Short Communication

Arboreal camera trapping for the Critically Endangered greater bamboo lemur *Prolemur simus*

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Abstract Camera traps are standard tools for assessing populations of medium–large terrestrial mammals, particularly for rare, elusive or cryptic species, yet few researchers have attempted to employ camera traps to document rare primates in arboreal settings. We examined different arboreal camera-trap techniques to document the Critically Endangered greater bamboo lemur *Prolemur simus* in Madagascar. We documented *P. simus* at two sites, confirming presence at one site. Most species, including 86% of all lemur occurrences, were documented in low light conditions (c. < 105 lux). Our study suggests that camera traps can be effective in validating unconfirmed sightings of rare or secretive primate species. We recommend that future work with cameras in arboreal settings considers seasonal activity patterns, targets sites with high food densities, uses local knowledge, and utilizes available techniques (e.g. traditional trapping techniques) and landscape topography to concentrate animal movement (e.g. steep slopes or ridge lines).

Key words Ankeniheny–Zahamena Corridor, camera trap, greater bamboo lemur, Madagascar, primate, *Prolemur simus*

Camera traps have relatively recently become standard research tools for assessing populations and life histories of wildlife (Kays & Slauson, 2008; O'Connell et al., 2011). Researchers are now employing camera traps to document rare, elusive or cryptic animals such as the tiger *Panthera tigris* (Karanth, 1995), owl-faced monkey *Cercopithecus hamlyni* (Easton et al., 2011), puma *Puma concolor* (Kelly et al., 2008) and fossa *Cryptoprocta ferox* (Gerber et al., 2010) that would otherwise be difficult to monitor. However, most research using camera traps has focused on terrestrial animals or on birds at their nests (see Kucera & Barrett, 2011 for a history of camera-trap use in animal ecology).

Although camera-trap projects have opportunistically documented arboreal species on the ground (e.g. Tobler et al., 2008; Blake et al., 2010), only a few researchers are beginning to breach the arboreal realm. Kierulff et al. (2004) placed camera traps at 2 m above the ground, aimed at a baited feeding platform, to document arboreal primates. Camera traps have been angled upwards to document factors influencing the fruit release of *Astrocaryum* palm trees (Agouti Enterprise, 2011). Overall, using camera traps to investigate the ecology of arboreal species remains relatively unexplored. Here we describe our application of arboreal camera traps to document the presence of the Critically Endangered (Andrainarivo et al., 2008) and highly secretive (Rakotonirina et al., 2011) greater bamboo lemur *Prolemur simus*, a species endemic to Madagascar and one of the most threatened primates (Wright et al., 2009).

Representing a monospecific genus, and having a highly specialized diet comprising primarily large-culmed bamboo, *P. simus* has recently been discovered in and around the Ankeniheny–Zahamena rainforest corridor in eastern Madagascar (Ravaloharimanitra et al., 2011). One of the largest new protected areas in the country, this corridor is now considered a priority site for the conservation of the species (King & Chamberlan, 2010) but direct sightings within the corridor remain difficult to obtain despite the intensive efforts of several research teams (Ravaloharimanitra et al., 2011; Randrianarimanana et al., in press).

Using knowledge from team members representing the Mamelontsoa, Faniry, Mami and Telomira local forest management associations, we placed seven camera traps in locations of known or suspected *P. simus* presence at multiple heights in the canopy (Fig. 1). We placed two cameras (PC800 HyperFire, Reconyx, Holmen, USA) at 6–8 m in the canopy and angled slightly downwards (hereafter,

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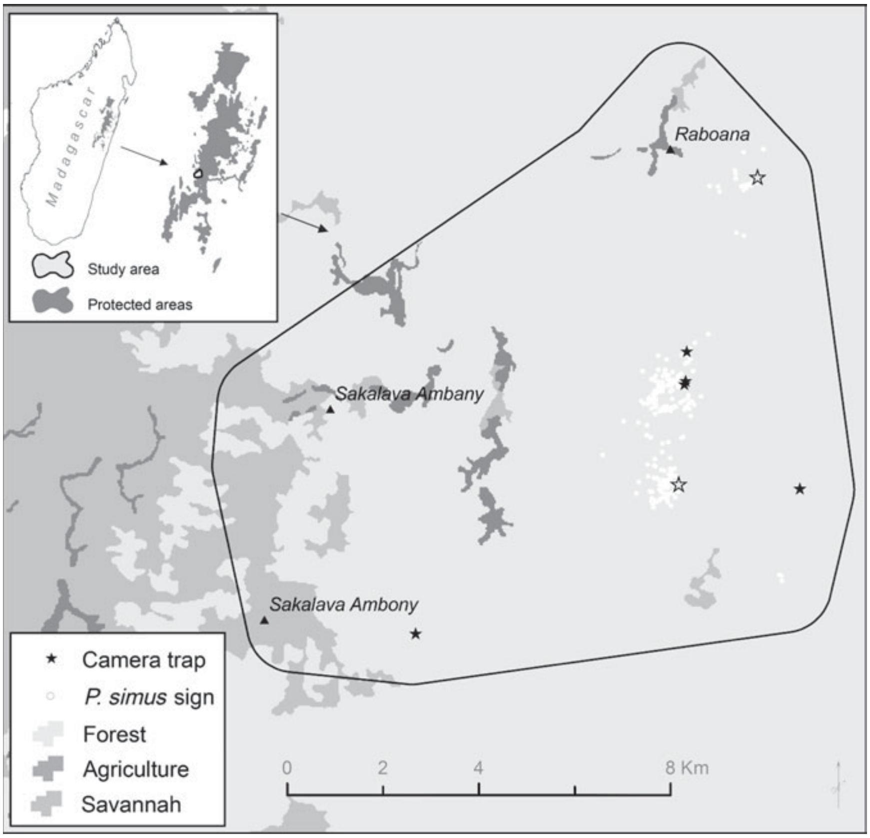

FIG. 1 Study area in the Morarano Gare commune of the Ankeniheny–Zahamena rainforest corridor, with the location of the seven camera traps (white stars indicate camera trap sites where the greater bamboo lemur *Prolemur simus* was photographed), direct or indirect signs of *P. simus* recorded during and prior to our study (Randrianarimanana et al., in press; L. Randrianarimanana et al., unpubl. data), land cover (Madagascar Ministry of Environment and Forestry, unpubl. data, 1996) and selected villages (triangles). Inset indicates the location of the main map in Madagascar and the protected areas near the Ankeniheny–Zahamena rainforest corridor.

sub-canopy), two at < 5 m angled downwards at ridge-top ground clearings with limited vertical and horizontal structures to funnel animal movement into camera foci (hereafter, lemur trap; mimicking traditional lemur trapping techniques; Ravaloharimanitra et al., 2011), and three along 21–34 degree slopes at 2–3.5 m height facing the direction of the slope aspect and capturing an area of 2–14 m high in the canopy (hereafter, hillside). We placed cameras in areas with high densities of the bamboo *Cathariostachys madagascariensis*, the main food source of *P. simus* within the Ankeniheny–Zahamena rainforest corridor (Ravaloharimanitra et al., 2011). Local knowledge guided us to focus cameras at sub-canopy heights because of the understanding that *P. simus* was undergoing a seasonal transition to a diet of bamboo stems rather than bamboo leaves higher in the canopy. All camera traps were located > 1 km apart in an attempt to capture different groups (Tan, 1999 estimated the home range of one group as 62 ha or 0.89 km in diameter), with the exception of two, centred on an area of intensive use by a group of *P. simus* (Randrianarimanana et al., in press; Sakalava Group I). Our study ran for 231 camera-trap nights between 7 August and 12 September 2011. We considered a capture event as all photographs within 30 minutes of the same species.

Our camera traps documented *P. simus* at two sites (Table 1). The species was readily identified from the distinctive pygal patch and white ear tufts, which both show up well in infrared photographs (Plate 1a,b). These results confirmed the presence of the species at one of these sites (Faniry Raboana), evidence for which had previously been based on feeding signs (Ravaloharimanitra et al., 2011) and that the species is active both day and night. Additionally, the camera traps documented several other species (Table 1; Plate 1c,d). There were two events in which the individual animals could not be identified because they were too close

TABLE 1 The species camera-trapped in the Morarano Gare commune of the Ankeniheny–Zahamena rainforest corridor (Fig. 1), with the number of events and times of photographs.

Species[1]	Events[2]	Time(s)
Greater bamboo lemur *Prolemur simus*	2	15.42, 22.07
Eastern grey bamboo lemur *Hapalemur griseus*	4	04.36, 10.39, 16.47, 17.00
Mouse lemur *Microcebus* sp.	2	03.46, 19.09
Tuft-tailed rat *Eliurus* sp.	1	00.24
Bush pig *Potamochoerus lavartus*	4	00.13, 22.39, 01.41, 01.33
Domestic cattle *Bos taurus*	1	01.46
Feral cat *Felis catus*	2	15.17, 15.42

[1]Includes only identifiable species
[2]A single event constituted all photographs of a species within a 30 minute time period

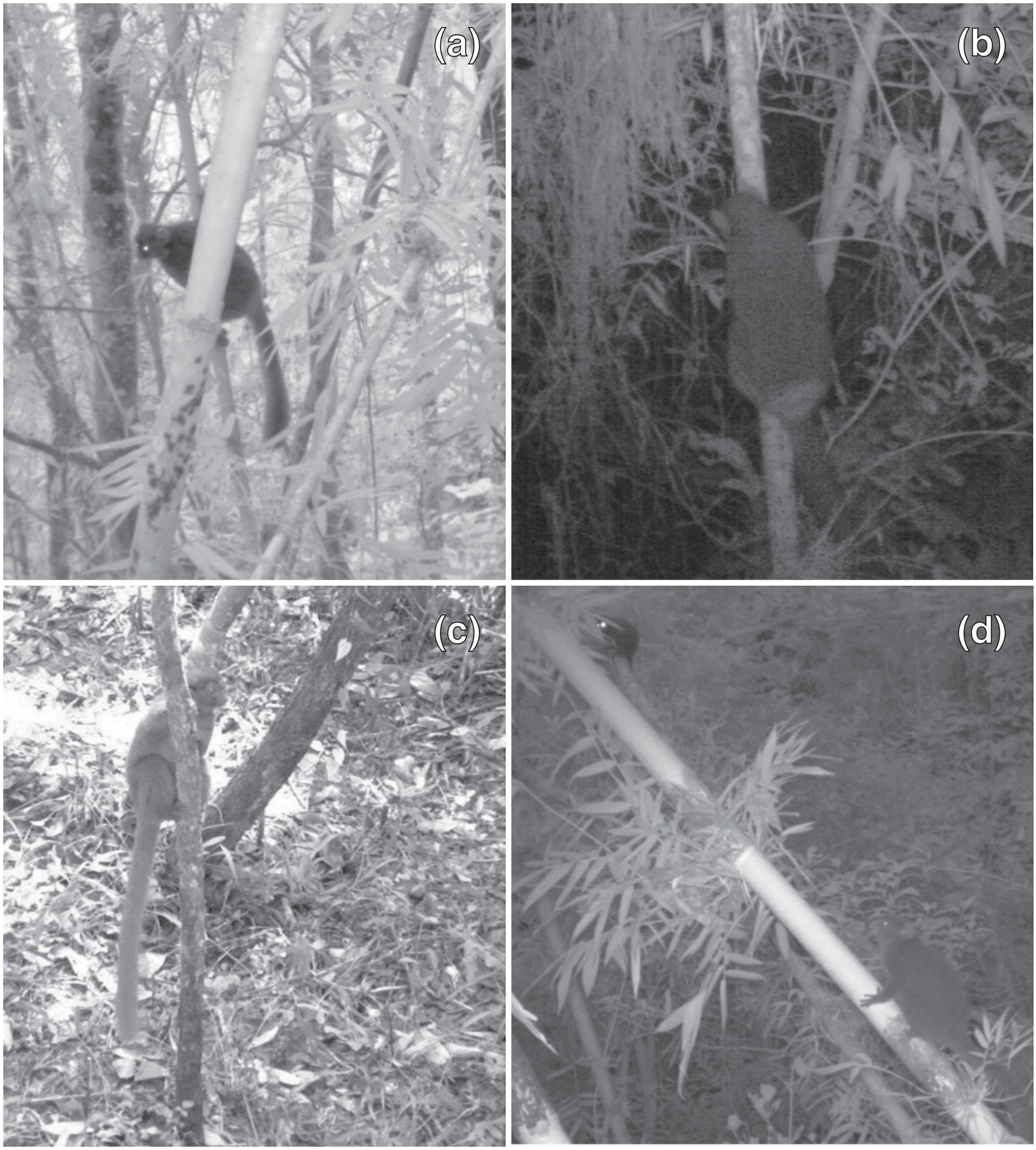

PLATE 1 Camera-trap photographs of the greater bamboo lemur *Prolemur simus* (a,b) and the eastern grey bamboo lemur *Hapalemur griseus* (c,d); images enhanced to improve visibility of focal species.

to the camera, and several individuals could only be identified to genus as we were unable to distinguish defining characteristics in the photographs.

There were different levels of success with each type of camera-trap placement. We documented *P. simus* at two of the three hillside placements despite not observing many *P. simus* signs at either site when placing or recovering the cameras. *P. simus* has been visually observed at both sub-canopy sites, two of the three hillside sites but neither of the lemur trap sites (Ravaloharimanitra et al., 2011; Randrianarimanana et al., in press). This suggests that the sub-canopy technique has a lower detection probability for *P. simus* than the hillside technique. However, because *P. simus* was not previously observed at either of the lemur-trap sites this technique's detection probability cannot be inferred.

The lemur-trap technique documented a greater number of species (range 3–4 species, n = 2) in comparison to the hillside technique (range 1–2 species, n = 3) and thus the lemur-trap technique may document multiple species, including terrestrial species. There were no capture events of any species at the sub-canopy camera traps, suggesting they may be less effective at capturing animal activity.

Most of the species we documented were recorded at night or at other times of low light levels (c. < 105 lux; 25 of 28 events, 89%) and 86% of all lemur events (6 of 7) were recorded during low light levels (between 16.47 and 04.36; Table 1). Direct observation is limited by available light and observer activity during the day, and thus because most activity occurred under low light conditions camera trapping can greatly enhance the ability to detect nocturnal, crepuscular or cathemeral lemurs such as *P. simus*. Furthermore, direct observation is likely to influence the activity patterns of nocturnal animals; creating a network of camera traps from the ground to the upper canopy in areas of high use may be less disturbing. This technique could be instrumental in providing information on little-known species such as the 40% of lemur taxa currently categorized as Data Deficient, almost all of which are considered nocturnal (Mittermeier et al., 2010). Additionally, camera placement at multiple heights in the canopy may reveal temporal and seasonal patterns of movement of arboreal animals that may otherwise be difficult to document.

Our study provided insights into the use of camera traps to monitor, document and validate indirect observations of arboreal species. We recommend that future work (1) targets sites with high food densities, (2) uses local knowledge on regional and micro-habitat use, (3) considers seasonal activity patterns, (4) uses techniques to concentrate animal movement (e.g. traditional trapping techniques or baits/lures), and (5) locates sites where vertical arboreal movements may be restricted (e.g. ridge lines, canopy gaps), or at nesting or roosting sites. Concerning *P. simus* in particular we have illustrated here the potential of using camera traps to confirm the occurrence of the species at sites for which there was indirect evidence of presence such as feeding signs or unconfirmed sightings (for example several of the sites reported by Ravaloharimanitra et al., 2011, and Rakotonirina et al., 2011). We therefore recommend incorporating the use of camera traps at a large-scale within the ongoing efforts to elucidate the distribution of this species in the wild, to better inform conservation decision-making (King & Chamberlan, 2010; Rakotonirina et al., 2011). This may be particularly informative at sites with only limited evidence of presence, or where logistical or safety issues reduce the potential for direct observations during periods of low light.

Our study suggests that camera traps can be used to document the presence and activity of animals in an arboreal setting, and can be effective for validating unconfirmed observations of rare or secretive primate species. Ecologists have a good understanding of the factors that influence the movements of terrestrial animals and are capable of locating areas of high traffic on the ground but understanding arboreal movement patterns is more difficult, limiting effective camera placement. Further research into the methods of arboreal camera-trap placement is warranted to determine fully the efficacy of camera trapping for primates and other arboreal species.

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References

Agouti Enterprise (2011) *The Machiavellian Plant Behavior Hypothesis*. Http://agoutienterprise.wordpress.com/2011/06/08/the-machiavellian-plant-behavior-hypothesis/ [accessed 7 June 2012].

Andrainarivo, C., Andriaholinirina, V.N., Feistner, A., Felix, T., Ganzhorn, J., Garbutt, N. et al. (2008) *Prolemur simus*. In *IUCN Red List of Threatened Species v. 2011.2*. Http://www.iucnredlist.org [accessed 7 June 2012].

Blake, J.G., Guerra, J., Mosquera, D., Torres, R., Loiselle, B.A. & Romo, D. (2010) Use of mineral licks by white-bellied spider monkeys (*Ateles belzebuth*) and red howler monkeys (*Alouatta seniculus*) in eastern Ecuador. *International Journal of Primatology*, 31, 471–483.

Easton, J., Chao, N., Mulindahabi, F., Ntare, N., Rugyerinyange, L. & Ndikubqimana, I. (2011) Status and conservation of the only population of the Vulnerable owl-faced monkey *Cercopithecus hamlyni* in Rwanda. *Oryx*, 45, 435–438.

Gerber, B., Karpanty, S.M., Crawford, C., Kotschwar, M. & Randrianantenaina, J. (2010) An assessment of carnivore relative abundance and density in the eastern rainforests of Madagascar using remotely-triggered camera traps. *Oryx*, 44, 219–222.

Karanth, K.U. (1995) Estimating tiger *Panthera tigris* populations from camera-trap data using capture-recapture models. *Biological Conservation*, 71, 333–338.

Kays, R.W. & Slauson, K.M. (2008) Remote cameras. In *Noninvasive Survey Methods for Carnivores* (eds R.A. Long, P. Mackay, W.J. Zielinski & J.C. Ray), pp. 110–140. Island Press, Washington, DC, USA.

Kelly, M.J., Noss, A.J., Di Bitetti, M.S., Maffei, L., Arispe, R.L., Paviolo, A. et al. (2008) Estimating puma densities from camera

trapping across three study sites: Bolivia, Argentina, and Belize. *Journal of Mammalogy*, 89, 408–418.
Kierulff, M.C.M., dos Santos, G.R., Canale, G., Guidorizzi, C.E. & Cassano, C. (2004) The use of camera-traps in a survey of the buff-headed capuchin monkey, *Cebus xanthosternos*. *Neotropical Primates*, 12, 56–59.
King, T. & Chamberlan, C. (2010) Conserving the Critically Endangered greater bamboo lemur. *Oryx*, 44, 167.
Kucera, T.E. & Barrett, R.H. (2011) A history of camera trapping. In *Camera Trapping in Animal Ecology* (eds A.F. O'Connell, J.D. Nichols & K.U. Karanth), pp. 9–25. Springer, New York, USA.
Mittermeier, R.A., Louis, Jr, E.E., Richardson, M., Schwitzer, C., Langrand, O., Rylands, A.B. et al. (2010) *Lemurs of Madagascar*, 3rd edition. Conservation International, Washington, DC, USA.
O'Connell, A.F., Nichols, J.D. & Karanth, K.U. (2011) *Camera Trapping in Animal Ecology*. Springer, New York, USA.
Rakotonirina, L., Rajaonson, A., Ratolojanahary, T., Rafalimandimby, J., Fanomezantsoa, P., Ramahefasoa, B. et al. (2011) New distributional records and conservation implications for the critically endangered greater bamboo lemur *Prolemur simus*. *Folia Primatologica*, 82, 118–129.
Randrianarimanana, L., Ravaloharimanitra, M., Ratolojanahary, T., Rafalimandimby, J., Rasolofoharivelo, T., Ratsimbazafy, J. et al. (in press) Statut et conservation de *Prolemur simus* dans les sites de Ranomainty et Sakalava du Corridor Ankeniheny–Zahamena. *Lemur News*.
Ravaloharimanitra, M., Ratolojanahary, T., Rafalimandimby, J., Rajaonson, A., Rakotonirina, L., Rasolofoharivelo, T. et al. (2011) Gathering local knowledge in Madagascar results in a major increase in the known range and number of sites for Critically Endangered greater bamboo lemurs (*Prolemur simus*). *International Journal of Primatology*, 32, 776–792.
Tan, C.L. (1999) Group composition, home range size, and diet of three sympatric bamboo lemur species (genus *Hapalemur*) in Ranomafana National Park, Madagascar. *International Journal of Primatology*, 20, 547–566.
Tobler, M.W., Carrillo-Percastegui, S.E., Pitman, R.L., Mares, R. & Powell, G. (2008) An evaluation of camera traps for inventorying large- and medium-sized terrestrial rainforest mammals. *Animal Conservation*, 11, 169–178.
Wright, P.C., Larney, E., Louis, Jr, E.E., Dolch, R. & Rafaliarison, R.R. (2009) Greater bamboo lemur *Prolemur simus* (Gray, 1871). *Primate Conservation*, 24, 7–8.

Biographical sketches

Erik Olson is studying wildlife conservation using geospatial and camera-trap techniques. Ryan Marsh is interested in forest governance in the tropics. Brittany Bovard is studying the human dimensions of wildlife management and conservation. Lucien Randrianarimanana is a field primatologist concentrating on the study and conservation of *P. simus* in Madagascar. Maholy Ravaloharimanitra focuses on facilitating community-based conservation schemes for sites included in The Aspinall Foundation's Saving *Prolemur simus* project. Jonah Ratsimbazafy is co-author of *Lemurs of Madagascar*, a member of the IUCN/Species Survival Commission Primate Specialist Group in Madagascar, and the General Secretary of the Madagascar Primate Research Group. Tony King plans, implements and evaluates conservation interventions for The Aspinall Foundation, including their Saving *Prolemur simus* project.