TESTING INDICES OF DEER ABUNDANCE USING CAMERA TRAPS

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ABSTRACT

Land managers commonly use camera traps to monitor abundance of pest animals over time. Images recorded by the cameras need to be analysed to estimate population density or, more commonly, converted into an index of abundance. To be useful, this index needs to have the same relationship with population size under all possible conditions (e.g. times, places). In this study we compare trends in indices of abundance with accurate estimates of abundance for two populations of feral rusa deer (*Cervus timorensis*).

Between 2019 and 2022 we deployed 44 and 35 cameras in a grid at Wild Duck Island and North Pine Dam respectively. Accurate density estimates were obtained using a spatial-mark resight analysis. We derived an activity index from the total number of deer detections divided by the number of trap days for each camera. We used population reconstruction to derive an independent population estimate at Wild Duck Island.

The activity index was simple to undertake yet was able to pick up significant differences in deer indices between at least some of the years. The activity index, spatial-mark resight and population reconstruction estimates were not always in agreeance, but all indicated decline in deer abundance from the start to the end of the study at Wild Duck Island. The activity index showed similar results on Wild Duck Island when half of the cameras were removed from the study, indicating that fewer cameras and larger grid spacings could be utilised. Land managers could easily incorporate the activity index into their camera trap monitoring in the absence of more sophisticated analyses.

Keywords: camera trap, rusa deer, monitoring abundance.

INTRODUCTION

Camera trapping is a powerful tool for land managers and researchers (Parsons *et al.* 2017). Cameras are increasingly being utilised worldwide to monitor deer abundance, even though their use is less reported in Australia (Forsyth *et al.* 2022). It is expected that this is changing with the advent of machine learning to process images (Forsyth *et al.* 2022; Sudholz *et al.* 2021).

There are many differing approaches to obtaining abundance information from camera traps (Rovero *et al.* 2013) varying from simple to extremely complex. A limitation of commonly used spatial-mark resight methods is that they usually rely on a proportion of the population to be individually recognizable and are often computationally complex (Bengsen *et al.* 2022; Rovero *et al.* 2013). However, they are useful for estimating an abundance and density estimate. Simpler, easy to implement methods may only be able to estimate an index of relative abundance, but to be useful they must be correlated with the actual density at the study site (Rovero and Marshall 2009).

As camera trap detection rate has been shown to have a linear relationship with density for deer overseas (Parsons *et al.* 2017), a modification of this method was trialled on two populations of feral rusa deer (*Cervus timorensis*) in Queensland. The aim of this study was to determine if the method was simple to analyse, able to detect increases or decreases in relative abundance, and show a relationship with the density or abundance of deer at the study site.

MATERIALS AND METHODS

Camera deployment

Camera grids were deployed as per Bengsen *et al.* (2022) at two study sites where rusa deer were being controlled. At Wild Duck Island (22.00ºS, 149.87ºE), 44 Swift 3C (standard angle) cameras (Outdoor Cameras Australia, Toowoomba, Queensland, Australia) were set on a 300m hexagonal grid for between 62 and 83 days in 2019, 2020 and 2021 and 182 days in 2022. At North Pine Dam (27.24ºS, 152.89ºE) we set 35 Reconyx HC600 cameras (Reconyx LLP, Holmen, Wisconsin) on a 500m hexagonal grid for between 42 and 96 days in 2019, 2020, 2021 and 2022. Individual deer were counted in detection events that consisted of a series of camera images separated by <10 min from the next series of photos. Metadata, such as number of individual deer per detection event, sex, and any recognizable (marked) individuals were added to images using the program Exifpro (Kowalski and Kowalski 2013).

SMR estimates

Spatial-mark resight (SMR) data were prepared and analysed in the software environment ‘R’ (R Core Team 2020) to obtain an accurate density estimate as per Bengsen *et al.* (2022). First, metadata was extracted from the camera images. Then detection histories were constructed from the metadata for marked and unmarked animals. Finally, Bayesian SMR models were used to estimate deer density from activity centres and point/time data from both the marked and unmarked detection histories.

Activity index

We derived an index of abundance from the raw data being the mean activity from the cameras for the study period. Activity was designated as the total number of deer detected on each camera divided by the number of trap days for that camera. Differences between time periods for the index of abundance were assessed using a one-sided Wilcoxon signed rank test (Bengsen *et al.* 2014). In addition, we re-calculated the activity index for Wild Duck Island on both even numbered cameras and odd numbered cameras effectively removing half the data.

Population reconstruction

The rusa deer population for Wild Duck Island was reconstructed from culling records for 2019 – 2022 and camera results for 2022. The population reconstruction followed Agetsuma (2018) where population in year t-1 (P_{t-1}) is derived from the number culled in year t-1 (H_{t-1}), the population at time t (P_t), and the population rate of increase (r) plus 1 as per the following (Eq. 1):

$$P_{t-1} = H_{t-1} + P_t / (r+1) \qquad \text{Eq. 1}$$

Three theoretical rates of increase were derived from the Euler Lotka equation (Caughley 1977; McCallum 2000) for the population reconstruction:

- r = 0.28. Realistic rate of increase based on females having 1 calf per year, 75% juvenile survival, and 90% adult survival;
- r = 0.42. Probable maximum rate of increase (r_m) based on females having 1.35 calves per year, 75% juvenile survival and 95% adult survival; and
- r = 0. No increase (r_{nil}) due to no recruitment and no adult mortality apart from culling.

The probable maximum rate of increase and no increase rates were used in lieu of 95% confidence intervals for the population reconstruction.

RESULTS

SMR estimates for deer abundance at Wild Duck Island indicated a decrease in deer abundance of approximately 54% from 2019 to 2021 as per Figure 1. The activity index at Wild Duck Island indicated a decrease in deer indices of approximately 73% from 2019 to 2020 (z = 3.53, n = 40, P = 0.0002) but no further reduction (z = 0.54, n = 37, P = 0.59) from 2020 to 2021 (Figure 1). The population reconstruction estimates indicated a decrease in deer abundance of approximately 73% from 2019 to 2021 (Figure 1).

SMR estimates for deer abundance at North Pine Dam indicated a decrease in deer abundance of approximately 75% from 2019 to 2022 as per Figure 2. The 2021 SMR estimate calculation has not yet been finalised. The activity index at North Pine Dam indicated a decrease in deer indices of approximately 40% from 2019 to 2022 (z = 1.7, n = 33, P = 0.045) (Figure 2). There was no significant reduction in the activity index from 2019 to 2020 (z = 1.5, n = 35, P = 0.07), a slight reduction from 2020 to 2021 (z = 1.92, n = 34, P = 0.03), and a borderline increase from 2021 to 2022 (z = -1.62, n = 32, P = 0.05).

Activity index values at Wild Duck Island for each year did not vary greatly with the removal of data from even or odd numbered cameras (Figure 3).

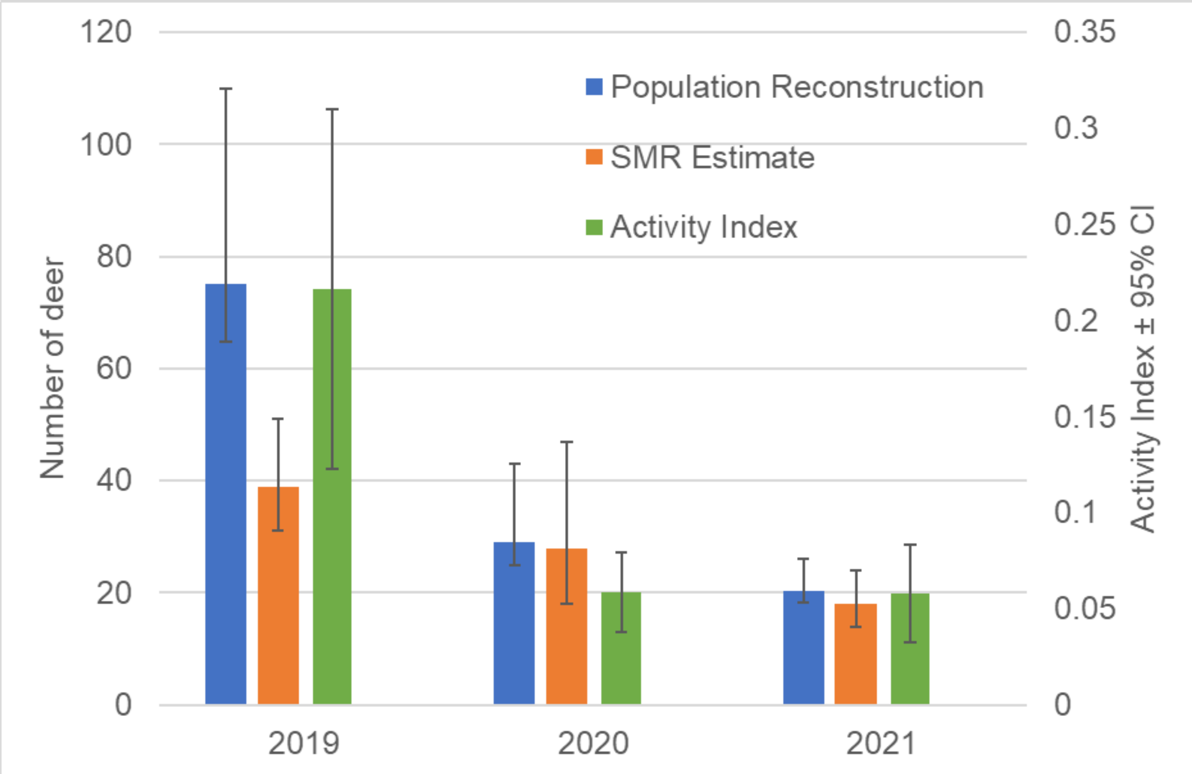

Figure1. Population estimates and activity index values of wild rusa deer at Wild Duck Island from 2019 to 2021. Population reconstructions estimates showing error bars of r_m and r_{nil}. SMR estimates and activity index showing 95% CI.

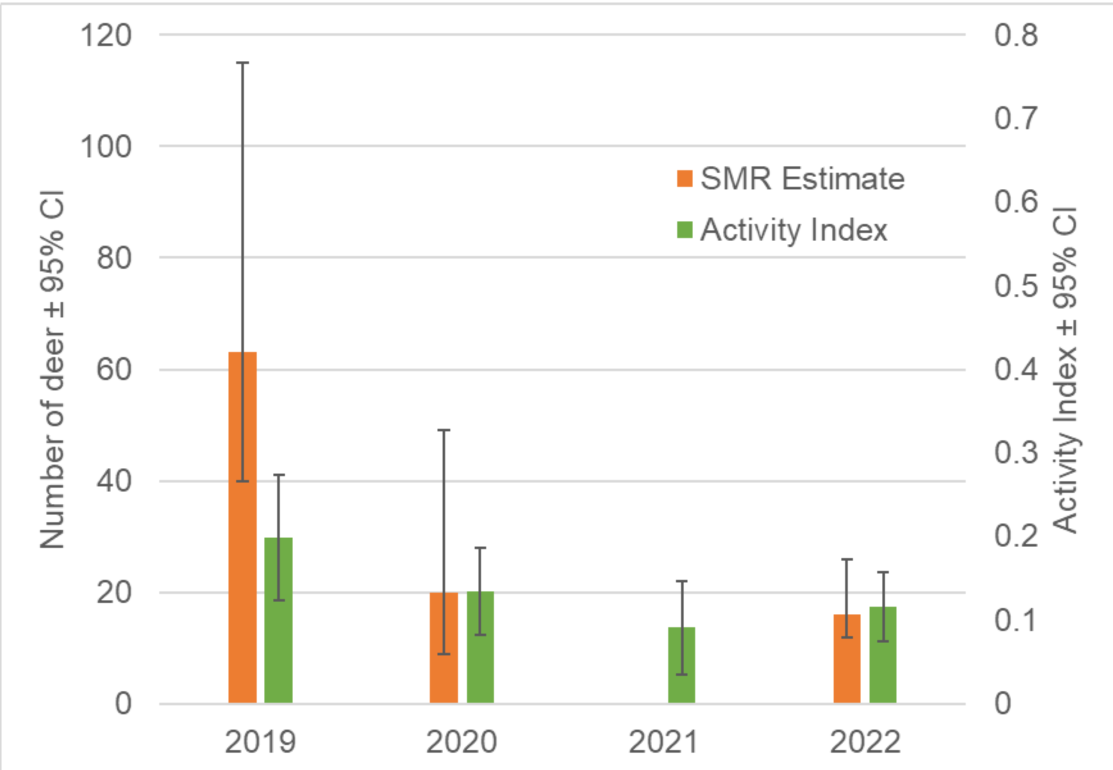

Figure 2. SMR population estimates and activity index values for wild rusa deer at North Pine Dam from 2019 to 2021.

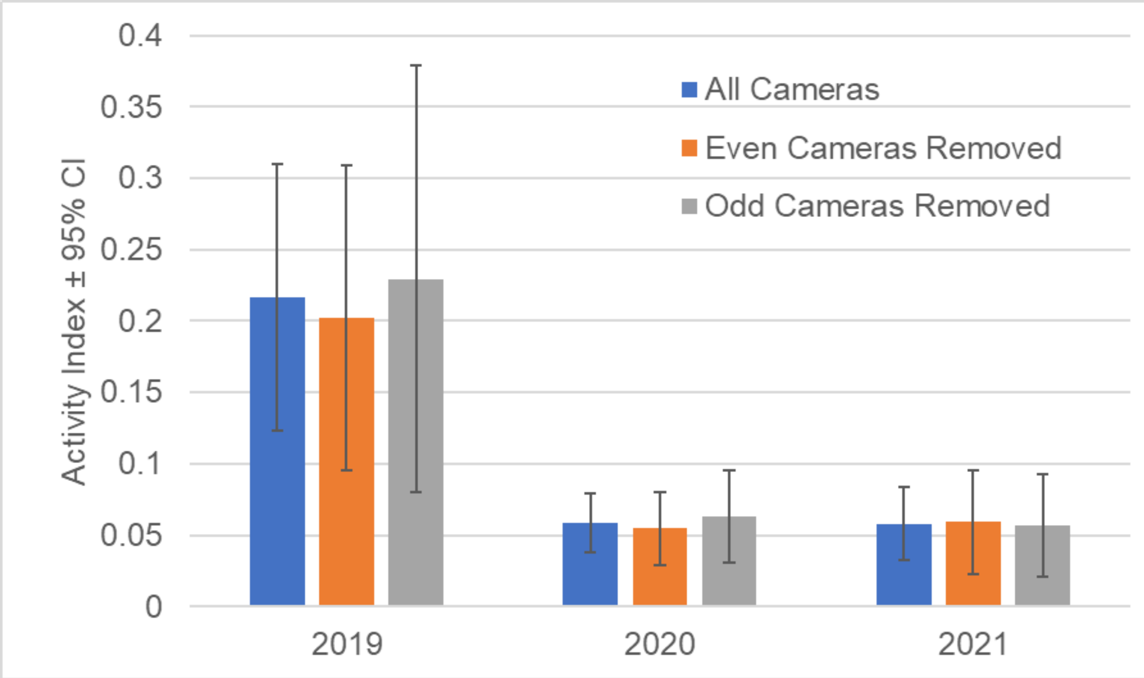

Figure 3. Activity index values for wild rusa deer at Wild Duck Island from 2019 to 2021 showing data from all cameras, even cameras removed and odd cameras removed.

DISCUSSION

The activity index was simple to undertake yet was able to pick up significant differences in deer indices between at least some of the years. At Wild Duck Island the population reconstruction and activity index methods indicated a similar abundance reduction from 2019 to 2021 but estimates from these methods were not as close in 2020. The activity index and SMR estimates did not indicate a similar abundance reduction from 2019 to 2021. However, the results between these two methods for 2020 to 2021 were better aligned. All three methods indicated a decline in deer abundance from the start to the end of the study at Wild Duck Island.

At North Pine Dam, the SMR and activity index methods both showed a reduction in abundance over the course of the study, but the proportional reduction varied for the two methods. However, these two methods both show similarity in the abundance levels between 2020 and 2022. The activity index also showed similar results on Wild Duck Island when half of the cameras were removed from the study, indicating that that the method was reasonably robust and that fewer cameras and larger grid spacings could be utilised.

Comparing the overall estimated decrease in abundance for the SMR and activity index methods at Wild Duck Island (54% SMR vs 73% AI) and North Pine Dam (75% SMR vs 40% AI) indicates that there is no predictable linear relationship between these methods in the absence of more formal analysis, as the activity index predicted a greater change in abundance at Wild Duck Island and a smaller change in abundance at North Pine Dam than the spatial-mark resight method. Therefore, the activity index method is not deemed to be as useful as one that always displayed a linear relationship with population size. However, the population reconstruction method undertaken at Wild Duck Island demonstrates that estimates from even complex methods can vary quite significantly, and the activity index aligned more closely to this method than the spatial-mark resight method.

In summary, the activity index was simple to analyse, was able to detect significant changes in relative abundance in at least some of the years and showed some correlation with other estimates of abundance. If the limitations of this method are acknowledged, land managers could easily incorporate the activity index into their camera trap monitoring in the absence of more complex and sophisticated analyses.

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