22. Motion-sensitive cameras for monitoring a range of animals in Malleefowl monitoring sites

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Abstract

The national Malleefowl monitoring system provides essential information on trends in Malleefowl populations at over 100 sites across Australia. By relating these trends to other information, such as management actions and environmental conditions, we gain understanding of what influences Malleefowl populations. In particular, Malleefowl may be affected by the abundance of other animals, especially predators such as foxes and cats, pests such as rabbits and goats, and natives such as kangaroos. All of these animals may have an impact on Malleefowl, but obtaining reliable information on them is difficult.

In 2013 we trialled the use of motion-sensitive cameras at two monitoring sites in Victoria in order to collect information on a range of animals simultaneously. To be most efficient in terms of cost and labour, we envisaged a system in which cameras were semi-permanent and visited only once per year to download photos and check that cameras were working properly. Accordingly, cameras were set up with solar panels and batteries and scattered through the mallee (not at mounds) to monitor animals throughout the year. We devised a simple system for volunteers to sort photos which proved effective, accurate and popular. Once sorted, the data were easily extracted and transferred to a database in preparation for analysis. The ensuing data provide a detailed view on the abundance of a range of species that may affect Malleefowl. The techniques promise to deliver cost-effective and valuable information to the Malleefowl Adaptive Management Project, and more generally to land managers.

Introduction

Monitoring Malleefowl provides data on the trends in the species populations which is essential for informed management. This information is made meaningful by relating it to other factors that influence Malleefowl populations, such as rainfall, fire history, and landscape context (Benshemesh, Barker & MacFarlane 2007). However, many important factors can't be tracked so easily. For example, foxes are the main predators of Malleefowl but are elusive and difficult to monitor; previous studies have resorted to counting fox scats on mounds as a means of estimating fox trends and their effect on Malleefowl populations (Benshemesh, Barker & MacFarlane 2007, Walsh *et al.* 2012). Obtaining useful data on the abundance of other predators and competitors that may affect Malleefowl populations is even more difficult (Benshemesh 2007), yet this information is essential if we are to make sense of Malleefowl trends and identify the most effective management options. As Malleefowl monitoring moves from a passive activity to a dynamic interaction with management under the Adaptive Management Project (Benshemesh & Bode 2011, Hauser *et al.* 2014), information on trends of predators and competitors will become increasingly important.

Motion sensitive cameras provide an efficient means of gathering data on a range of medium to large sized animals simultaneously (Silveira, Jácomo & Diniz-Filho 2003, Vine *et al.* 2009, Claridge, Paull & Barry 2010). In regard to Malleefowl monitoring, cameras could provide quantitative data on the abundance of several animals of interest, including predators such as foxes, dogs and cats, and potential competitors such as kangaroos, goats, and rabbits. Cameras might also provide alternative information on Malleefowl abundance that cannot be obtained through the current monitoring practice which focusses on breeding birds. In particular, cameras may provide some information on non-breeding Malleefowl, and help identify years in which recruitment of young occurs into the adult population.

As monitoring sites are only visited annually, the ideal setup would involve cameras that require little maintenance and are able to collect photos over a 12 month period. In this ideal scenario, people doing the Malleefowl monitoring each year would simply swap the full memory cards of the cameras with empty cards.

In this study we assessed the utility of camera traps for the Malleefowl monitoring and adaptive management projects. Twenty-four cameras with solar panels and external batteries were placed in two monitoring sites and evaluated in terms of the suitability of the technology, the ease of processing the photos, the usefulness of the ensuing data, and the practicability of developing a larger program in which camera traps might be placed in the majority of Malleefowl monitoring sites and provide information on the abundance and trends of a number of species of interest.

In particular, we were interested in the performance of the cameras and how best to set them up for continuous field operation. For example, should the cameras take multiple photos whenever triggered? Should they be made insensitive between trigger events or capture every trigger event?

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Methods

Faunatech (www.faunatech.com.au) supplied 25 cameras (KeepGuard KG-680v) and provided each with an SD card (4GB), battery (6V, 12Ah lead-acid dry-cell) and solar panel. Faunatech also supplied all necessary wiring and attachment brackets for the solar panels.

Twenty-four cameras systems were installed in neighbouring Malleefowl monitoring sites separated by 1km of agricultural cleared land: 16 camera systems in Wandown (area about 18 km^2) and eight in Menzies (area about 3.4 km^2). Cameras were placed 100-200m off tracks to facilitate access while keeping them out of sight from passers-by and were typically strapped to the base of mallee trees). Orientation was usually southerly to minimise glare from the sun, and care was taken to select a site and orientation that avoided vegetation that might move in the wind and trigger the camera. The battery was wrapped in plastic bags and covered with sticks or triodia clumps to reduce interference from animals. Solar panels were attached to a mallee stem 1.5 – 2.0 metres above the ground and orientated to the north.

Cameras were revisited by VMRG members who checked its condition, removed and replaced the SD cards, and restarted the camera. These people had no prior experience with the cameras, but were provided with each camera's GPS location and instructions that detailed the reading process.

The 24 cameras captured 29,494 photos over the first period (55 days: 24 March to 18 May 2014) and 84,854 photos over the second period (171 days: 18 May to 5 November 2014). All photos were in JPG format.

The data on the 24 SD cards was transferred to a PC and then copied to two 300GB hard drives for security, one of which was prepared for analysis. A separate folder was created for each camera, and photos were renamed with the camera number followed by the photo number using Ant Renamer, a Windows program designed to rename collections of files. Subfolders were created for eight species of interest: Malleefowl, Fox, Cat, Emu, Kangaroo, Pig, Rabbit/Hare, Echidna (rabbit and hare were combined as they were relatively rare).

We used Windows Explorer opened in two separate windows, or (preferably) FastStone Image Viewer (FastStone Soft) to scan through the photos rapidly and move them to the appropriate folders, and ExPrint (JD Design) to write the contents of the directory that included the photos to a spreadsheet (Microsoft Excel) and a database (Microsoft Access), including the file path and the Exif date/time.

All cameras were set to take two photos in rapid succession whenever the infrared trigger was activated, however inspection of the photos showed that there was no advantage in this as animals were usually readily identified from the first photo. In quantitative analyses, these second photos were ignored.

The photos from the first period were sorted by one of us (JB). The second set of photos was divided into eight batches of about 5,000 photos and sent to 15 volunteers who sorted them. People were asked to use the first 1,000 photos to become familiar with the task, and to time the sorting of subsequent groups of 1,000 photos.

During this assessment, all cameras were set to take a photo whenever they detected movement. However, the cameras can be set to enter an insensitive or 'rest' period after a photo is triggered. This minimises repeated photos of the same animal or other trigger event, but risks missing interesting animals that might pass while the camera is insensitive. To simulate different time interval settings on photo-sets that would eventuate from setting the cameras to be insensitive for 1 - 60 minutes after a photo was taken, we manipulated the data in Excel and Access to mimic insensitive intervals (i.e. photos were ignored if they were taken within a nominated insensitive period since the last trigger event).

Results

Installation of cameras took 10 - 20 minutes and exchanging the SD cards and checking the systems took less than five minutes, even for inexperienced volunteers. System failures occurred but were not common: one camera system failed to take photos during the first (54 day) period due to incorrect setup, and none failed in the second period. A few cameras developed an internal error that rendered daytime photos in monochrome pink but these nonetheless provided adequate detail to identify target animals.

Ten percent of photos were of target animals and the remainder were regarded as nulls without recognisable animals in them. Most likely these were triggered by moving vegetation or shadows. However, nulls also included photos of various bird species, especially white-winged choughs and magpies, as well as occasional photos of yellow throated miner, ravens, chestnut quail-thrush, tawny frogmouth, and a wedge-tailed eagle.

Target animals were photographed by every camera, averaging about 1.1 target-animal photos/camera/day. The proportion of photos that were of target animals averaged 20% across cameras, but this varied considerably between cameras from less than 1% to 64% due to some cameras at which a very high number of nulls occurred. Nulls were also recorded at every camera.

Camera rest periods

The **proportion of target animal species** detected by the cameras was not sensitive to the simulated rest periods after a trigger event (Figure 1). If a species was detected at a camera when there was no rest period, then it was generally also detected even if the insensitive rest period was up to 60 minutes. There were some exceptions, but changes were minor: Malleefowl were detected at 19 of the 24 cameras when there was no rest period, but at only 18 cameras when the rest period was one minute or greater. Rabbits/hares were detected at 22 cameras consistently until the rest interval was increased to 60 minutes, when it was not detected at one of the cameras. Non-target birds (XBird) were similarly detected at all 24 cameras until the interval was increased to 10 minutes and more when they were detected by 23 cameras. Foxes and kangaroos were the most ubiquitous animals and were detected at all cameras regardless of interval.

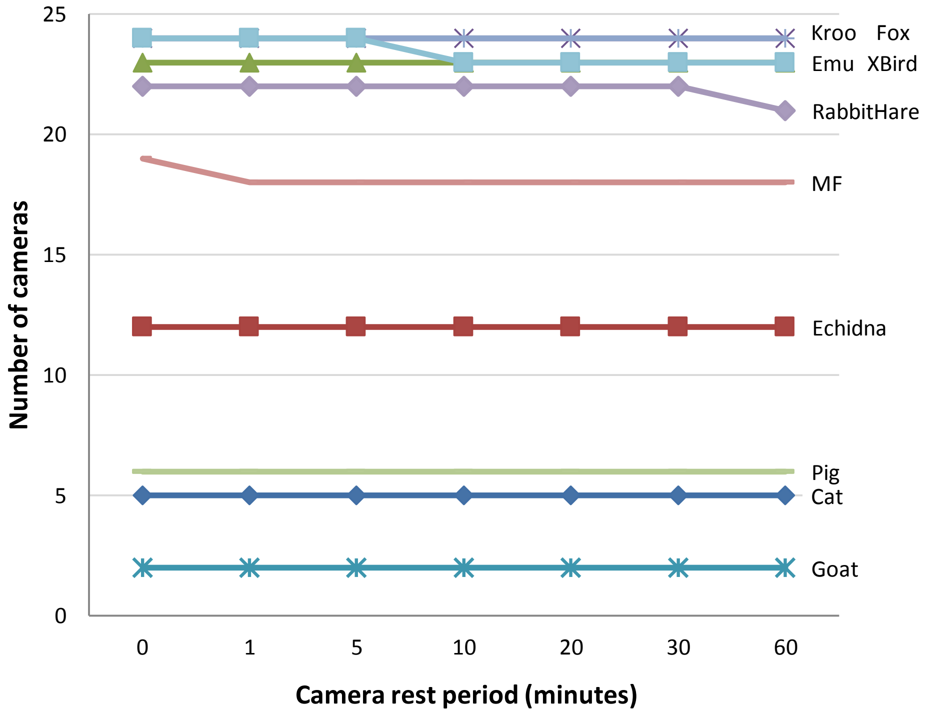


Figure 1. Number of cameras that detected target animal species for different photo intervals (24 cameras in total over 224 days).

While the proportion of cameras that detected each species was relatively constant in relation to camera rest intervals, the **number of photos of each target animal was greatly affected by rest length**. The number of nulls was greatly reduced when rest intervals increased: a one minute interval between successive photos reduced the number of nulls by 38%, a five minute interval by 65%, and a 60 minute interval by 87% (Figure 2). Similarly, the number of animal photos was reduced by 39%, 52% and 59% for one, five and 60 minute intervals respectively. The reduction in the number of nulls was greater than that of target animals, and consequently the proportion of animal photos increased with increasing intervals (Figure 2).

Target species responded differently to varying the interval length between photos. Kangaroos were the most commonly photographed animals, averaging 113 photos per camera in the original dataset, but this dropped to 50 photos per camera with a one minute rest interval, and to 29 photos per camera with a five minute interval. Thereafter, declines were slight (Figure 3). Emu and, to some extent, pig captures also followed this pattern of substantial reductions in captures with the introduction of camera rest periods, followed by only small changes with increasing rest interval. In contrast, foxes averaged 63 photos per camera in the original dataset, and this dropped less radically to 56 photos per camera with a one minute rest interval, and to 54 photos per camera with a five minute interval; thus fox became the most frequently captured species once a rest period of one minute or more was simulated, and with a ten minute or greater rest interval, were recorded at least twice as frequently as Kangaroo. The number of photo captures of Malleefowl, cats, rabbit/hare and echidna changed little with different interval length. In general, there was little change in the average number of photos per camera for target species with intervals greater than five to ten minutes (Figure 3). These data are represented in terms the proportional contribution of each species' photos for camera rest interval in Figure 4 where the contrast between capture patterns of kangaroos and foxes is particularly evident.

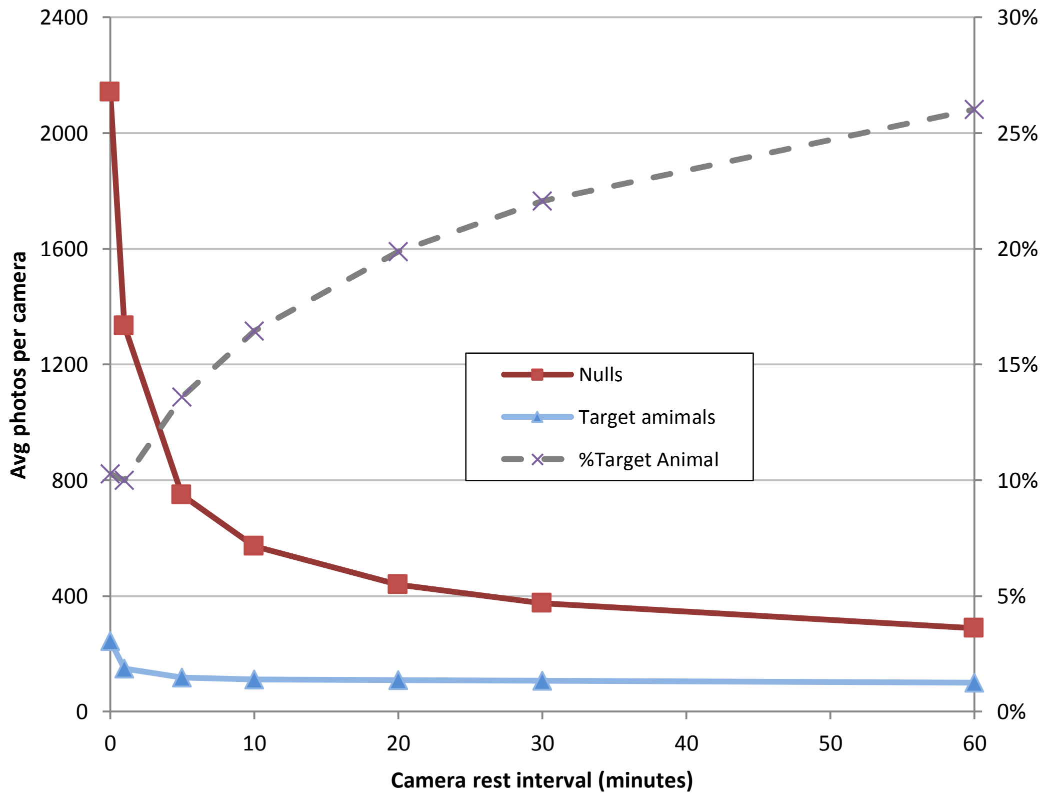
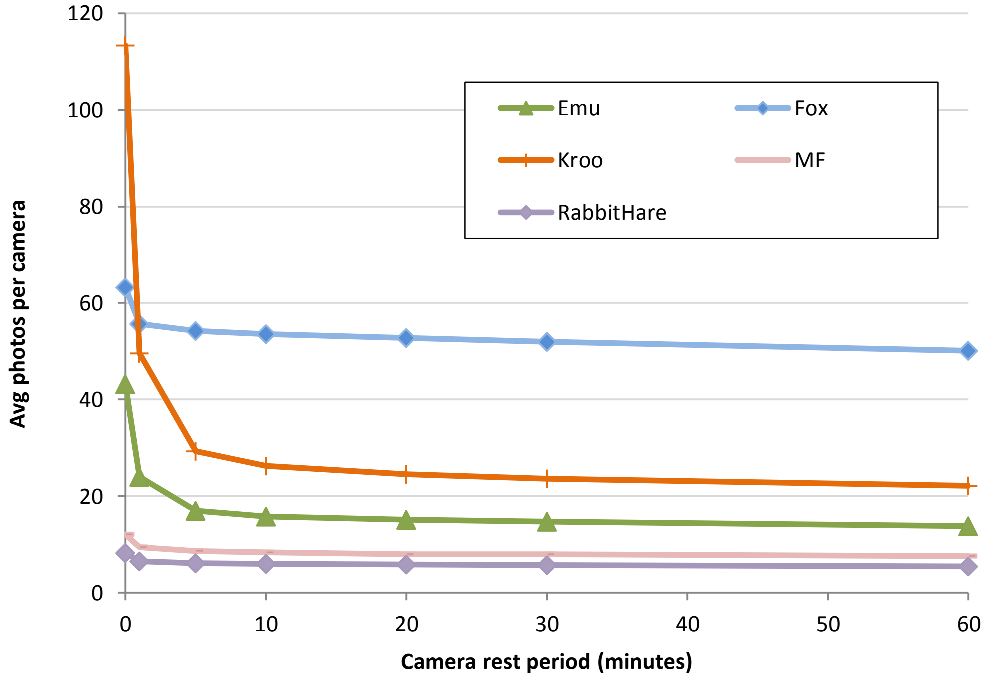


Figure 2. Average number of null and target animal photos per camera, and proportion of photos that were of target animals, in relation to camera rest intervals.

Species captures at Wandown and Menzies

Simulated numbers of photos with a ten minute rest interval were used to examine differences in the abundance of target animals at Menzies and Wandown (Figure 5). Kangaroos, emu and Malleefowl were more commonly photographed at Wandown and Menzies. Fox and rabbit/hare were photographed a similar rates at the two sites, whereas cat, pig and echidna were rarely photographed at either site.

a)



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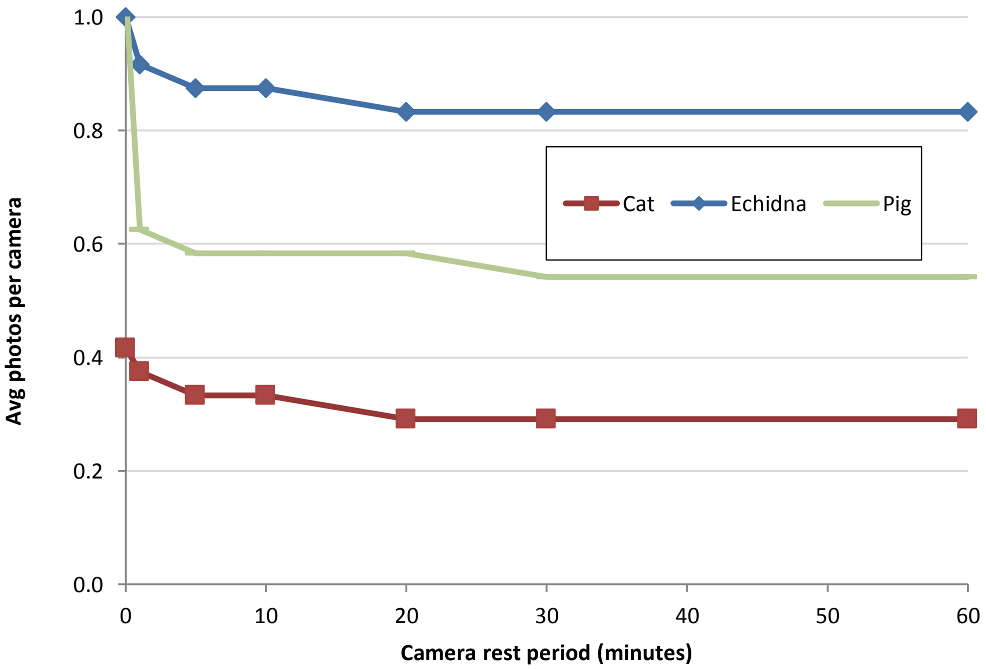

Figure 3. Average number of photos of target species per camera over the 224 day study period for different camera rest intervals between photos: **a)** most common species (more than 1 detection/camera); **b)** less common species (less than 1 detections/camera).

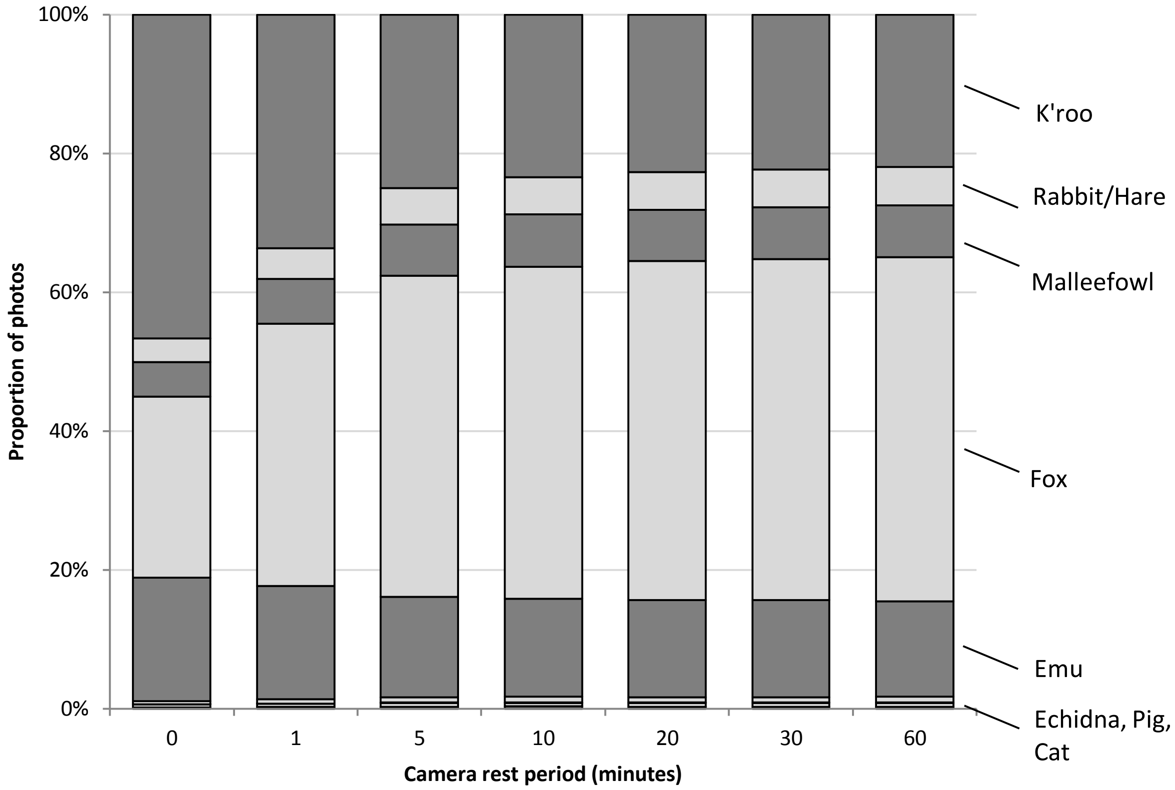

Figure 4. Proportion of photos of target species for different intervals between photos.

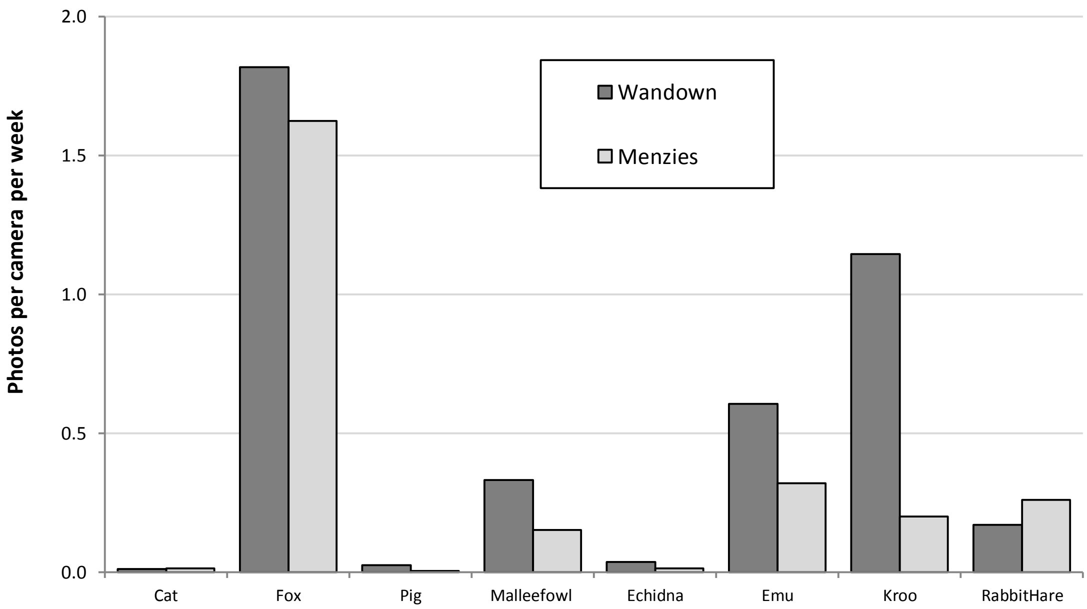

Figure 5. Number of photos of target species per camera per week at Wandown (dark grey) and Menzies (light grey) with a 10 minute interval between photos.

Sorting photos by inexperienced volunteers

Fifteen of the 16 people who volunteered for the task, returned a disk with sorted photos. Responses were overwhelming positive: all responders said they enjoyed the process, all said they would do it again, and all but one said they were prepared to sort three times as many photos each year if we were able to purchase more cameras (the only responder who was unsure was using a Mac computer and sorting was very slow).

The median time for volunteers to sort 1,000 photos was about 40 minutes. Times varied greatly from eight to 120 minutes per thousand photos (Figure 6). The variation in sorting rate probably reflected the nature of the photos being sorted; where there were many successive nulls or repeated photos of particular animals (especially kangaroos), sorting was faster because many photos could be dragged to the appropriate folder in a single action. Another source of variation was the computers that people worked with: the slowest volunteer was unable to use the recommended software and progress was very slow, estimated at 129 minutes for each thousand photos. It was also apparent that some people were simply faster than others. However, volunteers became faster at sorting with increasing experience: the 2nd thousand photos took a median of 50 minutes, the 5th thousand photos took only 35 minutes and the experienced sorter took only 28 minutes to sort one thousand photos (Figure 6).

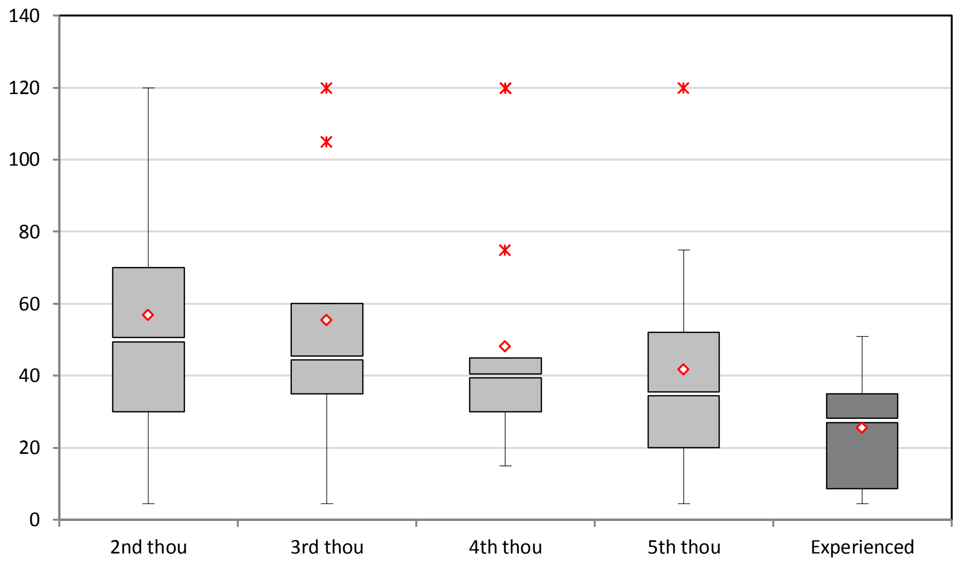

Figure 6. Boxplot showing the time to sort 1,000 photos in relation to experience. The central 50% of observations in each data set is shown as boxes divided in two by the median and bounded below by the first quartile and above by the third quartile. The whiskers (error bars) extend to 1.5 times the box height. Values outside the whiskers are considered to be outliers. Means are indicated by the diamonds.

Discussion

This study focussed on three issues that are critical to determining the feasibility of using motion sensitive camera to obtaining information of relevance to the Malleefowl monitoring program. The first of these concerned the technology. All of the cameras appeared to perform adequately provided they were set up correctly and the battery and solar panel arrangement also worked well.

The second feasibility issue concerns the practicability of running a program involving several cameras at numerous monitoring sites, potentially collecting hundreds of thousands of photos each year. Given the scale of project and difficulty of obtaining sustainable funding, we were particularly interested in whether volunteers would be capable and interested in taking a camera monitoring project on, as an addition to the regular mound monitoring. It was for this reason that we enlisted the help of volunteers in this study. The involvement of citizen scientist volunteers is necessary where appropriate resources to do the monitoring can't be obtained, but volunteers also provide the longevity that is necessary for an effective program; a program run by volunteers is relatively immune from interference and the vagaries of funding decisions, and can thus be maintained in the long-term with a degree of certainty. However, a wide scale camera trapping project would require another large commitment by volunteers and may not be sustainable long term if it was labour intensive.

In this study, volunteers installed half of the camera systems without technical assistance after being shown how, and another team of volunteers revisited the cameras and retrieved the photos with only written instructions and a GPS. Both operations were simple and straightforward and were successfully accomplished.

A bigger issue is the initial identification of photos, counting the animal detections and processing of information onto a database. Each camera is capable of taking tens of thousands of photos and processing these from many cameras could become a huge undertaking. However, in this study the processing of photos was found to be surprisingly fast and easy, and the most time consuming part, the sorting of photos, was well within the capabilities of volunteers. Set to trigger a photo at least five minutes after the last trigger, we estimate that an average of about 1,500 photo captures would be expected per year; sorting these photos is likely to take only about an hour (assuming the median sorting speed in this study). Supposing six to ten cameras would be needed at each site to provide information on trends in various animals, sorting the photos for a site could feasibly be done by one person in one or two days. In short, the labour requirement for processing a full year of photos does not seem excessive, especially as the effort could be spread out over many days or weeks.

Will citizen scientist volunteers be interested in taking on a camera monitoring project in addition to their mound monitoring? The indications are that they would be and we have been approached by a number of people offering their services. Viewing and sorting the photos is an inherently interesting task that is both informative and addictive. There is a high degree of site fidelity amongst volunteers involved in the Malleefowl monitoring, and people who monitor sites are likely to be very interested to see what other animals are recorded at the site. There has also been a great deal of interest in the motion camera project from volunteers who are unable to meet the physical demands of monitoring, which involves many hours of walking in remote regions, but who are nonetheless keen to help with less arduous activities.

The third feasibility issue concerns the usefulness of the data. In this study, a wide range of species that may impact on Malleefowl were detected, including foxes, cats, pigs, kangaroos, rabbits/hares and Malleefowl. Goats, sheep and deer are unlikely to occur at Wandown and Menzies, but are animals of great concern at other monitoring sites and would be easy targets for camera traps. Information on the abundance and trends in these animals is of great relevance to Malleefowl management and conservation, especially given the current emphasis on the development of a formal adaptive management program to guide management.

It seems clear that the camera trap results have the capacity to describe differences between sites and monitor species trends over time. In the current study, there were apparent differences between Wandown and Menzies: kangaroos, emus and Malleefowl were captured by cameras more often at Wandown than Menzies, whereas other species were captured at relatively similar frequencies. This result conforms to expectations as Menzies is a much smaller and disturbed isolate than Wandown, and also to our collective experience of these sites.

Camera traps as trialled in this study have clear advantages over alternative methods for monitoring the diverse set of animals of interest to Malleefowl conservation. The camera traps provide the ability to count the number of times a species of interest passes the camera every day and night for an entire year. These data provide a means of monitoring trends in a variety of species, and also provide information on when species are active, data that may be critical for understanding potential interactions. For example, the 24-hour patterns of foxes and Malleefowl show that while foxes (Figure 7) were generally much more commonly recorded than Malleefowl, foxes were largely nocturnal while Malleefowl were diurnal. Nonetheless, foxes were sometimes out and about during the day and at these times the frequency of recording them was similar to Malleefowl: Malleefowl may encounter foxes as frequently as encountering their own species.

In brief, the camera traps provide a relatively cheap, logistically simple and highly efficient means of collecting data on species of interest to Malleefowl conservation. Maintenance and data management requirements also appear to be low, especially considering the number of species that are monitored and the quantity and quality of ensuing data.

In this study we also examined the effect of different intervals between photos from the practical rather than statistical point of view. Short intervals between photos had the effect of increasing the proportional representation of kangaroos and resulted in a large numbers of redundant photos that would inflate the time needed for processing the photos and quickly fill up the SD cards. Part of the reason for this redundancy is that kangaroos tended to hang around an area for long periods, especially during the day when they were resting, and are social animals that occur in groups. Other animals that travel in groups (pig, emus) showed the same but less extreme patterns. The proportional abundance of different animals appeared to stabilise with intervals greater than five minutes, and intervals of five minutes also resulted in a manageable expected number of photos per year. Accordingly, setting the cameras to become insensitive to triggers for an interval of five minutes after each photo would seem advisable. Increasing the interval more than this would further reduce the number of photos that need to be processed, but would also increase the likelihood of missing rarer animals (such as juvenile Malleefowl). While these practical issues are of great importance, they should not be confused with the statistical issue of autocorrelation (i.e. the similarity of observations at successive times) which will need to be dealt with in any statistical analysis of the data. A related and more urgent statistical issue concerns the number of camera traps needed to adequately determine the abundance and trends of species at each monitoring site, a subject that Rosanna van Hespen (Melbourne University) will be examining in 2015 using the data described in this report.

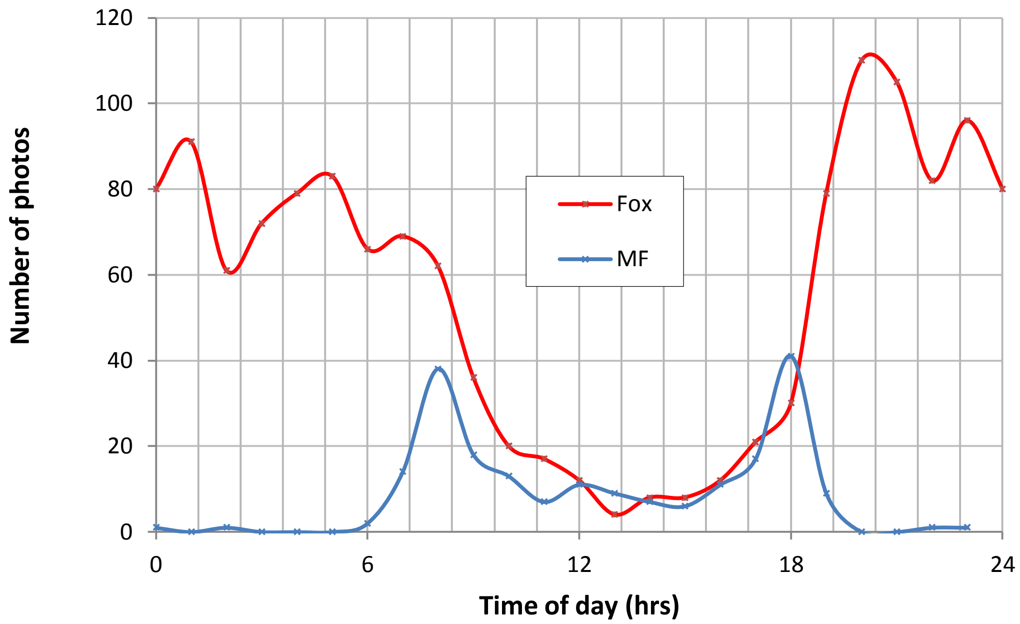

Figure 7. Diurnal activity patterns of Malleefowl and Foxes in relation to time of day. Fox abundance was highest through the night, but they nonetheless occurred during the day with similar frequency of photos as Malleefowl. Data based on five minute intervals between photos from 24 cameras at Wandown and Menzies monitoring sites between March and November 2013.

Conclusions

We made a lot of mistakes in this study, but in the process we have learnt lessons about how to achieve our objective of developing a manageable camera surveillance system for animals at monitoring sites. We know now that we should attach cameras to stakes rather than trees (because the movement of trees in the wind triggers photos), that a five minute rest interval is a good way of limiting the number of photos and increasing the proportion of target species photos without much loss in detecting uncommon species.

Over the period of this study the motion sensitive cameras proved to be reliable and successful at detecting a range of animals of interest to Malleefowl conservation, including Malleefowl themselves. The system (cameras, battery and panels) was adequate for the task and simple to install. Field labour requirements were low as the cameras need only be visited once per year during the monitoring, and an efficient way was developed of processing the large number of photos and entering the data onto a database. Sorting the photos was the most labour intensive part of the process but is within volunteer capabilities and is estimated to take only a day or two per monitoring site per year (assuming six to ten cameras per site). There is a high level of interest by the Victorian Malleefowl monitoring community in the project and we expect this will increase in time as it is inherently fascinating to see what animals pass the cameras, day and night, at sites where Malleefowl are monitored. Amid the drudgery of sorting thousands of photos there is an element of fun, surprise and learning that will increase its appeal and promote the sustainability over many years.

Given these results, expanding the project to include more Malleefowl monitoring sites would seem a worthwhile investment in Malleefowl conservation. Camera monitoring would greatly enhance the existing mound monitoring program by providing critical information on the abundance and trends of a range of animals that may impact on Malleefowl. In addition, Malleefowl are often detected by the cameras and these data are likely to prove very useful in determining trends in the abundance of adults and young. The information provided by the motion sensitive cameras will be of great value in analyses of the factors related to Malleefowl trends. This is particularly the case for the Adaptive Management Project where camera capture data would enable the effects of management actions, such as reducing fox abundance, to be directly measured.

References

Benshemesh J. (2007) Review of data routinely collected in the national Malleefowl monitoring program. Unpublished report to the Victorian Malleefowl Recovery Group and the Mallee Catchment Management Authority, Mildura.

Benshemesh J., Barker R. & MacFarlane R. (2007) Trend Analysis of Malleefowl Monitoring Data (revised version). Report to the Victorian Malleefowl Recovery Group and the Mallee Catchment Management Authority, Mildura.

Benshemesh J. & Bode M. (2011) Adaptive management of Malleefowl. In: 'Proceedings of the 4th National Malleefowl Forum 2011.' National Malleefowl Recovery Team. Renmark. Available at <http://www.Malleefowlvictoria.org.au/2011Forum/Paper%2020.pdf>.

Claridge A. W., Paull D. J. & Barry S. C. (2010) Detection of medium-sized ground-dwelling mammals using infrared digital cameras: an alternative way forward? *Australian Mammalogy* **32**, 165.

Meek P., Ballard G. & Fleming P. J. S. (2012) An introduction to camera trapping for wildlife surveys in Australia (p. 94). Invasive Animals Cooperative Research Centre.

Silveira L., Jácomo A. T. A. & Diniz-Filho J. A. F. (2003) Camera trap, line transect census and track surveys: a comparative evaluation. *Biological Conservation* **114**, 351.

Vine S. J., Crowther M. S., Lapidge S. J., Dickman C. R., Mooney N., Piggott M. P. & English A. W. (2009) Comparison of methods to detect rare and cryptic species: a case study using the red fox (*Vulpes vulpes*). *Wildlife Research* **36,** 436.

Walsh J. C., Wilson K. A., Benshemesh J. & Possingham H. P. (2012) Unexpected outcomes of invasive predator control: the importance of evaluating conservation management actions. *Animal Conservation* **15**, 319.