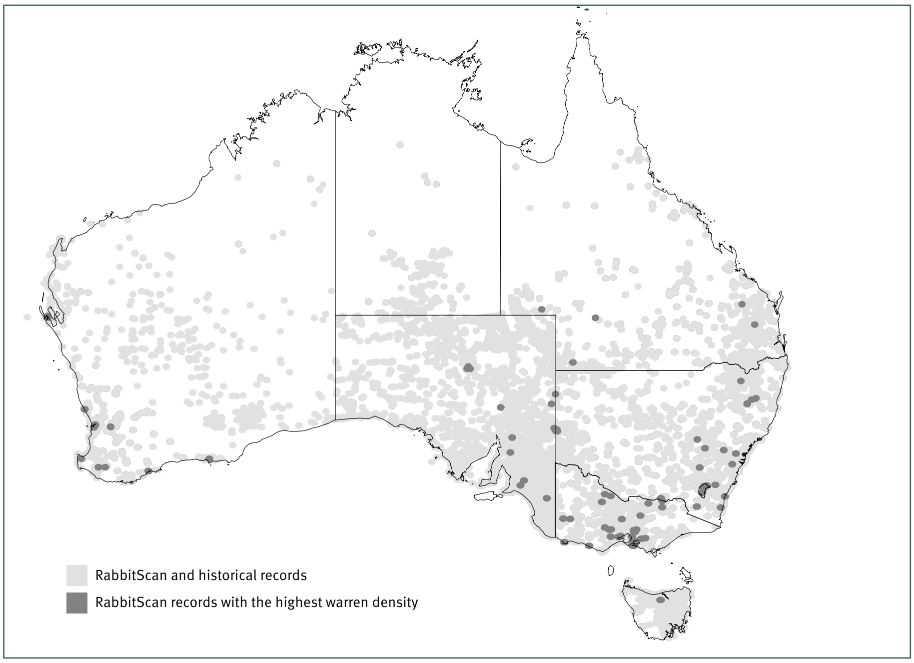

Figure 31.1 The total area exposed to the impact of rabbits in Australia (both historically and as reported via RabbitScan) and areas with the highest warren density as reported via RabbitScan; data points are surrounded by 20 km buffers representing the areas immediately threatened by dispersing rabbits

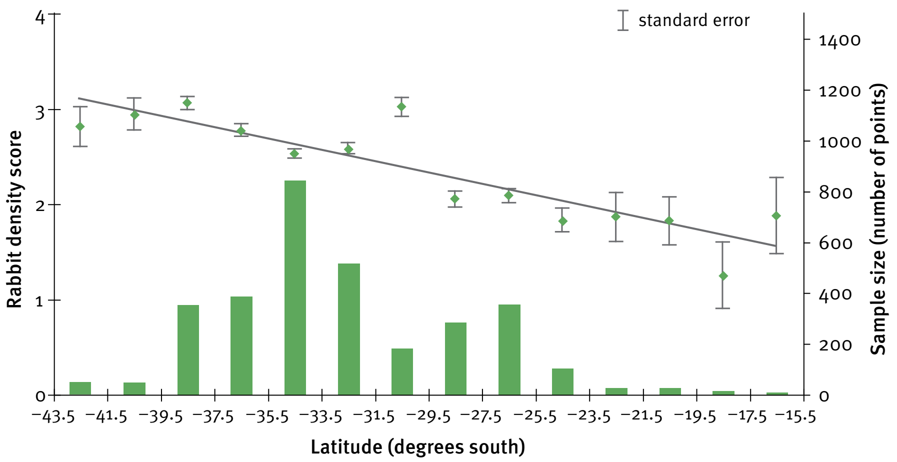

Figure 31.2 Rabbit density scores by latitude as reported by RabbitScan respondents and the sample sizes (shown as bars) for these latitudes

Funding in 2010–11

Land Protection Fund ($20 000)

Collaborators

- Rabbit Management Advisory Group
- Brian Cooke (Invasive Animals Cooperative Research Centre; University of Canberra)
- Susan Fuller and Grant Hamilton (Queensland University of Technology)

More information

Key publications

Berman, D & Cooke, B 2008, 'A method for mapping the distribution and density of rabbits and other vertebrate pests in Australia', in G Saunders & C Lane (eds), *Proceedings of the 14th Australasian Vertebrate Pest Conference*, The Vertebrate Pests Committee and the Invasive Animals Cooperative Research Centre, Canberra, p. 103.

Berman, D, Robertshaw, J & Gould, W 1998, 'Rabbits in Queensland: where have they been, what have they done and where are they now?', in *Proceedings of the 11th Australasian Vertebrate Pest Conference*, Bunbury, Western Australia, pp. 395–9.

For further information on this research project and access to key publications, visit the invasive plant and animal science pages on the Biosecurity Queensland website at www.biosecurity.qld.gov.au

32. Resistance to rabbit haemorrhagic disease virus in Australian rabbits (*Oryctolagus cuniculus*)

Project dates

July 2007 – 2013

Project leader

Peter Elsworth
Robert Wicks Pest Animal Research Centre
Tel: (07) 4652 1599
Email: peter.elsworth@deedi.qld.gov.au

Other staff in 2010–11

David Berman and David Aster

Objectives

- Develop a test protocol for determining resistance to RHDV in rabbits.
- Test rabbits from around Australia to determine if resistance is developing and to what level it has developed.
- Explore reasons behind any variation in resistance seen between populations.
- Test field strains of RHDV to compare virulence and effectiveness against the original release strain.
- Explore interactions between RHDV and the new suspected benign rabbit calicivirus (RCV-A1) discovered in Australian rabbits.

Rationale

RHDV has been a successful tool in the control of rabbits (*Oryctolagus cuniculus*) throughout Australia. It caused a great reduction in rabbit numbers on initial release and continues to keep numbers low in many areas. However, concerns have been raised about RHDV's continuing efficacy, as numbers of rabbits are increasing in some areas. Rabbits started showing resistance to myxomatosis about 10 years after its initial release and it has now been over a decade since RHDV was released. Anecdotal and observational information indicate rabbit numbers are increasing to levels not seen since the release of RHDV. Monitoring sites have also shown changes in rabbit populations during outbreaks of RHDV that may indicate the development of resistance. Rabbits are a major pest of agricultural and natural systems and if they were to return to the numbers present pre-RHDV, they would once again have a devastating effect.

Initial challenge tests showed that different populations of rabbits around Australia had differing levels of resistance to RHDV. The level of resistance was correlated to rainfall, with populations from regions of intermediate rainfall having the highest resistance levels. As rabbits develop resistance, changes in the virus to overcome this resistance can also be expected. Further challenge tests with virus collected from South Australia over three years showed that field strains are maintaining virulence. The original release strain, however, is less effective in this population, causing a lower mortality and a longer survival time (Figure 32.1).

We are now conducting a series of challenge tests on wild and domestic rabbit populations to determine whether resistance does indeed have a genetic basis. If resistance is genetically based, each subsequent generation bred from survivors should have increasing resistance levels.

Methods

We collect wild rabbits from Bulloo Downs in south-western Queensland, as well as domestic control rabbits, to form a parent generation (Generation 0). Prior to testing, offspring were bred from a random subset of Generation 0 to provide the next generation for testing (Generation 1). In challenge tests, each group of rabbits is administered a low oral dose of RHDV (1:25 dilution of stock solution, as the full dose would kill most of the rabbits regardless of whether they have resistance or not). Survivors of those trials are allowed to breed and their offspring is tested using the same procedures.

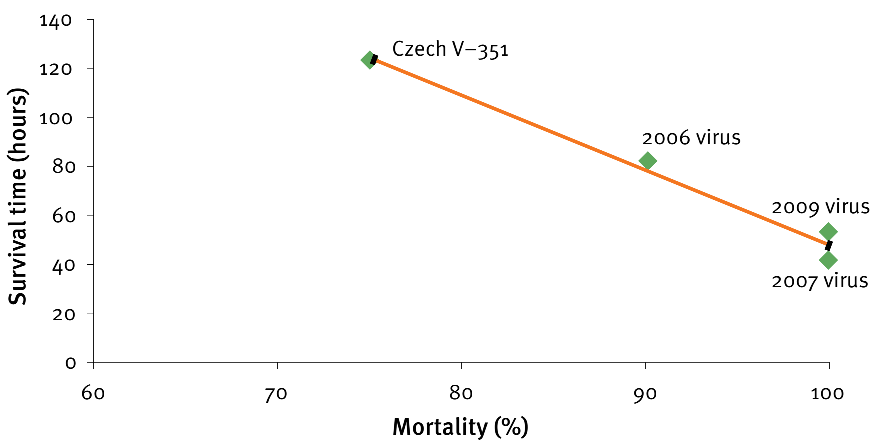

Figure 32.1 Mortality and survival time for rabbits orally challenged with the original release strain of RHDV (Czech V-351) and field strains collected in 2006, 2007 and 2009

Progress in 2010–11

For the wild rabbits, mortality was 90% for the parent group (Generation 0) and 80% for the offspring (Generation 1). For the domestic control rabbits, mortality was 100% for Generation 0 and 95% for Generation 1.

From the six surviving wild rabbits, a new generation of young rabbits has been bred to be tested later in 2011. It is expected that this group (Generation 2) will have a lower mortality than the two previous generations.

Funding in 2010–11

Queensland Government

Collaborators

- Brian Cooke (Invasive Animals Cooperative Research Centre; University of Canberra)
- Greg Mutze, Ron Sinclair and John Kovalivski (Biosecurity SA)

More information

Key publications

Cooke, BD, Elsworth, PG, Berman, DM, McPhee, SR, Kovalivski, J, Mutze, GJ, Sinclair, RG & Capucci, L 2007, *Rabbit haemorrhagic disease: wild rabbits show resistance to infection with Czech strain 351 RHDV initially released in Australia*, Report submitted to Australian Wool Innovation and Meat and Livestock Australia, Invasive Animals Cooperative Research Centre, Canberra.

Story, G, Berman, D, Palmer, R & Scanlan, J 2004, 'The impact of rabbit haemorrhagic disease on wild rabbit (*Oryctolagus cuniculus*) populations in Queensland', *Wildlife Research* 31(2): 183–93.

For further information on this research project and access to key publications, visit the invasive plant and animal science pages on the Biosecurity Queensland website at www.biosecurity.qld.gov.au