

Monitoring malleefowls with camera traps in Western Australia's Wheatbelt: a case study in citizen science

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Abstract

Staff from a biodiversity project engaged landholders to conserve privately owned remnant vegetation in the heavily cleared Wheatbelt agricultural region of South West Australia. Such remnants are often high in biodiversity, but are generally poorly surveyed. A family in the Wheatbelt was approached to discuss the potential protection of their extensive native bushland areas. Noting an apparent abundance and diversity of fauna, we deployed camera traps, which we termed 'sensor cameras', to engage critical stakeholders, on gnammas (rock waterholes) and on nest mounds of malleefowls (*Leipoa ocellata*) in the hope of highlighting uncommon species and interesting malleefowl activity to further engage with the family. The cameras detected more fauna species than had previously been known by the family and triggered immediate interest. We showed one family member how to use the cameras to monitor the malleefowl mounds and as his confidence grew the family purchased their own cameras. He recorded daily mound activity, courtship displays, predators, seasonal activity trends and two freshly hatched chicks. He set cameras in other

locations and recorded many other wildlife species. We discuss some of these findings, the family's increasing understanding of malleefowls and their threats, and their commitment to protecting malleefowls and the bushland. We emphasise the role of camera traps in landholder engagement and citizen science.

Introduction

Camera traps, sometimes known as motion-triggered cameras or motion-sensitive cameras, are now a well-recognised tool for fauna monitoring and studying animal behaviour in the fields of zoology and ecology (Rovero *et al.* 2005; Mattick 2012). In addition, many workers have found them to have great value in community engagement due to their ability to record captivating photos and video of wildlife, ease of deployment, minimal impact on fauna (Bolen 2012; Irvine Ranch Conservancy 2013), and, in more recent years, relative affordability. Video clips or photos of wildlife, particularly of uncommon or rarely seen animal species, often elicit a stronger response from community members and

landholders than written reports (authors' personal observations). Staff from Wheatbelt NRM's Healthy Bushland project (Wheatbelt Natural Resource Management 2013; Thomas, Chapter 8) operate camera traps with landholders on privately owned bush remnants across the Wheatbelt, encouraging maximum involvement of property owners wherever appropriate. To encourage the engagement of community members with the technology and to avoid potentially adverse responses to terminology, we referred to the camera traps as 'sensor cameras' because of possible association with live trapping, techniques with which the landholders and their community were familiar.

Western Australia's Wheatbelt is the state's primary sheep and cereal producing region, and is one of the most heavily cleared regions in the state where many fauna species are now extinct, locally extinct or in decline due to the effects of widespread clearing, habitat degradation and introduced species such as foxes and rabbits (Burbidge, 2004). Several bird species have declined and numerous mammal, bird and reptile species have disappeared from the Wheatbelt since the early 1900s (Leake 1962; Abbott 2008). The malleefowl (*Leipoa ocellata*) was common throughout much of the region until the late 1800s, but is now absent or rare in many areas of the western and central Wheatbelt (Abbott 2008), surviving only in larger, less disturbed bush remnants. Biological surveys across the Wheatbelt have shown that these larger bushland remnants are particularly important refuges for fauna and flora species (Keighery *et al.* 2004). However, due to property access issues surveys are generally restricted to reserves or Crown land and are rarely conducted on private property. As much of the remaining native vegetation is on privately owned land, we recognise that landowners can be important managers of local biodiversity and, with some training in equipment use, survey methodologies and data collection, may greatly assist the work of biologists and conservationists in assessing and monitoring fauna and flora.

In 2002, staff from WWF-Australia working on a bushland conservation project conducted a quad-

rat-based flora survey in a large remnant in the Avon Wheatbelt, yielding an extensive plant species list that was provided to the property owners. This focused extra interest on the bushland and its diverse flora, and was followed by several more visits over the next few years during which time various management options for the bushland were discussed. From 2009 to 2013, WWF staff worked alongside staff from Wheatbelt NRM and Greening Australia (WA) under the Healthy Bushland project to engage landholders and land managers for improved management and protection of their bushland. During this period, camera traps became a tool of engagement with landholders and land managers across the Wheatbelt.

This study aims to evaluate the effectiveness of 'sensor cameras' as a tool for engaging and developing relationships with a landholder, to establish if meaningful biological data could be collected from landholders with minimal training and assistance and, if so, if this could lead to any changes in behaviour and/or conservation outcomes.

Materials and methods

Study area

The study area lies within the Avon Wheatbelt IBRA bioregion in south-west Australia. South-west Australia is one of the world's 34 biodiversity hotspots as recognised by Conservation International in acknowledgement of the highly diverse flora of the region and the extensive loss of habitat (Conservation International 2013; WWF-Australia 2012). The area is relatively dry, receiving an average of 315 mm of rainfall per annum, though considerably less in some years (Bureau of Meteorology 2013). The site lies within an extensive patch of bushland of over 4400 ha in total, of which over 2000 ha is owned by the Sachse family. It is situated in the Shire of Mt Marshall in the north-east of the Wheatbelt. The vegetation and topography are varied, and include extensive stands of tall tamma (*Allocasuarina campestris*) heath, mixed tall shrubland dominated by *Acacia* species and tall 'broom-

bush' (*Melaleuca* sp.), large granite hills and outcrops, extensive areas of mallee (*Eucalyptus* sp.) and eucalypt woodlands.

Paul Sachse purchased the property in the 1970s and worked the farm for many years; he is now retired and lives in Perth, Western Australia. His son Russell lives in the local area, a short drive away from the bush property. They have always maintained a strong connection to this large area of bushland and both Paul and Russell visit often. In 2010, the authors brokered a voluntary conservation covenant on behalf of the Healthy Bushland project, protecting over 365 ha of the Sachse bushland. The family has long been aware of malleefowls and their nest mounds on this property.

Cameras

Our first camera deployment on the Sachse property was with a 'homebrew' type of camera trap comprising a stand-alone, incandescent-flash, 2005/6 model Olympus camera in a weather-proof Pelican case, complete with its own circuit board (constructed by Archipelago Consulting). Although complicated to use and set up, these cameras are capable of taking clear, high-quality images, including colourful night photos. We also deployed a 2009 Bushnell Trophy Cam™ (BTC, Model 119415) camera. Paul and Russell later purchased their own 2010 Bushnell Trophy Cam (BTC, Model 119455C) cameras. Both Bushnell models are conventional infrared-flash cameras with built-in viewers and are relatively easy to operate. We also used a second incandescent camera, a 2008 Cuddeback Capture™ (Model 1125) for several months and later a 2008 Leaf River™ IR-5 camera trap. The Leaf River was one of the first makes to feature audio-recording, a feature that was later used extensively by Russell.

Camera site selection, citizen training and camera deployment

Camera sites and site selection

The study sites included a shallow pan gnamma on top of a granite hill surrounded by remnant bushland ('Gnamma 1'), a large deep pit gnamma in low granite outcropping close to the edge of a pad-

dock, fenced to exclude livestock ('Gnamma 2'), two malleefowl mounds in tall heath and mallee shrubland (Malleefowl Mound 1 or 'Emu Mound', and Malleefowl Mound 2 or 'Fence Mound') and a mature sandalwood tree in the vicinity of 'Fence Mound' and surrounded by tall shrubland. 'Emu Mound' is deep within the bushland in the south of the remnant and 'Fence Mound' is close to the edge of bushland in the north. Both mounds had been active in recent years, but the level of activity at the time was unknown.

We set out to capture a wide diversity of native fauna species, including mammals, birds and reptiles, to maximise the family's interest in the cameras and the wildlife, hoping for footage of uncommon species or unusual animal behaviour for additional interest. Therefore, camera traps were not deployed at random or on a predetermined grid or trail monitoring design. We took advice from Paul and Russell Sachse on potential locations for camera traps that were likely to capture animals and were of interest to them. On our asking about water points, they suggested the two gnammas. Our focus later shifted to the two malleefowl mounds, 'Emu Mound' and 'Fence Mound'. In setting up cameras on these mounds, we were hoping to capture any unusual and/or impressive malleefowl behaviour that would likely further add to growing enthusiasm and engagement.

Training

Our instructions to Paul and Russell were in the technical operation of camera traps, included camera set-up, camera maintenance, battery handling, review, sorting and storage of video clips and photos, the use of baits and attractants and the ethics relating to interventions when making observations of behaviours such as nesting malleefowls and animals drinking. Later, we spent time on computer tasks relating to camera trap photos and video clips. Russell had a relatively new laptop computer when we started but had used it very little. In September 2010, Russell and Paul attended our 2-day Healthy Bushland camera trapping workshop aimed at giving practical instruction to

local landholders in the use of motion-triggered cameras.

Deployment

We operated the Olympus camera in the Pelican case on the first (shallow) gnamma with limited non-technical assistance from Paul and Russell. We operated the 2008 Cuddeback Capture on one of the malleefowl mounds ourselves for several months with increasing assistance from Russell. Later we replaced the Olympus camera on the gnamma with the 2009 BTC camera and then moved this to the second larger (pit) gnamma on the edge of farmland close to the bush remnant. We invited Russell to operate the BTC camera, showing him how to check and replace batteries and memory cards in the BTC so that he was able to operate the camera independently. After shifting focus to the malleefowl mounds, we invited him to operate the Leaf River camera despite it being more difficult to program than the Bushnell cameras. Retaining our original menu settings for the first few months minimised complications.

At the malleefowl mounds, we showed Russell our preferred method of setting up cameras with the aim of training him to monitor malleefowls independently; we used star pickets mounted 40–70 cm above the ground and aimed the cameras at the mound's lower and mid-slopes, orientated southward to minimise sun glare. We started by positioning the cameras well back from the mounds to ensure minimal disturbance of the birds and moved them slightly closer once it became clear that the cameras presented no problems to the birds. By mid-2011, our visits to the Sachse property had become less frequent due to time constraints, but were complemented by back-up assistance via telephone when required.

Participatory learning and landholder engagement

The opportunity to monitor malleefowl mounds was important in engaging the Sachse family, as malleefowls had long been of great personal interest to Russell and the idea of monitoring mounds

was particularly appealing to him. Russell experimented with camera set-up on the malleefowl mounds and at times mounted them as high as 90 cm high to capture the tops of the mounds.

Later he began looking further afield in the bushland for opportunities to use camera traps, and noticed fallen nuts on the ground beneath a sandalwood tree (*Santalum spicatum*) that had been cracked open by an unknown animal. With encouragement from us, he set up a BTC in February 2011 in an attempt to identify the animal responsible for the cracked seeds.

Data management

While our initial focus was on camera set-up and technical considerations of camera operation, we later spent time with Russell suggesting ways to save, review and sort video clips and photos. A simple data management system was used, consisting of an external hard drive to store the large volume of digital information (especially from videos) and a basic system of folders for each site and subfolders for camera traps. To maintain simplicity and encourage good data management with minimal learning impost on the Sachses, we did not introduce any file naming or file management programs.

Results

Fauna records

Russell captured at least eight species of birds, mammals and reptiles from the malleefowl mounds, and a total of (at least) 24 species at all sites including the gnammas and sandalwood tree (Table 9.1). Footage of hopping mice (*Notomys* sp. – likely to be *N. mitchelli* based on distribution), dunnarts (*Sminthopsis* sp.) and malleefowls, including a malleefowl lapsing into a daytime semi-sleep position under the tree, was captured.

Over 2 consecutive years of monitoring, Russell was also able to establish clear seasonal patterns in malleefowl activity that varied only slightly between the two years (Appendix 9.1). His cameras

Table 9.1. Fauna species recorded with camera traps in the north-eastern Western Australian Wheatbelt Healthy Bushland site, June 2010 – July 2012.

Site	Camera Make/Model/ Operator(s) RS = Russell Sachse; PL = Phil Lewis; MG = Mike Griffiths	Species recorded	
		Common name	Scientific name
Gnamma 1 (small shallow pan gnamma, top of granite hill in remnant bushland)	Archipelago Consulting 'home-brew' Olympus in Pelican Case, (incand) MG; Bushnell Trophy Cam 2009 model (IR) MG, PL, assisted by RS	Galah Australian ringneck Common Bronzewing Cat Red fox Western grey kangaroo Euro Grey currawong Elegant parrot Crested pigeon	<i>Eolophus roseicapilla</i> <i>Barnardius zonarius</i> <i>Phaps chalcoptera</i> <i>Felis catus</i> <i>Vulpes vulpes</i> <i>Macropus fuliginosus</i> <i>Macropus robustus</i> <i>Strepera versicolor</i> <i>Neophema elegans</i> <i>Ocyphaps lophotes</i>
Gnamma 2 (large deep pit gnamma, in low granite outcropping in paddock)	Bushnell Trophy Cam 2009 model (IR) MG and RS	Western grey kangaroo Euro Red fox Cat Australian raven Australian ringneck Mulga parrot Magpie-lark Bobtail Crested pigeon Australian magpie Yellow-throated miner	<i>Macropus fuliginosus</i> <i>Macropus robustus</i> <i>Vulpes vulpes</i> <i>Felis catus</i> <i>Corvus coronoides</i> <i>Barnardius zonarius</i> <i>Psephotus varius</i> <i>Grallina cyanoleuca</i> <i>Tiliqua rugosa</i> <i>Ocyphaps lophotes</i> <i>Gymnorhina tibicen</i> <i>Manorina flavigula</i>
Malleefowl Mound 1 'Emu Mound'	Cuddeback Capture (incand) MG; Bushnell Trophy Cam 2009 and 2010 models (IR) MG, RS , PL; Leaf River IR-5 (IR) PL, RS	Western grey kangaroo Euro Red fox Malleefowl Brown goshawk	<i>Macropus fuliginosus</i> <i>Macropus robustus</i> <i>Vulpes vulpes</i> <i>Leipoa ocellata</i> <i>Accipiter fasciatus</i>
Malleefowl Mound 2 'Fence Mound'	Bushnell Trophy Cam 2010 model (IR) RS	Western grey kangaroo Euro Red fox Malleefowl Chestnut quail-thrush Western bluetongue Gould's monitor	<i>Macropus fuliginosus</i> <i>Macropus robustus</i> <i>Vulpes vulpes</i> <i>Leipoa ocellata</i> <i>Cinlosoma castanotum</i> <i>Tiliqua occidentalis</i> <i>Varanus gouldii</i>
Sandalwood tree	Bushnell Trophy Cam 2010 model (IR) RS	Euro Malleefowl Hopping mouse (unident) Red fox Dunnart (unident) Grey currawong Southern scrub robin Cat	<i>Macropus robustus</i> <i>Leipoa ocellata</i> <i>Notomys</i> sp. <i>Vulpes vulpes</i> <i>Sminthopsis</i> sp. <i>Strepera versicolor</i> <i>Drymodes brunneopygia</i> <i>Felis catus</i>

recorded calls, courtship and male rivalry behaviour, and important life cycle events such as chicks emerging from the mound.

Russell's deployment of a camera beneath the sandalwood tree with fallen nuts resulted in footage of a large male euro (*Macropus robustus*) cracking the nuts and eating the kernels, thus answering his question of what was cracking the nuts and providing an behavioural observation that we could not find to be previously reported in scientific literature.

Participatory learning and training

The camera traps placed on the shallow pan gnamma in 2010 captured many photos and video clips of bird and mammal species, providing a vivid 'snapshot' of native and introduced species and triggering enthusiastic responses from the Sachse family. This was followed by more photos and video clips from the deep pit gnamma. After setting up cameras on 'Emu Mound' and capturing photos and video of malleefowls, Russell and Paul were happy for us to introduce additional cameras to their property. Russell began monitoring 'Emu Mound' with initial assistance from us (Plate 14), and then with increasing independence monitored the second mound, 'Fence Mound' and the sandalwood tree with only limited assistance from us.

Encouraged by early successes of the cameras on the gnammas and mounds, Paul and Russell purchased three BTC cameras of their own (infrared-flash 2010 model) in late 2010 and early 2011. These and the 2009 BTC models are relatively easy to operate, and we consider them to be suitable for first-time camera trap users with minimal instruction. They became the main type of camera used by Russell and he used them extensively.

By mid-2011 Russell was receiving only occasional guidance from us. He obtained clear video footage of malleefowls, foxes and other species on the mounds. He found that the Bushnell Trophy Cam camera traps were relatively easy to use, but the Leaf River IR-5 camera was more problematic. Using the Leaf River with our original programmed settings partly overcame this, and its audio-record-

ing capacity impressed him. He operated all cameras in video mode, which quickly became his preference over still photo (camera) mode. It allowed him to record behaviour and in the case of the Leaf River camera, vocalisations as well, which he found very rewarding.

Key skills learnt by Russell with guidance from us included positioning the cameras in relation to the sun, minimising wind-generated false triggers, managing batteries and operating the cameras to maximise their capabilities within the limitations of weather conditions and available time. Due to the long hot, windy summers in this district, false triggers are a particularly challenging problem, but Russell soon became skilled in this area. On several occasions we noted that the date and time data attached to the video clips were incorrect as settings had not been checked during camera set-up, making it difficult to properly analyse footage. We pointed out the importance of being vigilant with these settings to Russell and he took note. In earlier months, we received video footage from Russell in the form of unsorted video clips that often included hundreds of false triggers, necessitating much sorting on our part to view the significant footage, but this situation improved as his skills improved. Initially, Russell's lack of confidence in computing affected his capacity with computer-based tasks, and this was compounded by our lack of evaluation and understanding of his skill levels and previous experience.

Discussion

Faunal records and data management

Camera traps placed by citizen scientists provided information about the species visiting malleefowl mounds, gnammas and a sandalwood tree at the Healthy Bushland site, and enabled monitoring of malleefowl recruitment and behaviour and the visitation by predators and other animals. More species visited the gnammas than the malleefowl mounds. Red foxes, but not feral cats, were observed at malleefowl mounds, resulting in increased control effort targeting foxes.

Sorting, saving and managing video files were the biggest challenges for Russell; however, once we recognised this, we were able to take steps to rectify it. Russell's preference for video-recording necessitated greater storage requirements and greater vigilance in management. We pointed out the digital properties of date and time on the video clips and Russell began analysing the video clips and looking for patterns in malleefowl behaviour relating to time of day, later also establishing seasonal trends with variations in rainfall and temperature. Our initial lack of a system for sharing video files between visits impaired our ability to monitor Russell's progress and to provide feedback later in 2011 and in 2012 after our visits had decreased. We were able to address this issue in part by assisting him with the burning of CDs for mailing, along with use of USB drives (thumb drives), later leading to the use of internet file-sharing programs.

Participatory learning and landholder engagement

Russell and Paul showed great interest in the cameras and the diverse wildlife captured on them from the outset. The video clips were of particular interest to them, especially those showing particular malleefowl behaviour, and triggered renewed interest in the malleefowls. Russell lives locally and was able to assist us with the camera set-up on the first gnamma and first malleefowl mound; later we assisted him with a camera on the second gnamma and second malleefowl mound. We noted a steady increase in his involvement with the cameras, corresponding to a steady increase of his knowledge of the species and of his technical skills. Footage of fox visits to the mounds was of particular concern to him and Paul.

When we started wildlife monitoring on the Sachse property, Russell's limited computer experience meant that he was not familiar with available programs to review, edit and manage video files. However, we saw his confidence with computer tasks grow over the months as we passed on tips based on our own learnings. His early success with the camera traps on the malleefowl mounds

prompted him to spend more time with his laptop computer, and with some guidance from us this hastened his learning of computer skills considerably.

The video clips triggered particularly strong interest and awareness in the malleefowls on Russell's part (more so than the photos), as did the audio-recording capability. We feel that the many varied video highlights (Table 9.1 and Appendix 9.1) contributed considerably to his heightened interest in the malleefowls and other wildlife. He was surprised at the extent of the malleefowl presence on the mounds during the hot, dry months, and the recorded malleefowl calls on the Leaf River camera were possibly the first he had heard, and triggered great interest. Capturing two hatchling chicks emerging from the mound generated more excitement than any other events. Purchasing a reference book on malleefowl ecology late in 2011 allowed Russell to further understand and interpret behaviour captured on camera. By mid-2012, he was using three 2010 Bushnell Trophy Cam camera traps and monitoring both mounds and several other sites on the property with considerable enthusiasm.

After seeing repeated video footage of foxes around the malleefowl mounds, Russell recommenced and increased fox baiting on the property, concentrating on the areas around the mounds. This is now an annual activity for him and he reports a decline in fox numbers at the mounds and gnammas based on camera trap images and footage.

We found camera traps to be very effective in engaging with and developing relationships with the Sachse family from the outset. While the cameras did not directly lead to us brokering the conservation covenant, we feel that they helped the engagement process. Our earlier 2002 flora survey was met with mild interest and resulted in a small increase in awareness of local flora by the family, but the results of the fauna monitoring with camera traps triggered an immediate and enthusiastic response. Russell and Paul showed a strong interest in the cameras since the first deployment on their property, and with Russell's ongoing involvement and his strong interest in malleefowls and other

wildlife, his technical expertise with the cameras continued to grow. The level of interest was highlighted by Paul and Russell buying their own camera traps and Russell's purchase of a reference book on malleefowls. Though file management is an ongoing task for him, Russell has accumulated a large amount of video footage of malleefowl activity and behaviour with accompanying data on time of day and time of year. Russell's increased fox baiting was an important result of monitoring the malleefowl mounds with a camera trap after becoming aware of the large number of foxes at the mounds. (Here we saw a double role for the cameras: they were the tool for initially learning about the extent of the fox problem and also the tool for monitoring the results of fox baiting.)

Russell and Paul are now confident in operating camera traps, and Russell is particularly skilled at operating them in a variety of situations and challenging conditions. Furthermore, they have become very aware of malleefowls and other local fauna species, and have taught us many things about malleefowl behaviour, local fauna and ecology. Russell in particular has become very knowledgeable about malleefowl behaviour, ecology and their threats with his ongoing camera work and has taught us a considerable amount about malleefowl behaviour based largely on his observations from his camera's recordings. Working with enthusiastic and informed landholders makes our work considerably easier, and the Sachse family is now more enthusiastic than ever about protecting this large patch of valuable bushland.

The sensor cameras proved to be a valuable tool not only for project staff in engaging with the Sachse family but also for the family to make their own discoveries about their resident malleefowls and other wildlife in an area that has had few, if any, fauna surveys. Russell summed up his experiences as follows: 'The cameras have really opened my eyes with the malleefowls and also with the other species on the property like hopping mice, euros and quail-thrushes. Because the cameras are so unobtrusive they allow me to see natural behaviour of the animals that I'd never see otherwise. I

especially love watching footage of malleefowl courtship dances and hearing their calls.'

Conclusion

Lessons learnt

It was clear to us that the type of camera trap used is very important for first-time users, with an easy-to-follow 'intuitive' program menu being of great importance. If a first-time camera trap user must carefully read a user manual for basic camera operation, the camera is probably not suitable for landholder engagement. Training can only compensate partially for this.

We found video footage of wildlife triggered a stronger, more positive response than still photos from people we have worked with.

Maintaining good communication with landholders and land managers is vital to ensure they are overcoming challenges and not being frustrated by technical problems. Long-term communication is essential for good relationships and positive project outcomes.

Understanding the skills, interests and time availability of landholders and land managers is essential for the success of any interactive project where participation is expected.

Management of videos and images is one of the more challenging (and more demanding) tasks for many property owners and land managers, while sharing of video clips can also be challenging without access to on-line image-sharing systems, and this can hinder evaluation of sensor camera deployment.

In the context of the Western Australian Wheatbelt and many other areas of Australia, many feral animals are 'captured' by 'sensor cameras' in bush areas, and it is important to recognise that land managers' awareness of feral species is as important to conservation as the capture of rare or interesting native species.

We have no doubt that camera traps can be important tools in engaging landholders and land managers providing the cameras are easy to use

and support and training are given where and when required. Additionally it is essential that the landholders and land managers are interested in the project at hand, have time to participate and have the appropriate skills to enable meaningful training, and it is important to maintain good long-term communications. When used appropriately, we feel that camera traps are powerful tools to engage, educate and enthuse landholders and land managers. Many large bush remnants in agricultural areas are managed privately and it follows that increased owner awareness of threatened fauna and its ecological requirements and threats can have positive outcomes for conservation and play an important role in citizen science.

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References

- Abbott I (2008) Historical perspectives of the ecology of some conspicuous vertebrate species in south-west Western Australia. *Conservation Science in Western Australia* 6, 1–214.
- Bolen A (2012) *Camera Traps: Gotcha!* <[http://www.nwf.org/News-and-Magazines/National-Wild-](http://www.nwf.org/News-and-Magazines/National-Wildlife/Animals/Archives/2012/Camera-Traps-and-Conservation.aspx)
- life/Animals/Archives/2012/Camera-Traps-and-Conservation.aspx>.
- Burbidge A (2004) *Threatened Animals of Western Australia*. (Department of Conservation and Land Management, Kensington).
- Bureau of Meteorology (2013) *Climate Statistics for Australian Locations*. (Summary statistics Bencubbin). <http://www.bom.gov.au/climate/averages/tables/cw_010007.shtml>.
- Conservation International (2013) *Hotspots Defined*. <http://www.conservation.org/where/priority_areas/hotspots/Pages/hotspots_defined.aspx>.
- Irvine Ranch Conservancy (2013) *The Irvine Ranch Natural Landmarks. Wildlife Monitoring on the Natural Landmarks*. <<http://www.irlandmarks.org/Activities/Wildlife-Monitoring.aspx>>.
- Keighery GJ, Halse SA, McKenzie NL, Harvey MS (2004) A biodiversity survey of the Western Australian agricultural zone. *Records of the Western Australian Museum* 67(Supplement), 1–384.
- Leake BW (1962) *Eastern Wheatbelt Wildlife. Experiences of a WA Naturalist*. (Docket Book Co., Perth).
- Mattick B (2012) *Myth No longer: Myanmar Snubby Caught Live on Camera*. (People Resources and Conservation Foundation). <<http://www.prc-foundation.org/myanmar/snubby-caught-live-on-camera>>.
- Rovero FT, Jones T, Sanderson J (2005) Notes on Abbott's duiker (*Cephalophus spadix* True 1890) and other forest antelopes of Mwanihana Forest, Udzungwa Mountains, Tanzania, as revealed by camera-trapping and direct observations. *Tropical Zoology* 18, 13–23.
- Wheatbelt Natural Resource Management (2013) *Healthy Bushland Project*. <<http://www.wheatbelt-nrm.org.au/projects/biodiversity/healthy-bushland-project/>>.
- WWF-Australia (2012) SWAE Program. *Southwest Australia Ecoregion Ecohub*. <<http://swae-coregion.org/>>.

APPENDIX 9.1: OBSERVATIONS OF MALLEEFOWL ACTIVITY AND BEHAVIOUR

Russell's cameras on the two Malleefowl mounds recorded Malleefowl courtship displays and vocalisations many times (see Appendix Table A9.1). He captured a chick emerging from the mound one January night and a second chick emerging 2 days later at first light just before sunrise, events that triggered considerable excitement. His cameras also allowed

him to observe regular fox visits to the mounds. He recorded foxes interacting on the mounds, and on one occasion a fox, although largely out of sight, appeared to dig in the centre of the mound, triggering concern for the Malleefowl's eggs. On another occasion he captured a fox running into a mound and pouncing on an unseen animal within the crater.

Appendix Table A9.1. Russell Sachse's records of seasonal Malleefowl activity and behaviour observed with camera traps.

Time of year	Activities observed
February/March (Hot, dry windy)	<ul style="list-style-type: none"> • Malleefowl regularly visited the mound throughout the long dry summer–autumn period, at times visiting the mound almost daily. They were not scratching and did not appear to be moving leaf-litter into and out of the mound; rather they gave Russell the impression they were simply 'keeping watch' on the mound. • Malleefowl calling was recorded (a low 'oom, oom') on the Leaf River camera. • Many clips of Malleefowl courtship display were captured.
April/May (Warm days, cool nights, generally dry)	<ul style="list-style-type: none"> • Malleefowls recorded working the mound, raking leaf-litter. • Digital date and time data on the video clips allowed Russell to make further observations regarding daily activity: they often spent 3 to 4 hours in the morning raking leaf-litter out of the mound, then after a break of 1 to 2 hours would return and rake the material back onto the mound.
June/July (Cool days, cold nights, occasional rain)	<ul style="list-style-type: none"> • Malleefowls excavated ('cleaned out') the mounds, leaving an empty crater.
August/September (Mild days, cold nights, occasional rain)	<ul style="list-style-type: none"> • Malleefowls raked leaf-litter from a wide area surrounding the mounds into the centre of the mound, forming 'wind rows' of leaf-litter (litter trains) in the process.
September/October (Warm days, cool-cold nights, decreasing rain)	<ul style="list-style-type: none"> • Malleefowls filled the centre of the mound with freshly raked leaf-litter leading up to egg laying.
January (Hot, dry windy)	<ul style="list-style-type: none"> • Chicks hatched: first video of a Malleefowl chick was captured shortly after emerging from the mound at night [pre-dawn, 1 January 2012] followed by a second chick emerging 2 days later (post-dawn, 3 January 2012).