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Estimating western ringtail possum (*Pseudocheirus occidentalis*) density using distance sampling

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Abstract. A reliable estimate of population size is of paramount importance for making management decisions on species of conservation significance that may be impacted during development. The western ringtail possum (*Pseudocheirus occidentalis*) is regularly encountered during urban development and is the subject of numerous surveys to estimate its abundance. A variety of techniques have been used for this species with mixed results. This paper reports on a case study using distance sampling to estimate density of *P. occidentalis* in a small habitat remnant near Busselton, Western Australia. Density estimates obtained were within the range of previous studies of this species and we suggest that this technique should be employed in future surveys to improve the accuracy of population estimates for this species before development.

Introduction

Density estimates of wildlife populations are important for management and conservation efforts, particularly for threatened species and decisions associated with development that may impact on these species. In many cases, resource limitations result in poorly constructed surveys that may provide inaccurate population estimates, with potentially serious ramifications for management decisions.

The western ringtail possum (*Pseudocheirus occidentalis*) is an arboreal mammal with a bodyweight of 820–1020 g, and is a threatened species under both state and commonwealth legislation in Australia (Van Dyck and Strahan 2008). This species is regularly encountered by urban development (Thompson and Thompson 2009) throughout its distribution, which has contracted from what appears to have been a patchy distribution covering the south-west of Western Australia from south-east of Geraldton to the Nullarbor with the most inland recording from the Tuatanning Nature Reserve (de Tores *et al*. 1995). The distribution encompassed a variety of vegetation types including coastal peppermint (*Agonis flexuosa*), and peppermint/tuart (*Eucalyptus gomphocephala*) associations, eucalypt and casuarina (*Allocasuarina huegeliana*) woodlands, and mallee heath from the Hampton Tableland (Baynes 1987). Currently, *P. occidentalis* is mostly restricted to the coastal strip from Yalgorup to Two Peoples Bay just east of Albany, with isolated inland populations at Collie, Yendicaup and Moradalup (Jones *et al*. 1994*a*). Western ringtail possums are thought to be extinct at all other former inland locations (de Tores *et al*. 2004). Factors thought to have contributed to this decline include habitat loss, modification or fragmentation, changing fire regimes, disease, competition and predation by introduced predators (Clarke *et al*. 2008; DEWHA 2008).

The western ringtail possum has been the subject of a suite of surveys in the past 10 years (e.g. Elscot and Bamford 2003; Jones *et al*. 2007; Harewood 2008; Thompson and Thompson 2009), mainly by environmental consultants conducting population estimates to assist with development decisions and approvals. Techniques for surveying this species have included scat counts, direct spotlighting counts, drey counts, transect counts and estimates through trapping (Jones *et al*. 1994*b*; Wayne *et al*. 2005).

This study describes an evaluation of the use of distance sampling within an isolated remnant patch of peppermint and eucalypt woodland within the western ringtail possum core area (near Busselton, Western Australia) and includes a discussion of the usefulness of this technique for surveys of western ringtail possums in the future.

Methods

The study site consisted of a rectangular 5.3-ha isolated patch of peppermint (*Agonis flexuosa*) low closed forest with scattered marri (*Corymbia calophylla*) trees over arum lily (*Zanthedeschia aethiopica*) dominated understorey ~4 km from the Busselton town centre (33.66°S, 115.39°E). Possum surveys were conducted as part of an ongoing monitoring program which involved monthly two-night surveys between November 2008 and April 2009 and a further two-night survey in September 2009.

Possums were located by two people using head torches while walking along nine permanent transect lines that are 18 m apart and 220 m long within the study site on two consecutive nights during each monthly sampling period. The two observers were drawn from a pool of four observers, with the same two people undertaking the counts on consecutive nights. One observer

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would normally walk along the transect line and the other would walk ~4–5 m to the east side. Transect lines are a surface reticulation system used to water trees in the remnant. Two species of possums are found in this remnant, *P. occidentalis* and *Trichosurus vulpecula* (the common brushtail possum). When a possum was located, the species and perpendicular distance (m) from the transect line to a point directly underneath each possum were recorded. Distances were measured by the observer measuring the perpendicular distance between the position directly under the possum and the transect line. Possums did not flee during spotlighting, and so observer-induced movement should not bias the estimates. Another important assumption is that all individuals on the transect are observed ($g(0) = 1$). To fulfil this assumption, all possums immediately above the observer walking along the transect should be detected. These individuals are generally the easiest to detect as the observer is looking directly up into the foliage, often with a lighter night sky as a background, and individuals are the least distance from the observer. In addition, the second observer normally has an oblique view of any individuals directly above the transect line, reducing the masking of possums from the first observer by overhead vegetation. All counts commenced soon after sunset to coincide with periods when possums were most active (Thompson *et al.* 2009).

The density of western ringtail possums was estimated using the program Distance 6.0 (Thomas *et al*. 2009). All suitable models recommended by Buckland *et al.* (2001) were considered for estimating density. For each model the detection probability histogram and goodness-of-fit test statistics were examined. The most parsimonious model was selected on the basis of the lowest Akaike's Information Criterion, adjusted for small sample size (AIC_c). Variance estimators of Fewster *et al.* (2009) were used as they provide a much better estimate of true variance for systematic parallel line transect designs (Len Thomas, pers. comm.). We chose to use reticulation lines as our transects as this enabled the observers to concentrate on detecting possums rather than being distracted by following a preset coordinate. Parameter estimates were model-averaged using Akaike weights to account for model uncertainty (Burnham and Anderson 2002). Multiple models were selected and densities generated by each model were then averaged, weighted by relative AIC_c.

A detection function was calculated within Distance 6.0 using data pooled across the entire study period, as possum detectability is assumed not to vary throughout the year (Fig. 1). This provided a much greater sample size for the precise calculation of a single detection function, which was post-stratified with each sample session as a stratum, used to estimate monthly possum populations. No suspicious clustering was observed in the distance classes, so data were not grouped or truncated. A 90% confidence interval was selected to provide a more realistic level of certainty for surveying a species in relatively low abundance.

Results and discussion

The nine transect lines, spaced 18 m apart, were sampled a total of 14 times throughout the study, which resulted in a total survey effort of 34.4 km. We counted a total of 363 western ringtail possums in the study site between November 2008 and September 2009. The total number of western ringtail possums counted each month within the study site ranged between 35 (September 2009) and 70 (December 2008) (Table 1).

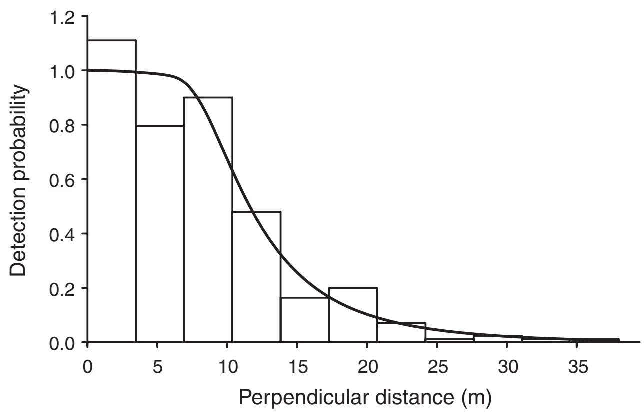

Fig. 1. Detection function for western ringtail possums (*Pseudocheirus occidentalis*) in a remnant habitat fragment near Busselton showing the probability of detection of western ringtail possums by perpendicular distance (m) from the transect line.

Density estimates obtained for the site ranged from a minimum of 2.9 possums ha^{-1} in September 2009 to a maximum of 6 possums ha^{-1} in December 2008 (Table 1; Fig. 2), reflecting the seasonal fluctuation in western ringtail possum abundance that is typical in the south-west of Western Australia (Thompson *et al*. 2009). While comparing count data with density estimates is problematic, our raw counts were similar to the modelled estimates, and presuming that other surveyors are thorough in their surveys, it is reasonable to compare data from raw counts with our estimates. For example, Jones *et al*. (1994*b*) recorded densities of *P. occidentalis* of 2.5–4.5 ha^{-1} at the Abba River and the Locke Estate, Busselton, although elsewhere (e.g. Geographe Bay and Emu Point) densities were less than 1.0 ha^{-1}. Jones *et al*. (2007) reported 30 *P. occidentalis* in 85 ha of pastoral land, 170 in 50 ha of a C-class nature reserve, 200 in 35 ha of beachside settlements and 270 in 35 ha of beachside recreation reserve (A class) used for camping since 1955 in the Siesta–Kealy area south of Busselton, and Harewood (2008) reported average densities of *P. occidentalis* of 13.5 ha^{-1} within urban reserves in Busselton.

Table 1. Summary of population estimates from distance sampling for *Pseudocheirus occidentalis* in a remnant habitat fragment near Busselton for seven surveys

Date	Population estimate	Minimum (90% CI)	Maximum (90% CI)	Possum count (observations in two nights)
November 2008	20.1	12	29	47
December 2008	31.7	23	40	70
January 2009	19.7	11	30	48
February 2009	19.6	14	26	46
March 2009	20.4	12	30	45
April 2009	16.8	8	28	37
September 2009	15.5	9	22	35

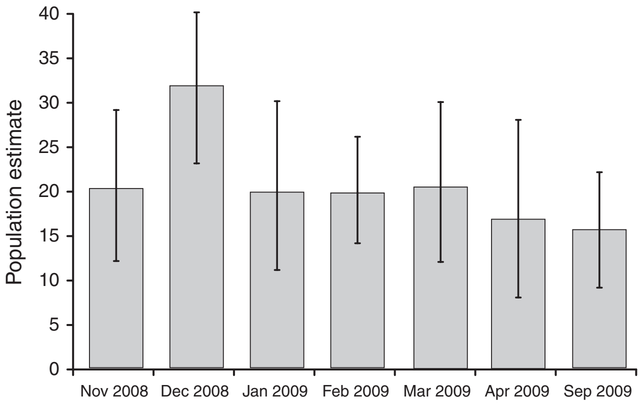

Fig. 2. Estimates of population numbers of western ringtail possums in an isolated habitat fragment near Busselton. Error bars show 90% confidence intervals.

Previous studies of the western ringtail possum have identified the difficulties in surveying this species in its natural habitat in the south-west of Western Australia (Jones *et al*. 1994*b*). Previous studies have also suggested that spotlight counts are an appropriate method for conducting population census for both common ringtail possums (Smith *et al*. 1989; Catling *et al*. 1997) and for the western ringtail possum (Wayne *et al*. 2005). These techniques provide incomplete counts that do not account for detectability and so provide only an index of the true population (Anderson 2001). More recently, distance sampling has been applied to monitoring of the arboreal colugos (*Galeopterus variegatus*) in tropical rainforests in Singapore (Lim and Ng 2010).

The principal aim of this study was to evaluate the application of distance sampling to estimate the abundance of western ringtail possums within an isolated habitat fragment. Density estimates obtained in this study are within the range of other studies of this species reported in the Busselton region (Jones *et al*. 1994*b*; Elscot and Bamford 2003; Jones *et al*. 2007; Harewood 2008), but there is an obvious variation among sites. Estimates for each month vary as expected due to seasonal changes in biological characteristics such as breeding and dispersal (Thompson *et al*. 2009).

The results demonstrate that estimating the density of western ringtail possums using distance sampling provides an estimate similar to the total counts conducted during each survey; however, the distance results have the added advantage of removing the bias associated with counting possums twice within a small isolated habitat patch. Calculated population estimates are less than half of the two-night total count, showing that, indeed, some possums were located twice, but distance sampling inherently accounts for this bias.

It would also be possible to reduce the survey effort while using the same detection function, which would therefore lead to a reduction in survey effort required to complete a suitable survey, which could therefore minimise time and cost, an issue often faced in similar surveys. Along with a reduced survey effort, the use of a greater number of separate transects, each of a shorter length, would likely lead to more precise population estimates (tighter confidence intervals), though this was difficult in this survey due to the size of the remnant forest patch. Buckland *et al*. (2001) recommend a minimum of ~20 separate transects be surveyed.

With the application of this technique to areas with permanent transects, the collection of data for a regular monitoring program for this species would also be easily achieved. Such monitoring surveys are an important factor in determining the continued impact of habitat fragmentation on this species.

Further advantages of distance sampling for this species include an increase in precision of estimates, with statistically valid estimates of uncertainty, using complex modelling. It is advantageous over standard counts of strip transect counts as it accounts for variation in sighting probabilities by incorporating a detection probability function into the estimate of density (Buckland *et al*. 2001) and less total survey effort is likely to provide more information using distance than using standard transect sampling, the method most often applied for estimating population size in this species.

Although distance sampling is unlikely to be applied to all western ringtail possum surveys, we suggest that distance sampling for possums using fixed-transect distance sampling has the potential to provide a more precise, less biased method and should be considered for western ringtail possum surveys in fragmented habitat throughout the range of this threatened species in future.

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