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COMMENTARY

Design, evaluate, refine: camera trap studies for elusive species

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The rapid expansion of camera trap surveys for elusive species has led to the widespread application of this technique, often with little standardization across studies. For example, even when targeting the same species, the amount of effort (i.e. trap nights or camera days) can vary widely from 450 trap nights (Trolle & Kéry, 2003) to 2280 (Maffei *et al*., 2005) for a single survey. The distance between camera traps also varies dramatically from site to site even for the same target species (Silver *et al*., 2004). The number of camera stations deployed for a target species can range, for example, from 17 (Kelly, 2003) to 32 (Wallace *et al*., 2003), and the extent of area surveyed can differ by orders of magnitude (DiBitetti, Paviolo & De Angelo, 2006; Maffei & Noss, 2007). Of course, not all camera-trapping studies are designed to address the same questions since, for example, some are used for species inventory (Tobler *et al*., 2008), others for abundance and density (Karanth & Nichols, 1998; Silver *et al*., 2004) and still others as potential indices of abundance (O'Brien, Kinnard & Wibisono, 2003).

While Tobler *et al.* did not intend to address all of the concerns mentioned above, they do address issues surrounding trapping effort, camera spacing and animal size for inventory studies only of large- to medium-sized mammals. Their study highlights two important issues. First, a substantial number of trap nights are needed to conduct a complete inventory. They captured 86% of species assumed to be in the area in 2340 trap nights. Their study also provides useful guidelines for the number of trap nights needed given a particular trap success for a certain species. This can help tremendously in guiding other studies because trap success values are already available for many species. Second, while Tobler *et al.* show that thousands of trap nights are needed to conduct a thorough inventory, with enough camera traps this can be completed in a 2-month time period. This reveals that camera traps are particularly efficient for species inventories of medium to large mammals, especially considering that inventories by alternate methods at their study site took 1–21 years to complete.

The authors assessed the impact of camera spacing on a species inventory through the analysis of data from nested camera grids. They found that the same number of species was obtained with either 1 or 2 km spacing between stations. While this finding is interesting, autocorrelation may play a role as both surveys shared six (or 26%) of the same camera stations. But perhaps more to the point, camera spacing has never been seriously implicated as a factor impacting species inventories as it has for species abundance and especially density estimation (Dillon & Kelly, 2007). For inventories, maximizing potential photographs of all species is paramount and camera spacing likely has little bearing on successful documentation of species present in an area. Nonetheless, we now have a reference in Tobler *et al.* to support this supposition.

Recent studies have shown that animal size can impact photo rates (Kelly & Holub, 2008; Thompson *et al.*, in press). The authors examine this issue by comparing animal size with the number of photo pairs only, discounting photos when only one camera fired. The fact, however, that one of two opposing cameras did not trigger may be more related to the idiosyncrasies of camera placement rather than animal size in this instance. The authors used 50 cm height for camera placement which is substantially higher than other studies designed to photograph ocelots at 20 cm (Trolle & Kéry, 2003) and 30 cm (Dillon & Kelly, 2007). Remote cameras are known to have a fairly wide heat/motion sensor horizontally, but not vertically, and height issues have not yet been fully addressed in camera studies. Lowering cameras to 20–30 cm will likely increase photographic rates of small species while not compromising photographic rates of larger species. Additionally, all this may be a moot point as newer digital camera models have been shown to photograph smaller species at substantially higher rates than commonly used film cameras while still photographing medium and large mammals at the same rates (Thompson *et al.*, in press).

I was intrigued by the authors' supposition that capture frequencies (i.e. trapping rates) 'are a relatively poor index for relative abundance among surveys . . . as can be seen when looking at the large differences in capture frequencies for several species between the two surveys in this study.' I compared the capture frequencies found in Table 1 of Tobler *et al.* (2008) of terrestrial mammals from the two surveys and found the opposite: capture frequencies were highly correlated between years (Fig. 1). Even when removing the obvious outlier of white-lipped peccaries with very high trap success, the relationship between years is still very strong ($n = 25$, $r_s = 0.826$, $P < 0.0001$). There is a clear debate surrounding the general use of indices of abundance (Anderson, 2001, 2003; Engeman, 2003) and surrounding the specific use of camera trap data as an index of species abundance (Carbone *et al.*, 2001, 2002; Jennelle, Runge & MacKenzie, 2002). But given the fact that trap success appears highly correlated between years, trap effort is straightforward to calculate, and in the field, cameras are likely to be subject to fewer sources of error than other indices (e.g. variable ability of technicians in variable field conditions), it seems reasonable to explore this issue further. Perhaps new camera-trapping studies should focus on calibration of trapping rates to independent assessments of species density so that the substantial information gained from camera studies on both target and non-target species could be made more useful for long-term species conservation.

There is no question that the rise of these machines has opened up new avenues for the study of elusive species. However, there are still substantial methodological issues to explore and far too often remote camera studies give little forethought to study design and subsequent data analysis. This problem may be compounded as methodology becomes outpaced by technology (e.g. faster, more sensitive digital cameras, directly downloadable images from base stations or satellites, etc.). Studies such as Tobler *et al.* are still needed to further refine methodology, thereby allowing us to build more thoughtful and useful remote camera studies in the future.

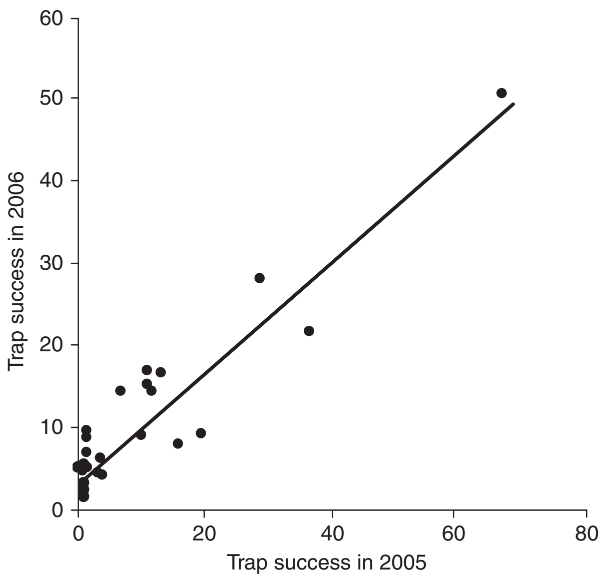

Figure 1 Correlation between trap success (capture frequency per 1000 trap nights) for terrestrial mammals in 2005 and 2006 (n=26, r_s=0.846, P<0.0001). Data from Tobler *et al.* (2008), Table 1.

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