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Assessing Variation in Wildlife Biodiversity in the Tien Shan Mountains of Kyrgyzstan Using Ancillary Camera-trap Photos

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*During the summer and fall of 2005 while documenting snow leopard (*Panthera uncia*) abundance (McCarthy et al 2008), we collected ancillary camera-trap photos taken in the Tien Shan Mountains of Kyrgyzstan and assessed their usefulness for biodiversity surveys of larger animal species. The study was conducted in 2 separate areas; one that had been declared a strictly protected national park, and a second that had no formal protection but was used as a hunting reserve by foreign interests. By using 22–24 pairs of cameras placed for 49 days in both areas, we photographed 9 of 13 probably occurring large (>1 kg) mammal species identified in a country-wide review. Of the 9 species that appeared in photographs, 4 also were identified genetically from simultaneously collected scat samples. Two species identified by the genetic sample were not photographed. Photo rates differed between areas and corresponded to independent abundance estimates for snow leopards (from fecal genetic individual identification), and for* argali *(*Ovus ammon*) and Siberian ibex (*Capra ibex*; both from visual surveys). The photo rates of ungulates were highest, and those for large carnivores were lowest, in the "strictly protected area," which suggested an effect from illicit control of predators by occupants of the surrounding villages. In contrast, in the unprotected area, where hunting was managed and local residents and visitors were few, the species diversity and photo rates for most species were higher. Our use of ancillary camera-trap photos was valuable for authenticating species presence and, sometimes, for documenting differences in species abundances between areas with different conservation histories. In addition, this study indicates the importance of continued outreach and collaboration with villagers to ensure effective wildlife conservation within Kyrgyz national parks.*

Keywords: *Camera-trapping; biodiversity; conservation; mammals; protected areas; Tien Shan Mountains; Kyrgyzstan.*

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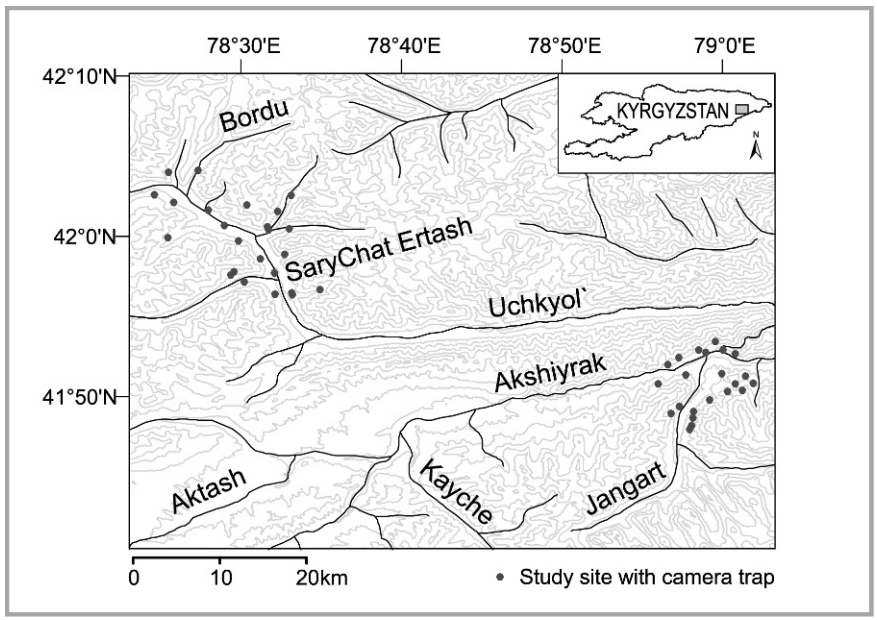
Introduction

The extensive mountain habitat in central Asia has a high biodiversity, with a plethora of endemic plant and animal species (Agakhanjanz and Breckle 1995; Olson and Dinerstein 1998). The former Soviet Republic of Kyrgyzstan was once thought to host one of the highest levels of species richness in the region (Ministry of Environmental Protection 1998) and throughout the Soviet era, poaching of natural resources generally occurred at low levels in Kyrgyzstan. However, with the fall of the Soviet Union, corruption and unemployment increased drastically in the mountainous regions. The concurrent increase in black market trade led to unprecedented levels of poaching in Kyrgyzstan and other former Soviet republics, with many families subsisting solely on the income generated from the illegal sales of wildlife products (Koshkarev and Vyrypaev 2000). Today, many of the former socialist republics continue to struggle with the promotion of a sustainable development agenda. Once citizens of a superpower, the people have now been forced to accept their new status as members of marginalized states, with drastic increases in poverty levels (Sievers 2003). Poaching continues, largely unchecked, and, in many of the former Soviet republics, there has been a lack of published wildlife research, with the post-Soviet status and distribution of many species remaining an enigma.

After the breakup of the Soviet Union, the newly independent Kyrgyz Republic struggled to balance economic development with conservation of the abundant natural resources. However, forest cover has decreased by nearly 50%, and drastic declines in the abundance of mammals and birds have been noted (Ministry of Environmental Protection 1998). In response, the government has launched a concerted effort to stem rampant poaching of carnivore and ungulate species, and has increased the development and enforcement of protected areas (Ministry of Environmental Protection 1998; Dexel 2002; Chapron 2005). However, in some cases,

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FIGURE 1 Location of study sites and camera traps in the Tien Shan Mountains of Kyrgyzstan. (Map by Kyle McCarthy)



rather than aid in the conservation of biodiversity, the development of protected areas has instead contributed to higher levels of poaching. Enforcement officials, who are commonly recruited from villages nearby to protected areas, are poorly paid and often resort to unhindered poaching of wildlife within the park boundaries. There have been some efforts to gain baseline data from protected areas to facilitate more effective management, but published wildlife research about existing biodiversity levels has been largely lacking. Most research has focused on charismatic megafauna such as snow leopards (*Panthera uncia*) (eg Hussain 2003; McCarthy and Chapron 2003; McCarthy et al 2008). Because of the lack of ecological knowledge about many of the species in the region, the development of protected areas has often focused on single species conservation. In most areas, there has been little postdevelopment follow-up to assess the multispecies conservation efficacy of such protected areas, and there is little if any outreach to local villagers living on the borders of the parks.

Camera traps have been used extensively as a noninvasive method to generate density estimates of cryptic species (eg Karanth 1995; Karanth and Nichols 1998; Trolle and Kery 2003). In addition to capturing images of the target species, camera-trap studies commonly record numerous additional species, although much of this extraneous data has been historically marginalized and rarely published. It may, however, provide important information about the biodiversity in the region, differences between areas, efficacy of protected areas, and documentation of species thought to be extirpated (Stein et al 2008; Can and Togan 2009).

Herein, we assess the use of opportunistically collected camera-trap photos as a biodiversity monitoring tool in the Tien Shan Mountains of Kyrgyzstan. We examined the difference in species composition between a national park that has been classified by the government as strictly protected and an unprotected area that is used as a hunting preserve by foreign interests. To accomplish this, we compared (1) photo results with published species occurrence information and with simultaneously collected genetic data and (2) differences in photo rates between areas to independently estimate abundance of several species. These data were used as a basis for examining the efficacy of protected areas for multispecies conservation in Kyrgyzstan.

Study sites

From June to December 2005 we conducted a camera-trapping project in 2 areas of the Tien Shan Mountains of eastern Kyrgyzstan (Figure 1) to assess various methods for estimating the density of snow leopards (McCarthy et al 2008). The SaryChat Ertash Zapovednik (SaryChat; 41° 57′ 43.92″ N, 78° 32′ 4.1994″ E) is a 720-km^2 protected area and a key component of the Issyk Kul Biosphere Reserve. As an officially declared Zapovednik, SaryChat has been withdrawn from economic use, including use for tourism, and was granted permanently protected status by

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FIGURE 2 A Siberian ibex standing next to one of a pair of camera traps along a ridgeline. (Photo by Kyle McCarthy)



the government (Braden 1984). The reserve was established for the protection of the alpine ecosystems of the Tien Shan and the rare species that occur there (specifically the snow leopard and the argali [*Ovus ammon*]). No hunting is permitted in SaryChat, although there are several villages located along the border, and extensive poaching by rangers and local villagers was previously reported (Koshkarev and Vyrypaev 2000).

The Jangart Hunting Reserve ([Jangart]; 41° 51′ 26.6394″ N, 78° 58′ 56.6394″ E) is located 80 km southeast of SaryChat and near the Kyrgyzstan–China border. The area has not been granted any official protection status, but, because of restrictions along the border zone, there has been some amount of quasiprotection in the past and little permanent habitation. After the breakup of the Soviet Union, Jangart was designated as a foreign currency hunting reserve, hosting non-nationals who come to Kyrgyzstan to hunt ungulate species. This brings intermittent use to the area and some foreign currency, because hunts are guided by local villagers.

Each of the study sites exhibits the typical habitat of the Tien Shan, with broad, dominant river valleys rising to mountain peaks of over 4000 m. However, there are some microhabitat differences. In SaryChat, the major valley is wide and rich with short grass species, and the mountainsides and ridgelines quickly become barren as they rise from the valley. In Jangart, there is a high density of tree species, large shrubs and tall grasses near the narrow river valleys, with an increasingly barren and rugged landscape as the ridgelines lead sharply up away from the river.

Material and methods

During June–September 2005, we used CamTrakker™ Ranger Cameras (CamTrakker, Wattkinsville, Georgia, USA) in SaryChat and Jangart to document wildlife occurrence and abundance. We placed 22 (SaryChat) and 24 (Jangart) pairs of cameras roughly every 2 km throughout the study area at elevations of 3049–3661 m in SaryChat (mean camera elevation of 3363 m) and 2377–3552 m in Jangart (mean camera elevation of 3055 m). Cameras were placed in areas where signs of snow leopards were identified, or along game trails, on ridgelines, and in valleys where snow leopards were likely to travel (Figure 2). Cameras were generally orientated north or south to reduce solar glare, and set at a height of 45–50 cm from the ground. In each location, paired cameras were set on opposite sides of a trail, roughly 3 m apart. Cameras were set for 49 consecutive days in both areas and were checked every 8–10 days to change batteries and/or film.

We classified photographed species whenever possible, but only snow leopards were individually identified (by "spot patterns"; McCarthy et al 2008). When both cameras took a photo of the same individual, or when we obtained multiple photographs of a species that could not be uniquely identified within the same 24-hour interval, we recorded the photos as a single event. In cases where one or more photos were taken of group of animals (eg ungulates), the maximum number of individuals in any one photo was recorded, but the photos were defined as a single event for that species. For each area, we recorded the number of nights each pair of cameras (a trap), was deployed and capable of taking photos. We calculated photo rates as the number of photo events for each species per 100 trap nights and compared photo rates with simple χ^2 tests at $\alpha = 0.01$ to account for multiple comparisons.

Because there have been no published species accounts for the specific study sites, we predicted mammalian species occurrence from several different sources (Vorobeev and Van der Ven 2003; Smith and Xie 2008; IUCN 2009; P. Zahler, Wildlife Conservation Society, pers. comm.). Species were excluded from the list if their projected distribution did not encompass the study site, if a species' habitat requirements were not in the study site, if they were not documented to occur at the general elevation of the study site, or if they were considered by the International Union for Conservation of Nature (IUCN) to be extirpated in the region, which resulted in the identification of 13 large mammal species that could be classified as likely occurring within the study area. We did not include species that weighed less than 1 kg so to take into account the level of sensitivity of the infrared triggers and the general set-up of the camera-traps. We also compared occurrence of photographed species with results from genetic species identification of scats collected during the course of the study (McCarthy 2007; McCarthy et al 2008).

We independently identified the relative abundance of snow leopards from genetic identification of individuals from collected scats (McCarthy et al 2008). Visual surveys

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TABLE 1 Photo rates (number of photo events per 100 trap-nights) of wildlife species captured by camera-trap in different topographic habitats in the SaryChat Ertash Zapovednik (SaryChat) and Jangart Hunting Reserve (Jangart).

Common name	Scientific name	SaryChat			Jangart		
		Ridge (570)[a)]	Valley (570)	Total (1140)	Ridge (1171)	Valley (49)	Total (1220)
Gray wolf	*Canis lupus*	0	0	0	0.09	0	0.08
Red fox[b)]	*Vulpes vulpes*	0.15	0.21	0.17	1.29	0	1.23
Brown bear	*Ursus arctos*	0	0.21	0.08	0	0	0
Snow leopard[b)]	*Panthera uncia*	0.15	0	0.08	0.69	0	0.66
Stone marten[b)]	*Martes foina*	0	0	0	0.17	0	0.16
Argali[b)]	*Ovis ammon*	2.86	7.16	4.64	0.09	0	0.82
Siberian ibex[b)]	*Capra ibex*	3.76	1.89	2.98	2.15	0	2.05
Tolai hare[b)]	*Lepus tolai*	0.30	0	0.18	0.34	9.02	0.74
Gray marmot	*Marmota baibacina*	1.80	1.26	1.58	0.09	0	0.08
Eurasian lynx	*Lynx lynx*	0	0	0	0	0	0
Eurasian badger	*Meles meles*	0	0	0	0	0	0
Pallas's cat	*Felis manul*	0	0	0	0	0	0
Wild boar	*Sus scrofa*	0	0	0	0	0	0

[a)] Number of trap-nights per area.
[b)] Indicates χ^2, $P < .01$.

to calculate Siberian ibex (*Capra siberica*) and argali sheep (*Ovis ammon*) abundance (McCarthy et al 2008) followed SLIMS (Snow Leopard Information Management System) methodology as defined in Jackson and Hunter (1996).

Results

In total, 117 photos of wildlife in SaryChat, and 118 in Jangart, were obtained during 1140 and 1220 camera-trap nights, respectively. Nine of the 13 mammal species thought to occur in the region were recorded (Table 1). Two mammal species not photographed (Pallas's cat [*Felis manul*] and wild boar [*Sus scrofa*]) were also 2 of 6 species (including red fox [*Vulpes vulpes*], gray wolf [*Canis lupus*], stone marten [*Martes foina*], and snow leopard) that were identified genetically from scats collected during the camera surveys (McCarthy 2007) and thus definitively occur in the area but were missed by the camera-traps. Two other species potentially occurring in the study areas but not photographed or identified genetically were Eurasian lynx (*Lynx lynx*) and Eurasian badger (*Meles meles*).

In SaryChat, 10 cameras were set in valley and/or cliff base locations, and 14 were set along ridgelines. In Jangart, only 1 camera pair was set in a valley and/or cliff base location, whereas the other 21 camera pairs were set along ridgelines. Photos of some species were more common in ridge or valley trap sites in both areas (Table 1). In valleys, these included argali, red fox, and brown bear in SaryChat, and hare in Jangart. Along ridges, these included snow leopard, ibex, hare, and marmot in SaryChat, and included wolf, red fox, snow leopard, marten, argali, ibex, and marmot in Jangart. Again, the observed topographical distribution of animals in Jangart may be influenced by the lack of camera placement in valley settings.

Overall, χ^2 tests ($P < .01$) showed that there were relatively more photos of argali, ibex, and marmots obtained in Sarychat but more red foxes, snow leopards, martens, and hares in Jangart. The single photos of a wolf and a brown bear suggest a marginal difference (χ^2, $P = .013$) between study areas (Table 1). Independent estimators of snow leopard, ibex, and argali all indicated that photo rates reflected consistent differences in abundance between areas (Table 2).

Discussion

To date, there has been little effort to validate the protected area system in Kyrgyzstan. In response to a perceived loss of biodiversity, several scientific studies

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TABLE 2 Comparative abundances of large mammals in 2 study areas in the Tien Shan Mountains of Kyrgyzstan. (Data other than photo rates from McCarthy et al 2008).

Species	Method of estimation	Study area	
		SaryChat	Jangart
Snow leopard	Photo rate (number photo events/100 trap-nights)	0.09	0.66
	Scat genetics (minimum number of individuals)	3.00	5.00
Siberian ibex	Photo rate (number of photo events/100 trap-nights)	2.98	2.05
	Visual survey (number individuals/100 km^2)	162.00	13.00
Argali	Photo rate (number of photo events/100 trap-nights)	4.64	0.82
	Visual survey (number of individuals/100 km^2)	282.00	0

have been launched to study the population status of particular species within the country. However, most are focused specifically on the conservation and protection of snow leopards (eg McCarthy et al 2008). Although snow leopards may act as an umbrella species, there is a paucity of research into the distribution of sympatric carnivores, ungulates, and small mammals. Consequently, there is a significant overriding lack of information on the efficacy of Kyrgyz protected areas for a broad range of species. Because of a lack of long-term, detailed research, to date, there is a limited empirical understanding of the performance of various types of reserve, and it has been difficult to definitively identify the factors, or characteristics, that affect the efficacy of protected areas for biodiversity conservation (Gaston et al 2008). Gaston et al (2008) indicate that, not only is more research needed on the performance of different types of successful and unsuccessful protected areas and of the biodiversity features they encompass but that research is specifically necessary to examine the interaction between populations inside and outside of protected areas.

Our data indicated that abundance of argali and ibex were greater in SaryChat, the area where hunting is strictly prohibited, and development of the protected area specifically targeted the conservation of those species. In addition, the wide valleys and abundant grassland are consistent with habitats favored by argali (Namgail 2001), whereas the rugged ridgelines and steep cliffs provided suitable habitat for ibex (Fox et al 1992). Marmots were also photographed more often in the SaryChat, which may reflect a preference for short-grass habitats. However, despite ungulate biomass appearing relatively lower than in SaryChat, and guided hunts are frequently conducted, the numbers of photographs of every other species were higher in Jangart. Red fox, hare, and snow leopard were all photographed more often in Jangart than in SaryChat. In addition, 2 species that were not photographed in SaryChat, wolf and stone marten, were identified in Jangart. The only species to be photographed in the SaryChat and not in the Jangart was a brown bear.

The difference in biodiversity between the strictly protected SaryChat Reserve and the unprotected Janagart hunting preserve may reflect an underlying problem in the reserve system in Kyrgyzstan. Although one might intuitively think that mammalian biodiversity should be higher in the governmentally protected national park, a lack of development and supportive initiatives for local people often led to increased poaching in protected areas. Such was the case in SaryChat when the reserve was initially developed. Koshkarev and Vyrypaev (2000) reported extensive poaching of ungulates and carnivores soon after the area was declared a reserve, and it was thought that villagers and park rangers were responsible for the majority of this activity. The government subsequently replaced nearly the entire park staff, and nongovernmental organization involvement (the Kyrgyz based Community Business Forum [CBF]) was increased to aid in community development. Despite these initiatives, anecdotal evidence suggested that poaching of some carnivore species was continuing in and around the reserve at the time of our study, although poaching of ungulate species seemed to be reduced. This historical and current activity likely plays a significant role in the differences in species composition between the 2 areas. Jangart, although officially unprotected, is much more isolated from local villages than SaryChat, where rangers and their families have settled along the edges of the park. In Jangart, human usage of the area appears limited to hunting parties and occasional border patrols. In addition, the infrequent visitation and short trip duration of hunting parties likely prohibits anything but opportunistic poaching of nontarget animals.

The findings of this study indicate not only the necessity of comprehensive biodiversity monitoring for the successful creation and management of protected

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areas but also highlight the importance of collaboration with local villagers to ensure continuing conservation within the preserves. In the absence of supportive developmental initiatives for the villagers living adjacent to the park, the conservation of biodiversity will continue to be a challenge.

Conclusions

The present data validate the use of camera-trap photos for larger-scale biodiversity assessments. Nine of the 13 terrestrial mammal species thought to possibly occur in the Tien Shan region were photographed during the course of the study. This is a significant proportion of the species present, when considering that all the cameras were set along ridgelines or in other areas in which snow leopards were thought to travel frequently. If cameras had been set in a more generic manner, covering multiple habitats and terrain, then one might expect some or all of the other species to have been captured. In addition, the use of cameras with "covert" flashes may reduce the likelihood of a potential startle response in some carnivore species, again increasing the likelihood of more photos of these species (Gibeau and McTavish 2009). Consideration must be given that there has been no previous documented biodiversity survey in the Tien Shan of Kyrgyzstan. Although the genetic analysis presented in McCarthy et al (2008) was again biased toward the collection of feces thought to be snow leopard, only 2 species were confirmed to be present in the area that had not been captured by the camera-traps, Pallas's cat and the wild pig. We feel that, with continuous camera-trap efforts and a slightly altered methodology, camera-trapping studies previously focused on the flagship species of the region, such as the snow leopard, have the potential to provide important information on the overall biodiversity in the region. In addition, an apparent relationship between the ungulate surveys conducted and the photo rate of ungulates in SaryChat and Jangart, indicate that camera-trap photos may also be used to provide a relative index of abundance for certain species.

In addition to providing a biodiversity assessment for the Tien Shan Mountains, these data also highlight the need to evaluate species richness both inside and outside of current protected areas in Kyrgyzstan to maximize efficient species conservation. Currently, nearly 4% of Kyrgyzstan's area is set aside in 86 protected areas (Ministry of Environmental Protection 1998). However, a large proportion of these areas were designated as protected during the Soviet era, and there has been little monitoring or assessment in the years since the fall of the Soviet Union (Ministry of Environmental Protection 1998). Those protected areas that have been established since the end of the Soviet era were often developed in the absence of sound scientific data on the biodiversity present. Although SaryChat has been declared an official Zapovednik, or strictly protected area, nearby Jangart, which lacked official protection, exhibited a higher level of biodiversity and a higher photo rate for all species, except for the ungulates and marmot. SaryChat appeared to be an effective sanctuary for two of its target species, the ibex and the argali, but another of the target species, the snow leopard, exhibited a higher photo rate in the Jangart (McCarthy 2007; McCarthy et al 2008). Jangart appears to host not only an increased density of snow leopards (McCarthy et al 2008) but also a higher abundance of nearly every other identified species and an increased overall species diversity. Although using large megafauna as umbrella species may be an effective tool in some instances, the present data indicate the necessity of detailed research on a broad range of focal species to allow for more robust identification of critical habitats for multiple species and effective development of protected areas.

Finally, the engagement and support of local people is necessary for the effective functioning of protective areas. Extensive poaching in SaryChat soon after its designation as a national park may have contributed to the lower biodiversity documented there. In recent years, the International Snow Leopard Trust and CBF have worked together to build capacity in several of the villages surrounding the park. Through an innovative program that allows the villagers to create handicrafts for sale on the international market, the 2 organizations are working to provide alternate forms of income for the families, while encouraging a conservation agenda (Mishra et al 2003). The long-term efficacy of this program should be evaluated through continued biodiversity studies within the park and, if proven successful, expanded to other parks in the region.

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