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Camera trap, line transect census and track surveys: a comparative evaluation

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Abstract

Rapid faunal assessments can use different methods depending on environmental conditions and costs. To compare the efficiency of three methods in detecting species richness and abundance, we tested them in the grasslands of Emas National Park, central Brazil. Track census was the most effective method for detecting richness, followed by camera-trapping and direct faunal counts. Track census reached an asymptote for number of species after only 12 days, but all methods converged on similar estimates of species richness after around 30 days. There was no significant spatial correlation for species richness or total abundance, between camera trap and tracks, across the 29 samples distributed in the park. However, for some species, abundance showed significant spatial correlation between methods. Also, these rates were significantly correlated across species and the spatial correlation between methods was significantly associated with log-transformed body mass across species. We conclude that, despite the high initial costs for camera-trapping, this method is the most appropriate for mammal inventory in all environmental conditions, allowing a rapid assessment of wildlife conservation status.

Keywords: Camera trap; Line transect; Abundance estimate; Species richness; Rapid faunal assessment

1. Introduction

Efficient and reliable methods for rapid assessment of species richness and abundance are crucial to determine conservation priorities. Tracking animals by following footprints in dust, mud, sand or snow, is probably the oldest known method of identifying mammal's presence in an area (Bider, 1968). Counts of dung, nests, trails, calls and direct observation along line transects are also widely used for richness and abundance estimates (Eberhardt and Van Etten, 1956; Gannon and Foster, 1996; Fragoso, 1991; Fashing and Cords, 2000; Barnes, 2001; McNeilage et al., 2001). In the past years, new surveying techniques, using remote triggered photographic camera units, have become popular. The method is efficient for inventories, especially of cryptic animals, as well as for population studies of species for which individuals can be individually recognized by marks (Karanth, 1995; Carbone, 2001). Photo-trapping has also been widely used in population studies of tigers (Karanth and Nichols, 1998) and bears (Crooks et al., 1998; Kucera and Barrett, 1993; Mace et al., 1994). Capture–recapture models using photo-marked individuals have also been proposed for monitoring populations (Mace et al., 1994; Karanth and Nichols, 1998). Thus, camera-trapping furnishes an important non-invasive tool for assessing patterns of abundance throughout space and time, and their link with activity patterns, habitat use and reproductive information, which are key elements for wildlife conservation.

Despite the variety of field techniques that can be used for terrestrial mammal surveys, not all can be efficiently applied in every ecosystem and for all species. Some landscapes can be so remote, steep or so densely vegetated that only a few methods could be practicable. Sometimes the choice is limited not by technique efficiency, but by field costs. Track surveys are efficient and usually involve low costs, but depend on suitable field conditions and trained personnel (Burnham et al., 1980; Smallwood and Fitzhugh, 1995). Camera-trapping is

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more costly at the beginning, but is not so dependent on the environment to be sampled, constant assistance or even experienced field staff (Rappole et al., 1985).

There is an increasing need for comparing methods to be used in rapid faunal assessment, due to urgent conservation needs worldwide. In this paper, we evaluate camera-trapping, track survey and transect census efficiencies in detecting Cerrado fauna in Emas National Park, central Brazil.

2. Methods

2.1. Study area

This study was carried in Emas National Park (ENP) (18°19′ S, 52°45′ W), located in the central-western Brazilian plateau. The Park's 132,000 ha are composed mainly of grassland habitat (98%) covering a flat landscape. ENP is widely known for its rich and abundant grassland fauna (Redford, 1985) and is considered one of the country's best Cerrado Park (Erize, 1977).

2.2. Sampling

A total of 440 km of dirt roads is distributed across Emas Park. For this study we selected a segment of road in the north-central region of the Park for the camera trapping and track survey. During January and March 2002, we placed 29 Cam Trakker™ (CamTrak South, Watkinsville, GA, USA) automatic cameras by the road at 1.5 km apart. Each camera was considered a sampling unit covering a radius of 750 m. Each camera sampling unit was also considered as a track sampling unit (1.5 km long). A daily track census was carried for 44 days in each unit by driving a vehicle at 20 km/h. A brush of palm leaves was tied at the back of vehicle and dragged during the census, in order to clean previously recorded tracks. In that sense, only fresh tracks were available during the census. Also, two observers rode on the back of the pick-up, recording every mammal sighted. We also carried out a mammal census along other internal Park roads during the same period (day and night hours), to match the sampling efforts from camera-trap and track surveys. However, to avoid excessive disturbance in the sampling area, we only performed line transect surveys for each of the 29 areas during the track census. The remaining effort was accumulated across the entire park. Thus, line transect sampling is not directly comparable with tracks and camera traps for the spatial analyses.

2.3. Data analyses

For the overall sampling effort (summing all 29 areas), we calculated how each method accumulates expected species richness through time, for the entire area. We also estimated relative abundance (photographic rates and track rates, both expressed as records per day) of each species, based on the three different methods.

We performed correlations between richness, total abundance (capture-rate) and capture rates for each species, estimated by the two methods (camera trap and track count) across the 29 areas. Pearson's correlation coefficients were calculated as a measure of spatial similarity between the two methods. However, because of the spatial distribution of sampling units, statistical tests could be biased by autocorrelation structure in data (Legendre, 1993; Koenig, 1999). We computed, for each variable, spatial correlograms using Moran's I coefficients estimated at five distance classes, whose upper limits, in km, were 5, 10, 15 and 20 km (Legendre and Legendre, 1998). The correlograms were then used to assess the number of degrees of freedom to be used for significance tests (M), as suggested by Dutilleul (1993). The logic underlying this procedure is that, under short-distance positive spatial autocorrelation, the closest sampling stations are pseudo-replicas of the same phenomenon, and so do not furnish independent information about the ecological processes.

After, we regressed the similarity (i.e. correlation) between methods against the average body size for each species (log transformed), obtained from the literature (Eisenberg, 1989; Redford and Eisenberg, 1992, 1999; Emmons, 1997), in an attempt to explain the similarity between the methods for different species, or groups of species.

3. Results

We accumulated a total of 24,840 h of camera-trapping, 30,600 h of track census and 28,050 h of faunal census (line transect) in the entire area. Of the 28 terrestrial medium–large sized mammal species found in the Cerrado grasslands of ENP, 19 (68%) were detected through track surveys, 17 (64%) through camera-trapping and 16 (57%) through direct observation. Track census was the most effective surveying method for detecting richness through time, reaching an asymptote after only 12 days (Fig. 1). Despite these differences, all three methods converged on similar estimates of species richness after about 30 days. Since our main purpose was to compare these different methods, especially camera-trapping and track counts, we focused on the 14 species that we caught by both methods (Table 1) and that, as expected, can be found predominantly in open habitats (see Rodrigues et al., 2002, for detail).

Significant spatial autocorrelation was detected for most variables and for the two methods, in such a way that degrees of freedom for testing correlations were

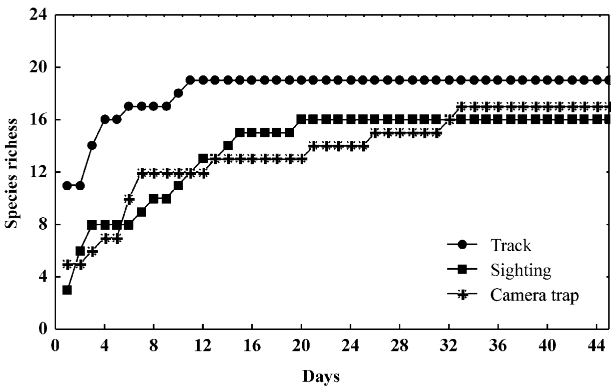

Fig. 1. Increase in species richness during the sampling days, according to the three different methods (camera trap, line transect and tracks).

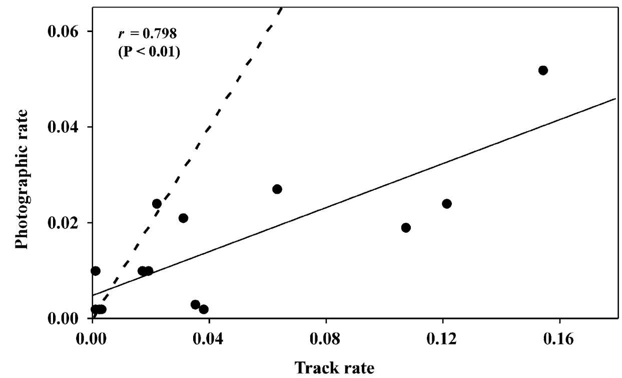

Fig. 2. Cross-species comparison of overall photographic and track rates (records per day). The solid line indicates regression of photographic rates against track rates, while the dashed line indicates the expected regression if both methods estimate similar rates (i.e. $b=1$) (regression equation $Y=0.00478 + 0.798X$).

reduced. There was no significant spatial correlation for species richness ($r=0.312$; $P=0.167$) and total abundance (0.422; $P=0.078$) between camera trap and tracks across the 29 sampling areas, using conservative probability estimates that take into account spatial autocorrelation in data. No clear spatial structure was detected in these two variables, except for a moderate positive Moran's I in the last distance class for camera-trap estimating richness and tracks estimating abundance.

However, for some species, abundance rates showed significant spatial correlation between methods (Table 1). Of the 14 species for which comparisons between track rates and photographic rates were compared, only in four no spatial structures were detected, for at least one of the measures. As expected, in most cases there are positive Moran's I in the first distance class, that tend to decrease in the largest distance classes. This indicates that close sampling units in space tend to be more similar (for the estimated rates) than expected by chance alone, in such a way that a more conservative number of degrees of freedom must be used.

The photographic and track rates were also significantly correlated across species ($r=0.798$; $P<0.01$) (Fig. 2), although the slope is clearly different from 1.0 ($b=0.22$; $t=15.37$ for $\beta=1$; $P<0.01$). This indicates that, once more, photographic rates are lower than track rates, across species. The spatial correlation between the two methods, used as measure of similarity between them, was also significantly associated with log-transformed body mass across species ($r=0.792$; $P<0.01$) (Fig. 3). Thus, both methods converge to relative similar abundance rates in space when dealing with large-bodied animals.

Table 1
Photographic and track rates (records per day) for 14 different mammal species in Emas National Park[a]

Species	Habitat	Body mass (kg)	Photographic rate	Track rate	r (P)
Panthera onca	O/C	94.5	0.024	0.022	0.422 (0.070)
Puma concolor	O/C	74.5	0.010	0.017	0.246 (0.206)
Oncifelis colocolo	O	3.0	0.010	0.001	−0.242 (0.140)
Leopardus pardalis	C	10.0	0.002	0.001	−0.357 (0.853)
Chrysocyon brachyurus	O	22.0	0.052	0.154	0.006 (0.970)
Dusicyon vetulus	O	4.0	0.027	0.063	0.109 (0.497)
Conepatus semistriatus	O	2.5	0.002	0.038	−0.275 (0.159)
Tapirus terrestris	O/C	240.0	0.024	0.121	0.458 (0.060)
Ozotocerus bezoarticus	O	35.0	0.019	0.107	0.117 (0.539)
Tayassu pecari	O/C	30.0	0.010	0.019	0.703 (0.001)
Priodontes maximus	O	27.0	0.003	0.035	0.230 (0.026)
Euphractus sexcinctus	O	5.5	0.002	0.003	−0.066 (0.750)
Myrmecophaga tetradactyla	O/C	30.0	0.021	0.031	0.403 (0.040)
Tamandua tridactyla	O/C	5.2	0.002	0.002	−0.051 (0.790)

[a] For each species, habitat type (O, open cerrado areas; or closed habitats, C, such as galley forests, dense cerrado areas) and average body mass, are indicated. The r refers to the spatial correlation among abundance rates estimated by both methods (camera trap and tracks), across the 29 spatial sampling units. The Type I error (P) of the correlation coefficient was defined after correcting for spatial autocorrelation, according to Dutilleul (1993).

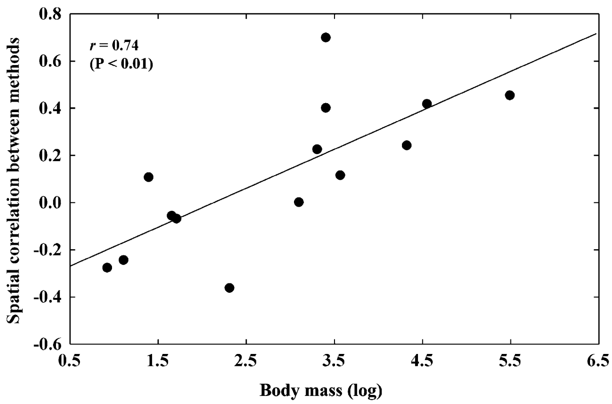

Fig. 3. Cross-species relationship between spatial correlation between methods (camera trap and tracks) and body size (log-transformed) (regression equation $Y = -0.3909 + 0.792X$).

4. Discussion

Track counts have proved to be the most efficient rapid method for detecting species richness and relative abundance in Emas Park, but some considerations should be taken into account. This method needs the minimum of two persons (a driver and an observer) and a vehicle, to cover extensive areas. The field personnel needs to have considerable experience with signs of the local fauna. Climate and ground conditions can be relevant limitations, and too wet or too dry ground can determine the detectability and identification of tracks, and thus validate or invalidate a survey. Although game trails are important sampling areas for tracks, they can also be biased in determining habitats and therefore might not be representative for a general area.

Contrary to the environmental pre-requisites that limit track surveys, camera-trapping is a efficient non-intrusive method in almost any field conditions. The advantages also involve the accuracy of species determinations, as well as the possibility of evaluating age, sex, population structure and density in large tracts of land (Seydack, 1984; Kelly et al., 1998; Mace et al., 1994). In naturally marked species such as tigers, leopards and jaguars the method can raise relevant ecological information, as substitutes for other intrusive methods, such as capturing and radio-collaring of individuals.

Direct animal counts along line transects are probably the most limiting of the three methods, for general purposes. It is not just dependent on favorable field conditions and well trained researchers, but in some areas it is also biased towards large-bodied diurnal species.

It is important to note that both track and photographic rates can overestimate abundance, since the same animal can be counted more than once. Anyway, tracks will be more suscetible to this bias, because photographs taken at very short time intervals (probably counting the same animal) can be discarded. Perhaps this explains, at least in part, the higher track rates obtained in this study, when compared with photographic rates.

Finally, the costs of a sampling method are commonly a limiting factor for surveying large areas. Despite the high initial costs of camera-trapping, this method, compared with track censuses and line-transects, can be handled more easily and with relatively low costs in a long term run. The advantages also includes accuracy of species identification, low environmental disturbance, similar efficiency in the detection of nocturnal and diurnal species (at least when compared with direct counts) and additional possibility of studying activity patterns, ease in handling by non-trained personnel, extent of area that can be simultaneously sampled and possibility of being used in further population studies.

In this paper, we showed how two different parameters (abundance and richness) could be accurately estimated for a mammal assemblage in Emas National Park through camera trapping, in a short period of time. A comparative evaluation of different areas or habitats within the Park, as well as long-term monitoring programs for some species, could provide information about abundance fluctuations and about activity, reproductive patterns and habitat use. Therefore, all these data can be used as a rapid assessment of wildlife conservation status in the region and, this way, be a guide to establish conservation priorities as well as efficient management programs.

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