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Original Article

A Direct Comparison of Camera-Trapping and Sign Transects for Monitoring Wildlife in the Wanglang National Nature Reserve, China

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ABSTRACT Wildlife monitoring plays a critical role in evaluating the management and conservation of biodiversity. During monitoring activities in Chinese nature reserves dedicated to giant panda conservation, indirect sign surveys along fixed transects are the standard methodology used to monitor large-mammal populations. Camera-trapping has been recently introduced to these reserves as an additional monitoring tool. We present a case study of comparing current sign-transect monitoring with camera-trapping in Wanglang National Nature Reserve, China, from September 2004 through October 2005, and we assess the effectiveness of both methods in detecting terrestrial fauna. Camera-trapping detected 21 mammal species, while sign transects detected 16 species. We found no significant difference in the animal community detected by each method; however, sign transects were weighted toward detecting large-sized animals. Each survey technique had different strengths; therefore, a combined sampling of camera-trapping (800 camera-days) and sign transects (80 km) was sufficient to detect 95% of detectable large, terrestrial mammal species within this 323-km^2 reserve. Our estimate of species richness based on camera-trapping (39.0 ± 13.6 species) and sign transects (20.0 ± 4.4 species) suggests that camera-trapping can detect more species when extensive sampling effort is employed by both methods. Camera-trapping also has the potential for more robust estimates of population parameters than are possible with sign transects. We propose that the giant panda reserves in China can increase their efficiency and range of species monitored by using a system that integrates camera-trapping with sign transects. © 2012 The Wildlife Society.

KEY WORDS large mammal, monitoring index, protected area management, species richness, temperate forest, wildlife monitoring.

Monitoring plays a critical role in evaluation of the management and conservation of wildlife (Sheil 2001, Pereira and Cooper 2006, Marsh and Trenham 2008). Robust data systematically collected from well-designed long-term programs provide trend information on the spatial and temporal distribution of populations, which is critical for population and habitat management (Peterjohn and Sauer 1994, Gregory et al. 2007, Teder et al. 2007).

The region encompassing the mountains of Southwest China is identified as a global biodiversity hotspot due to its unique diversity and the fact that it faces great threats from human development (Myers et al. 2000, Mittermeier et al. 2005). Large mammals are often considered a surrogate taxon for overall biodiversity (Morrison et al. 2007), and they are the focus of the current monitoring system in the forests of this region (Gu et al. 2004, 2005). For decades, the giant panda (*Ailuropoda melanoleuca*), whose distribution is largely confined to this region, has been considered a flagship species for conservation (Schaller 1994, Lu et al. 2000, Loucks et al. 2001). Sixty-two nature reserves, a network covering 29,000 km^2, which is the primary entity for designing and conducting wildlife monitoring, have been established to focus on giant panda and other rare animals within the region. For most large mammals in this region, direct sightings are rare occurrences because of the relatively low animal densities and elusive habits, as well as dense vegetation and complex topography (Schaller 1994, Gu et al. 2005). Indirect sign surveys along predetermined transects has been the standard methodology to document wildlife during the monitoring activities since the late 1990s (Gu et al. 2004, SFA 2007). Sign transects combined with a measure of bamboo fragment length recovered from the feces (see Garshelis et al.

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2008) was the methodology adopted for the Third National Giant Panda Census, and has been applied to all nature reserves throughout the giant panda range (SFD 2003; SFA 2006, 2007).

In practice, however, sign records usually are confined to a few, high-profile species (Gu et al. 2005). There are several potential reasons for this bias. First, the visibility and durability of animal signs can vary broadly under different vegetation and weather conditions (Bang and Dahlstrom 2001, Ma et al. 2001). Second, the signs of many species, such as small carnivores or medium-sized ungulates, are either impossible to discriminate based on their appearance alone (Davison et al. 2002), or discriminating them is beyond the abilities of most reserve staff (Ma et al. 2001). Because of these difficulties, additional methods are needed to better estimate the diversity within these important reserves.

The use of infrared-triggered cameras (henceforth, called "camera-trapping") has become prevalent in wildlife study and monitoring in recent decades, and is considered one of the most effective tools to record and study elusive wildlife in remote areas (Karanth and Nichols 1998, Cutler and Swann 1999, Silveira et al. 2003, Swann et al. 2004, Rowcliffe and Carbone 2008). Camera-trapping was introduced to China in the late 1990s and has been used for ecological studies of various species (e.g., Tilson et al. 2004, Lu et al. 2005, Ma et al. 2006, Li et al. 2010*a*) and for wildlife management (Wang et al. 2006). Camera-trapping has been introduced to numerous giant panda reserves as an ad hoc monitoring tool (Lu et al. 2005, Wang et al. 2006, Li et al. 2010*b*); therefore, there is a need to compare this approach with the traditional sign-transect survey method with respect to both detection rates and effort over comparable conditions.

Most survey protocols currently being used in Chinese nature reserves are an index based on a ratio of detections divided by a measure of effort (Gu et al. 2004, 2005; Li et al. 2010*b*). The index for sign transects usually is the number of mammal tracks and sign detected per km of trails traversed (Blom et al. 2005); for camera-trapping, the index is photographs per day of operation (Carbone et al. 2001). There are 2 critical elements of these indexes: 1) the detectability of a species for the survey method and 2) the amount of effort required to detect sufficient signs to make inferences about management activities. Although most surveys strive to detect all mammals within an ecological community, there is usually a logistical trade-off between the number of species detected and the amount of staff effort required to complete the survey.

Here, we evaluate the effectiveness of surveys using camera-trapping and sign transects to detect the same terrestrial fauna at Wanglang National Nature Reserve, China, from 2004 to 2005. We focus on species richness because it provides a gauge of the "depth" of information that a technique can provide about the mammal community. We made comparison of the rapidity with which species were detected, which could indicate the amount of effort needed (a basic but essential information to local nature reserves for their wildlife management) before use of more sophisticated occupancy modeling to monitor the species occupancy rate or relative abundance (Mackenzie et al. 2002, 2006). We are not advocating species richness as the basis of a monitoring program, but as a basis for comparing 2 techniques conducted at the same time on the same mammal community. Our objective is to determine which technique, or combination of techniques, produces the most complete record of large-mammal richness for the least amount of effort.

STUDY AREA

We conducted this study in Wanglang National Nature Reserve (104°3′E, 32°56′N; hereafter, Wanglang), located in northwest Sichuan Province, China (SFA 2006). Wanglang was established in 1965, primarily for the protection of endangered species and their habitat, and it encompasses 323 km^2. Sixty-two mammal species and 162 bird species have been recorded within Wanglang since its establishment (WNRA 1999). The elevation of Wanglang ranges from 2,400 m to 4,980 m. Along an increasing elevation gradient, the major vegetation types are deciduous forest, conifer–deciduous mixed forest, conifer forest, subalpine scrub, and alpine meadow. Though among the first nature reserves established in China, Wanglang did not have systematic wildlife monitoring until the late 1990s (Chen et al. 2003). In 1997, Wanglang initiated monitoring of the giant panda population, and shortly thereafter surveys were extended to all large mammalian and avian species (Chen et al. 2003). The entire reserve was divided into 6 regions for monitoring activities (Fig. 1).

METHODS

Camera-Trapping

We conducted the camera-trapping survey in Wanglang from September 2004 through October 2005. We divided the entire reserve into 1-km^2 blocks within a Geographic Information System, but due to access difficulties and camera malfunctions, only 118 (of the original 131) forest blocks below tree-line could be included in this analysis. We placed one camera unit in each block for 1 month, and all sampling sites were separated from each other by >300 m. We used two models of passive infrared-triggered camera units: Ten DeerCam™ units (Non Typical, Inc., Park Falls, WI) and 20 units locally manufactured by the authors for this project. These units had specifications of sensor sensitivity, detection range, and reaction speed (0.6–1.0 s) similar to DeerCam cameras, and the two models performed equally well in informal testing. ISO 400 negative films were used, and the date and time of each exposure was printed on the photograph.

We attached camera units to trees along animal trails (as identified by field staff) 30–50 cm above ground and 3–5 m from the trail. We set all the units to work 24 hours/day with 2.5–3.0 minutes delay between consecutive exposures. We checked the camera units once in the middle of the 1-month sampling period to replace batteries and-or film if needed, and relocated to another cell at the end of the sampling period.

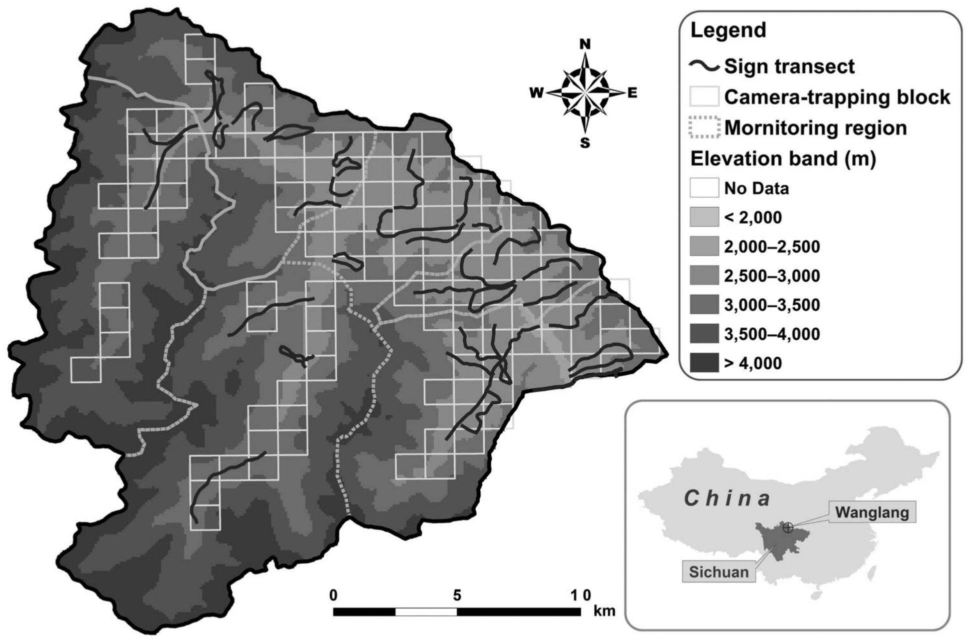

Figure 1. Location of sign transects and camera-trapping blocks within Wanglang National Nature Reserve, China, September 2004–October 2005. Tree-line occurs at approximately 3,400 m; all sampling occurred below 3,300 m.

Sign Transects

During the same period as the camera monitoring, 34 sign transects that overlapped most parts of the camera-trapping area were surveyed by reserve field staff. Animals and/or their signs encountered within 10 m on either side of those transects were recorded. Animal signs were identified to species based on staff knowledge. At the time of the comparison, all field staff had been part of the monitoring team for at least 2 years and had obtained training on identification of animal signs from wildlife experts.

Data Analysis

For camera-trapping, we identified mammal species captured on photographs based on their body size, physical characteristics, and coat pattern, according to Wang and Hu (1999) and Smith and Xie (2008). We calculated the photographic rate, defined as the number of independent detections/100 camera-days, for each species. Independent detection of a species was defined as all photographs of the species separated by >30 minutes at one sample location. For sign transects we also calculated the encounter rate, defined as the number of signs (observations)/100 km of transect, for each species.

We estimated species richness using SPECRICH2 (http://mbr-pwrc.usgs.gov/software/specrich2.shtml), a closed capture–recapture model with heterogeneous detection probabilities from Program CAPTURE (Rexstad and Burnham 1991, Hines et al. 1999), where we assumed that there was no new species colonization or extinction occurring within the study area during our survey period. Prior to the analysis, the camera-trapping effort was divided into successive 100 camera-days sampling occasions ($\bar{x} = 5.3$ species detected/unit) and the sign transect was divided into successive 10-km sampling segments ($\bar{x} = 4.8$ species detected/unit). We also created a combined sampling unit, which consisted of 100 camera-days + 10-km of transect. For all analyses, we excluded mammals whose body weight was <200 g due to the uncertainty of identification. Species accumulation curves for the large-mammal species were generated for camera-trapping, sign transects, and the combined method, based on the sampling units outlined above.

All variables were examined for normality (1-sample Kolmogorov–Smirnov test) prior to analysis (no transformations were necessary). We used Pearson's correlation to compare detection rates (i.e., camera-trapping photographic rate and sign-transect encounter rate) and animal body mass. We used the 2-sample Wilcoxon rank test to compare camera-trapping versus sign transects for detecting mammal species richness. All tests were completed using software SPSS 13.0 at a significance level of 0.05 (SPSS Inc., Chicago, IL).

RESULTS

We sampled 118 blocks with camera-traps for a combined 3,793 camera-days, and a staff labor of 501 person-days (Fig. 1). Photographs of mammals ($n = 312$) were used to identify 21 mammal species (Table 1; Appendix), including 2 new species records for the reserve: the wooly hare (*Lepus oiostolus*) and mountain weasel (*Mustela altaica*; WNRA 1999). Meanwhile, 34 sign transects were surveyed by the field staff for a total length of 503 km, and a staff labor of 374 person-days, producing 616 animal records of 16 mammal species (Table 1; Appendix; Fig. 1). Direct observation accounted for 1.5% of the mammal records, with the remainder being records of sign (Table 1). Feces were the primary type of animal sign used for identification (55.1%),

Table 1. Results of sign transects and camera-trapping in Wanglang National Nature Reserve, China, September 2004–October 2005.

Variable	Camera-trapping	Sign transect
Sampling effort	3,793 camera-days	503 km
Staff labor[a]	501 person-days	374 person-days
No. of mammal species detected[b]	21	16
No. of mammal records	312[c]	9/607[d]
Estimated mammal species richness	39.0 ($\pm$13.6)	20.0 ($\pm$4.4)

[a] For both surveys, we assumed a field team contained $\geq$2 staff members, due to safety concerns. Most of the sign transects were completed by 1 day of field-work. Setting and-or collecting cameras at some remote sampling locations took up to 3 days of hiking and camping.
[b] Only the species that could be identified from the photographs were counted.
[c] No. of photographs.
[d] No. of direct observations/No. of signs.

followed by feeding signs (21.1%), and tracks (17.0%). No new species were detected during this period through sign surveys.

Camera-trapping and sign-transect surveys detected 18 and 15 large-mammal species, respectively, while the combined list totaled 19 species (Appendix). Our estimate for species richness was 39.0 (SE = 13.6) species using the camera-trapping data, 20.0 (SE = 4.4) species using the sign-transect data, and 30.0 (SE = 7.3) species using data from the combined method (Table 1). Although no method detected the estimated number of species, camera-trapping detected more species than did sign transects, and it had the potential for detecting significantly more species based the capture of species per unit of effort.

The species accumulation curves of mammals showed the same asymptotic pattern for all 3 methods (Fig. 2). The accumulation curve reached an asymptote (i.e., 95% of species detected) at 21 sampling units for camera-trapping (i.e., 2,100 camera-nights) and >50 sampling units for sign transect (i.e., 500 km of trails). When we combined the

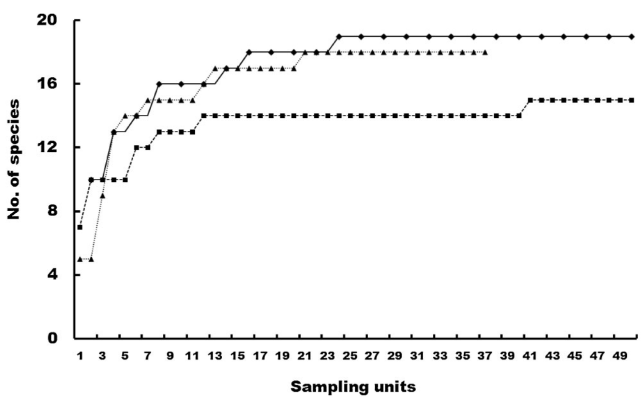

Figure 2. Species accumulation curves from data collected using camera-traps (triangles), sign transects (squares), and combined techniques (diamonds) to detect large mammals within forests of Wanglang National Nature Reserve, China, September 2004–October 2005. Individual sampling units on the x-axis are 100 camera-days for camera-trapping, 10-km segments for sign transects, and 2-unit intervals (1 unit from each method) for combined techniques.

2 methods, the species accumulation curve for the hybrid method was similar to the camera-trapping curve, but a 95% detection rate for all known mammal species could be achieved with the effort of 8 combined sampling units (i.e., 800 camera-nights and 80 km of trails; Fig. 2). We estimate this combined sampling effort would require approximately 165 person-days, 56% less than that consumed by the current annual sign transect.

Camera-trapping detected more small-bodied (<1 kg) animals than did sign transects (62% and 6% of all detections, respectively). Body size did not influence the detectability of each method equally: There was no significant correlation between the photographic rate and animal body mass ($r = 0.382$, $P = 0.478$, $n = 26$), but there was a positive correlation between the number of signs detected per unit of transect and the animal's body mass ($r = 0.778$, $P = 0.010$, $n = 17$). This result suggests that sign transects under-detected small-bodied species. Five large-bodied species (i.e., giant panda, takin [*Budorcas taxicolor*], goral [*Naemorhedus goral*], golden snub-nosed monkey [*Rhinopithecus roxellana*], and wild boar [*Sus scrofa*]) accounted for 79.5% of all detections along the sign transects. Their relative ease of detection (i.e., as indicated by no. of photographs or signs) for known species in our survey was not significantly different between methods ($Z = 0.961$, $P = 0.337$, $n = 27$), but 7 of the 10 least-detected species on the camera-trapping were undetected by the sign transects.

DISCUSSION

Camera-trapping detected more species than did sign transects for comparable effort. Camera-trapping also detected smaller-bodied species more readily. Our results were obtained using an older generation of camera-traps, so some of our camera limitations will no longer be pertinent given the rapid development of camera-trapping technology. If the goal of monitoring is to detect the most species for the least amount of staff effort, then a combination of camera-trapping and sign transects is preferable because it produced the same results as did sign transects alone with approximately 56% less staff effort. Staff effort could be further reduced if field trips for both surveys were combined (e.g., set and-or collect cameras while conducting sign transects). We suggest that this integration should be conducted because it can be achieved with little additional investment.

In remote areas, the lack of well-educated staff for camera-trapping, data management, and data analysis is a common limitation that can be resolved with training and technical support from higher administration bureaus, academic institutions, and conservation nongovernmental organizations. Our group found 2–5 days of training to be sufficient for reserve staff to become proficient in camera operation, set-up, and data collection (Wang et al. 2006, Li et al. 2010*b*). In addition, the new generation of digital camera units, with rechargeable battery packs and large-capacity memory cards, has led to greatly increased operating duration in the field, markedly reduced costs for supplies (e.g., no film or lithium batteries required), and simpler logistics for field operation.

Species List and Richness

No single survey method provides a complete species inventory, because each has limitations based on animal body size, mode of animal movement (e.g., terrestrial vs. arboreal), and habitat conditions. Within the appropriate taxa for monitoring with camera-trapping, our cameras failed to detect some species listed on Wanglang's baseline survey (WNRA 1999). There are several potential reasons for these absences. First, some nondetected species live in habitats beyond the forested areas where our sampling was confined. For example, we failed to detect the alpine musk deer (*Moschus chrysogaster*), which generally inhabits alpine shrub and meadows (Wang and Hu 1999, Zhang and Hu 2004). The sign transects in our study surveyed a broader elevation band and recorded possible sign of musk deer beyond the elevation band used for camera-trapping, which detected only the forest musk deer.

Alternatively, some nondetected species, such as leopard (*Panthera pardus*) and Asian golden cat (*Catopuma temminckii*) are elusive (Sunquist and Sunquist 2002) and exist at low densities. Our sampling effort probably was not sufficient to detect these rare species using either technique. Both techniques might require tailored camera placements or survey routes to detect such rare species. Using sign transects to detect rare species is not cost-effective, whereas modern cameras traps could be cost-effective for monitoring rare species because they can operate for $\geq$6 months without being checked.

Finally, some undetected species, such as clouded leopard (*Neofelis nebulosa*), lynx (*Lynx lynx*), and large Indian civet (*Viverra zibetha*) have never been documented within the reserve since its establishment. Original accounts for these species came from interviews with local villagers or historical regional species lists (WNRA 1999), and their presence within the reserve is unlikely. The minimal sampling effort required to detect a rare species varies broadly among sites, especially for large, solitary mammals (Carbone et al. 2001, Datta et al. 2008), but camera-trapping is the best approach for detecting such elusive terrestrial animals. Robust estimates derived from well-designed camera-trapping data and appropriate modeling should help to determine the presence or absence of these species so that the reserve's species-list could be updated. After all, it does not benefit conservation in the region to have species that probably do not occur in the region listed as potentially occurring in reserves across the mountains in Sichuan.

Misidentification and Biases

Few wild animals were directly observed during sign transects, so animal signs were the primary evidence used to identify species; misidentifications undoubtedly occur. For example, there were 59 records of golden monkeys during the sign transects (Appendix), but during subsequent interviews by supervisors, these records were found to be misidentifications due to confusion between feeding sign left by flying squirrels (*Trogopterus xanthipes*) and golden monkeys. Unfortunately, there is little opportunity to verify unexpected observations associated with sign-transect records.

Although there is a much lower probability of species misidentification for camera-trapping as compared with sign transects, some biases may exist. We did not detect a significant correlation between photographic rate and animal body mass, but sensor detection range can correlate with body size for the passive camera units (Swann et al. 2004, Rowcliffe et al. 2011). Therefore, comparisons of the photographic rates of species that differ widely in body size are not necessarily valid due to likely differences in detection probabilities. However, the infrared sensors on modern camera-traps can capture small- as well as large-bodied animals. This allows detections of small rodents and even bats, as well as large mammals. Specific animal behavior related to the camera or flash (e.g., camera-shyness or curiosity; Wegge et al. 2004) also may influence detection probability among species. Moreover, the sensors used in most camera units are sensitive to temperature and humidity (Li et al. 2010*a*), although this issue has been partly resolved in newer camera models. For example, when ambient temperature equals or exceeds body temperature, sensitivity of infrared-triggered cameras is reduced (Swann et al. 2004). These limitations do not negate the suitability of camera-trapping, but do require attention during study design and data interpretation.

Monitoring Index

For the animals with unique coat patterns and sufficient detections, camera-trapping data could be used to produce robust population estimates (Karanth 1995; Karanth and Nichols 1998; Heilbrun et al. 2003, 2006; Jackson et al. 2006). For other species, however, transforming the number of signs or photographs into a population index requires a series of underlying assumptions that are difficult to justify (Jennelle et al. 2002, Stephens et al. 2006). Other researchers suggest that, with a better understanding of the basic ecology and behavior patterns of wildlife, reasonable indices of abundance, density, or species richness are possible from camera-trapping (Carbone et al. 2001; O'Brien et al. 2003, 2011). Recently developed approaches of incorporating detection probability reduces the bias of false-absences (i.e., present, but not detected) for a species across different sampling conditions and provide reasonable estimation of occupancy rate (MacKenzie et al. 2002, 2006; Tobler et al. 2008). These advances benefit many survey methods, but the measure of effort for camera-trapping (i.e., camera-nights) is readily converted into repeated samples, as compared to re-walking the same kilometer of trail. Furthermore, Rowcliffe et al. (2008) gave a theoretical basis for estimating animal population density based on photographic rate, measurements of group size and movement rate, and the distance and angle of the cameras. These developments enhance the feasibility for nature reserves to track species abundance and composition within their reserve using camera-trapping records and provide robust information for management decisions.

Given the current limitations at most Chinese nature reserves (e.g., limited funding, lack of well-trained staff, poor capacity for data management, and analysis), reserve staff are not trained to understand, let alone use, advanced estimates of abundance. This situation will not rapidly improve even though the Chinese government has recently allocated sustained financial and technical support to these reserves (Li et al. 2010*b*). Simple monitoring indices (e.g., sign encounter rate, photographic rate from camera-trapping) that can be easily understood and generated by reserve staff are more practical and useful for their current wildlife monitoring activities. The key to a successful monitoring protocol, however, will be collecting data that can serve the dual purpose of providing understandable indices for local use, while simultaneously providing data for regional or national analyses that employ advanced analytical techniques. Camera-trapping has the capacity to provide rich data sets that can serve these dual purposes. This is not the case for sign transects. Camera-trapping also has the advantage of providing data that are not discernible from sign transects, such as activity patterns (Pei 1998, Li et al. 2010*a*), sex ratios, and social organization (Li et al. 2010*a*).

CONCLUSIONS

We suggest that wildlife reserves in China should incorporate camera-trapping into their standard monitoring programs for several reasons. First, compared with traditional sign transects, camera monitoring provides documentation of a species' presence that can be verified by experts. Second, the operation of camera units is relatively simple and can be conveyed to new staff without the requirement for experience in identification of wildlife species and their signs. Third, our research has demonstrated that the most effective use of staff time would be to integrate the 2 survey methods to generate inventories that are more complete and monitor a broader range of species. Finally, camera-trapping has the capacity to provide a suite of information that is needed for advanced analysis and, it involves technology that is rapidly evolving and will likely improve its range of detectable species in the future.

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APPENDIX

Species recorded by sign transect and camera-trapping in Wanglang National Nature Reserve, China, September 2004–October 2005.

Common name	Scientific name	Threatened status[a]	Body mass (kg)	Sign transect: No. of direct observation	Sign transect: No. of sign	Camera-trapping: No. of photograph	Camera-trapping: No. of sites detected
Golden snub-nosed monkey	*Rhinopithecus roxellana*	EN	6.5–17	0	59	0	0
Swinhoe's striped squirrel	*Tamiops swinhoei*	LC	0.08–0.1	1	0	8	5
Complex-toothed flying squirrel	*Trogopterus xanthipes*	NT	0.25–0.4	0	4	7	3
Chinese white-bellied rat	*Niviventer confucianus*	LC	0.06–0.14	0	0	2	2
Short-tailed porcupine	*Hystrix brachyura*	LC	10–18	1	3	13	11
Other rodents[b]				0	1	61	31
Moupin pika	*Ochotona thibetana*	LC	0.07–0.14	0	0	5	4
Wooly hare	*Lepus oiostolus*	LC	2–4.3	0	0	2	2
Giant panda	*Ailuropoda melanoleuca*	EN	85–125	1	174	7	4
Asiatic black bear	*Ursus thibetanus*	VU	54–240	0	9	2	2
Hog badger	*Arctonyx collaris*	LC	9.7–12.5	0	7	29	13
Yellow-throated marten	*Martes flavigula*	LC	0.8–2.8	0	0	17	12
Siberian weasel	*Mustela sibirica*	LC	0.5–1.2	0	0	32	27
Mountain weasel	*Mustela altaica*	NT	0.08–0.28	0	0	1	1
Himalayan palm civet	*Paguma larvata*	LC	3–7	1	0	7	4
Leopard cat	*Prionailurus bengalensis*	LC	1.5–5	0	17	17	9
Wild boar	*Sus scrofa*	LC	50–200	1	52	3	2
Tufted deer	*Elaphodus cephalophus*	NT	15–28	1	11	13	12
Forest musk deer	*Moschus berezovskii*	EN	6–9	0	26	2	2
Takin	*Budorcas taxicolor*	VU	250–600	3	139	24	9
Blue sheep	*Pseudois nayaur*	LC	50–70	0	8	3	2
Chinese serow	*Capricornis milneedwardsii*	NT	85–140	0	36	28	20
Goral	*Naemorhedus goral*	NT	32–42	0	61	4	3

[a] IUCN 2007. EN: Endangered, LC: Least Concern, NT: Near Threatened, VU: Vulnerable.
[b] Squirrels, flying squirrels, and rats that could not be identified to exact species.