Indian Forester, 141 (10) : 1011-1019, 2015
http://www.indianforester.co.in

ISSN No. 0019-4816 (Print)
ISSN No. 2321-094X (Online)

CULTURAL TRADITION AND WILDLIFE CONSERVATION IN THE HUMAN-DOMINATED LANDSCAPE OF RURAL WESTERN RAJASTHAN, INDIA

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ABSTRACT

An investigation was carried out regarding the role of the Bishnoi people's protection blackbuck antelope for conservation of this threatened species by testing the prediction that villages with Bishnoi have more blackbuck than villages without Bishnoi. There was significantly more blackbuck in villages with Bishnoi despite no significant difference in available habitat or human population between village classes. It was estimated that blackbuck occupied approximately one-third of total habitat and had high overall persistence over a four year period. This study provides evidence that Bishnoi lands can be important for blackbuck conservation and, more broadly, evidence that cultural traditions are important for conservation in human-dominated landscapes.

Key words: Bishnoi community, Blackbuck, Conservation, Human-dominated landscapes, Rajasthan.

Introduction

Human activity has impacted an estimated 70% of non-ice covered land on planet earth (Ellis and Ramankutty, 2008), sparking a debate of whether or not this planet has entered a new geologic epoch called the *Anthropocene* (Zalasiewicz *et al*., 2011). Meanwhile, overall biodiversity has suffered from human activity as humans transform the landscapes, environments, and the climate (Buchart *et al*., 2010). To help mitigate these negative impacts to wildlife, human populations, among a variety of strategies, have established wildlife preserves and protected areas that limit or otherwise prohibit human activity and impacts in certain areas (UNEP, 2014). The success of protected areas in preventing species loss has been considerable, but is sometimes compromised due in large part to complex social-ecological issues that arise from the creation and maintenance of protected lands (Robins *et al.*, 2005). Emerging research suggests that the preservation of wildlife may benefit from an interdisciplinary approach to conservation that accounts for the complexity of social-ecological systems where human/wildlife conflict is increasing (Marvier, 2014).

Historically, populations of ungulate species struggle to persist and coexist with human populations (Brashares *et al*., 2001; Averbeck *et al*., 2009; Estes *et al*., 2012; Sundaresan *et al*., 2012). Unsustainable hunting, habitat fragmentation or destruction, and invasive species propagation are just some of the threats human activity levy against ungulates dating back to the Holocene (Tshar *et al*., 2009; Krausman and Bleich, 2013). It is expected that many ungulate species will continue to struggle to survive in an increasingly human-dominated landscape (Madhusudan and Mishra, 2003; Chhangani, 2004; Karanth *et al*., 2009; Krishna *et al*., 2009; Mallon and Jiang, 2009; Singh *et al*., 2010; Dzialak *et al*., 2011). In India the government took steps to address the specific threat of hunting with the India Wildlife Protection Act, which outlawed hunting of most ungulate species (Indian Wildlife Protection Act, 1972). Despite the 1972 act, subsequent conservation efforts, and the prevalence of various cultural traditions that discourage the killing of animals [e.g. Jainism, Hinduism (Brockmann and Pichler, 2008; Jain, 2011)] many ungulates across India are poached for sport and/or subsistence (Lal, 1991; Fisher, 1997).

In Rajasthan, India's largest and most rural state, the Bishnoi people, a regional cultural group (caste), have practiced a form of ungulate conservation that focuses on the protection of blackbuck antelope (*Antilope cervicapra* [Goyal *et al*., 1988; Fisher, 1997; Brockmann and Pichler, 2008; Jain, 2011]). Since the founding of the Bishnoi culture members of this caste have protected blackbuck antelope populations, deterring would-be poachers through direct confrontation and legal action (Fisher, 1997; Brockmann and Pichler, 2008; Jain, 2011).

Blackbuck population was significantly higher in the areas with Bishnoi as compared to the areas without Bishnoi.

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The Bishnoi are not alone in the practice of protecting wildlife, but they are unique in that they have been specifically protecting this species for more than 500 years (Brockmann and Pichler, 2008; Jain, 2011). Several scholars have reported on the positive association of blackbuck and Bishnoi (Goyal *et al*., 1988; Rahmani and Sankaran, 1991; Islam and Rahmani, 2002; Geholt and Jakher, 2007; Brockmann and Pichler, 2008; Mallon and Jiang, 2009; Kala and Sharma, 2010) but to date there has been little quantitative comparison of blackbuck populations in areas with Bishnoi people versus areas without Bishnoi.

This study sought to answer two primary questions about blackbuck and Bishnoi in a localized rural area of Rajasthan. First, we asked were there significant differences in the presence and numbers of blackbuck between villages with Bishnoi versus villages devoid of Bishnoi. Second, we asked if differences did exist, then were they associated with known landscape characteristics that impact blackbuck (e.g., land area and human population [Karanth *et al*., 2009]). If blackbuck presence were associated with the former question and not the later then we would consider it strong preliminary evidence for a positive association between blackbuck and Bishnoi. More broadly our study serves as a case study to examine the viability of human/wildlife coexistence spaces for conservation in human-dominated landscapes.

Methods

Study area

Our study area included villages within 50 km of Jodhpur, Rajasthan (26°18'N, 73°08'E) bordering the Thar Desert (Fig. 1). The semi-arid landscape is dominated by farmland primarily punctuated with *Prosopis cineraria* (locally known as the Khejeri tree), an arid-lands tree species. Temperatures in our study area can reach highs of 50°C in May and June and lows of ~1°C during January and February. Annual rainfall averages 360 mm with 90% occurring during the monsoon season (July – September). Rajasthan's primary industry is agriculture and most rural populations practice some form of agropastoralism (Fisher, 1997; Tewari and Arya, 2005). Monsoon rains are essential for agricultural crops, drinking water, and livestock. During droughts, which occur relatively frequently, local people face considerable economic and subsistence challenges (Fisher, 1997; Tewari and Arya, 2005).

We conducted fieldwork in 19 villages totaling an area of 321 km^2. Village areas were chosen based on the availability of village surveyors for questionnaires and our own ability to access those same village areas. These conditions were primarily facilitated by a local non-governmental organization (NGO) the School of Desert Sciences (SDS). SDS is a social and ecological development NGO that focuses on improving the lives of rural peoples through a variety of education and research programs. For the past 15 years SDS has conducted various wildlife and socio-economic surveys in the region and are known to most villagers within the study area. This type of relationship was essential to carrying out our study, as we depended on villager observations for part of our data on blackbuck presence. Although selection of villages in this manner was non-random, it was essential because villager familiarity with outside researchers was necessary in order to gain access to survey village lands.

All villages in the study area were organized in the roughly the same way, a centralized housing area with agricultural and community (e.g., fallow/grazing land, water catchment area) lands located on the periphery. Village boundaries are established by land ownership (land owned by members of different villages) or delineated by roads. Each village shared a border with at least one other study village. The caste composition of villages was heterogeneous ranging from two to seventeen distinct castes groups (i.e. Bishnoi, Jain, Rajput, and Megwal caste groups living in one village). The percentage of Bishnoi in eight of the 19 villages also varied, ranging from 13% to 78% (Hall, unpublished data).

Study species

Blackbuck antelope are endemic to the Indian subcontinent. They are most commonly found in open plain or scrubland forest (Isvaran, 2003) and travel in groups of two to as many as several hundred (Mungall, 1978; Ranjitsinh, 1989). Blackbuck are sexually dimorphic; males (35kg) are larger in size than females (25kg) and possess two long spiraling horns (as long as 75cm), and have a distinctive dark brown or black coloration (Fig. 2) for which the species is named (Mungall, 1978; Ranjitsinh, 1989; Isvaran, 2003). Blackbuck populations in suburban settings generally persist on village community land because land used for agriculture has low quality forage and impedes an animal's ability to escape predators (Rahmani and Sankaran, 1991; Fisher, 1997; Geholt and Jakher, 2007).

Village questionnaires

The presence or absence status of blackbuck within our study villages was initially determined in 2007 through village questionnaires. The School of Desert Sciences first conducted the blackbuck questionnaire in which villagers reported whether or not blackbuck had been seen in their village in the last year. SDS repeated

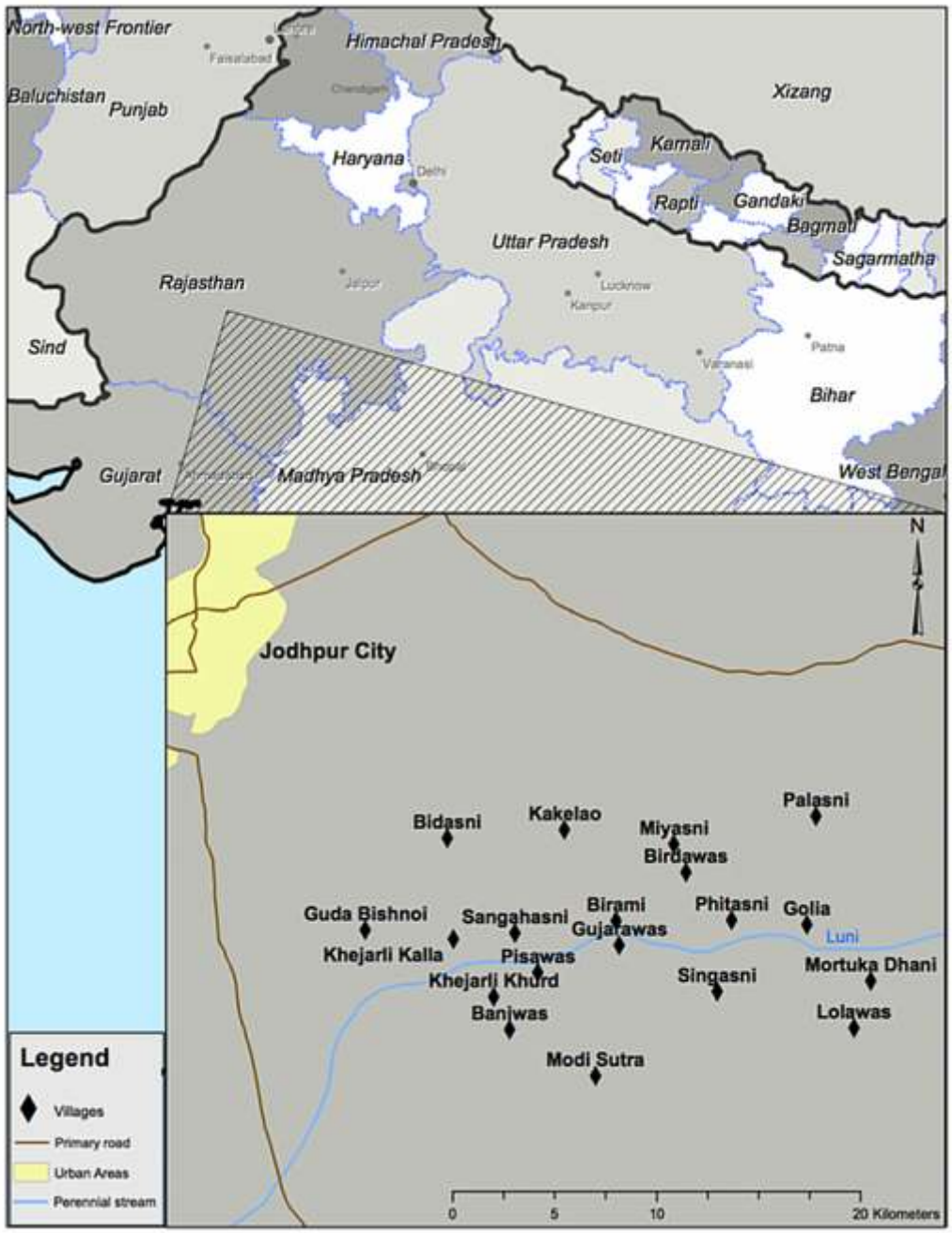

Fig. 1 : Study area including nineteen villages. Jodhpur city located northwest of village area

Fig. 2 : Male blackbuck crossing the road in front of a local woman with her child

this questionnaire in 2009 preceding our first field season in the same year. We recorded blackbuck presence/absence during a separate questionnaire in 2009. Two final questionnaires – one carried out by SDS and the other by the authors – were conducted in 2010 bringing the total to five records of blackbuck presence/absence over three years of questionnaires. The location and land type (agricultural, community, or residential land) of blackbuck locations was also reported during questionnaires. Participants in questionnaires were all male groups of no less than two and no more than twelve individuals. Neither SDS nor the authors

recorded names of villagers that reported blackbuck presence though we can report that the majority of questionnaire participants over the course of our study were the same individuals. Each village typically has specific persons who are most knowledgeable about the fauna of the village. In many cases during the authors' questionnaires these individuals were sought out if not initially present for the start of the interview. Because of this we consider questionnaire data to be the accounts of "local experts" who posses a unique knowledge of the presence/absence status of blackbuck on village lands (Karanth *et al*., 2010).

Village biological surveys

In 2009 we conducted a low intensity survey (a visual survey of each village from a vehicle on roads that bisect village lands) of each village to confirm the presence/absence status of blackbuck.

In 2009 and 2010 we revisited village sites that reported blackbuck presence to count the number of animals present. Due to logistical limitations we were not able to equally census villages in 2009 and thus only report and analyze blackbuck numbers recorded in 2010. In 2010 in each of the villages that reported blackbuck presence we recorded the number of animals present visiting reported sites a total of four times. To maximize detection probability our observations took place between 07:00-09:00 hours and 17:00-19:00 hours (two morning and two evening observations for each village), times when blackbuck are most active and likely to be on or within close proximity of sleeping territory (Mungall, 1978); the later being important because blackbuck are most vulnerable to predation and poachers at dusk and thus are less likely to frequent areas where said risk would be high(Karanth *et al.,* 2010).

Analysis

We compared the total number of blackbuck counted and the average number of blackbuck per village during 2010 biological surveys between village classes (Bishnoi vs. non-Bishnoi) using a Chi square test. Differences in blackbuck populations, if not solely associated with Bishnoi presence, would likely be associated with differences in village characteristics (e.g. more blackbuck in areas with more continuous habitat and less blackbuck in village areas with more livestock and/or human populations [Rahmani and Sankaran, 1991; Geholt and Jakher, 2007; Karanth *et al*., 2009; Karanth *et al*., 2010]). We therefore collected data on four village demographic characteristics– total village area, community land area, total human population, and total livestock population –thought to influence blackbuck populations. We then compared these metrics between village classes using Mann-Whitney U-Test to determine if any blackbuck population differences were associated with influential demographic differences.

To determine the overall presence and persistence of observed blackbuck in our study area we used occupancy modeling (MacKenzie *et al*., 2002) and the combined presence/absence data from questionnaires and biological censuses in 2009 and 2010. The use of occupancy modeling can provide estimations of the presence status of an organism within a geographic area when observers do not always detect organisms that are present (MacKenzie *et al*., 2002). We chose to treat each village as a site due to our ability to collect reliable data on blackbuck presence and to reflect studies and accounts that claim blackbuck congregate in certain villages where they are more likely to be sheltered from poaching (Goyal *et al*., 1988; Rahmani and Sankaran, 1991; Fisher, 1997; Islam and Rahmani, 2002; Brockmann and Pichler, 2008). Ideally we would have used a grid based sampling method (MacKenzie and Royle, 2005; Karanth *et al*., 2009; Zeller *et al*., 2011) to assess blackbuck occupancy. Because this was not feasible given access limitations in certain villages, we addressed the issue of non-random sampling by bootstrapping our data (500 iterations) for 2009 and 2010 and estimated occupancy and detection probabilities to evaluate the bias of our results. To determine the probability of blackbuck disappearing from a given village (either by predation, poaching, death, or movement to another village) we calculated the overall extinction probability of blackbuck within our study area from 2007-2009 and from 2009-2010 where a low overall extinction probability would indicate a relatively stable presence/absence population of blackbuck while a high value would indicate the opposite. We also evaluated the impact of potential differences in detection probability under several model assumptions (Table 1) to determine if over the course of our study blackbuck detection was constant or variable. We used Akaike's Information Criterion (AIC) to determine which model for detection probability was best (Bozdogan, 1987; MacKenzie *et al.,* 2002; MacKenzie *et al.,* 2003; Karanth *et al.,* 2010).

Results

Village questionnaires

Seven out of the nineteen villages in our study area reported the presence of blackbuck. In every case these populations persisted on community land within the village boundary. Half of the villages with Bishnoi had blackbuck (four out of eight) while three out of the eleven villages (27%) without Bishnoi had blackbuck. Status of blackbuck remained constant across all years in every village (i.e. no village reported blackbuck present one

Table 1 : Outline and explanations of occupancy models tested for blackbuck data. Different models were tested to determine the impact of varying assumptions of detection differences between who is collecting blackbuck presence/absence data (the School of Desert Sciences or the authors), the different villages surveyed, the season in which the data was collected, and a constant detection probability across all sites and/or years.

Time Period	Model	Assumption
2009 & 2010	Constant p	Detection probability is constant across sites
	Survey Specific p	Detection probability varies from site to site
	Source Specific p	Different detection probabilities between SDS data and authors' data
2007-2009 & 2009-2010	Constant p	Detection probability is constant across sites
	Seasonal p	Detection probability is different between years across sites
	Source Specific p	Different detection probabilities between SDS data and authors' data
	Individual p	Different detection probability for each site and sampling occasion

year and then reported them absent the next or vice versa). Low intensity surveys in 2009 showed a 100% correspondence with questionnaire data, as we were able to locate blackbuck in every village that reported their presence and failed to locate any blackbuck in villages that reported their absence.

We estimated that blackbuck occupied approximately 37% of community lands in villages from 2007-2010. Blackbuck were estimated to occupy the highest proportion of the study area in 2010 with a generally high likelihood of being detected throughout the study (Table 2). Our bootstrap results yielded occupancy and detection probabilities very similar to our original data, suggesting limited impacts of our non-random approach to sampling villages (Table 2). Extinction probability remained zero across both time periods suggesting that local village populations persisted in specific areas while remaining consistently absent from others (Table 2). A seasonal difference in detection probability between 2009-2010 was the only model effect found to impact survey data (0.771 vs. 1.0 in all other years). Otherwise we found no difference in the detection probability of blackbuck between SDS and the authors' questionnaires and no difference between 2007 and 2009 surveys. Overall blackbuck within our study area remained consistently detectable throughout our study.

Village biological census

We observed three times as many blackbuck in villages with Bishnoi compared to villages without Bishnoi during 2010 (Table 3). This difference was highly significant ($p=2.067^{-15}$) as was the difference in the average number of blackbuck observed per village ($p=0.0003$). We found no statistically significant difference between suspected influential village characteristics to explain blackbuck population differences between village classes [total village area ($p=0.442$), community land area ($p=0.840$), human population ($p=0.657$), livestock population ($p=0.545$)].

Discussion

Blackbuck in Bishnoi areas versus non-Bishnoi areas

We found within the 19 villages in our study that blackbuck populations were significantly higher in areas with Bishnoi versus areas without Bishnoi. Although the association between Bishnoi and blackbuck has been reported. This is the first study that directly compares blackbuck populations in areas with and without Bishnoi.

Blackbuck persisted in every village with the exception of one, Mortuka village. Between village

Table 2 : Occupancy model results for individual year data (A) and for multiple years combined data (B). For both sets of data occupancy estimates (ψ) remain consistent. Detection probability estimates decrease in 2010 due to equal sampling in villages and thus more accurate presence/absence data of blackbuck populations. Bootstrapped data denoted by ($_B$).

Year	Ψ (se)	p (se)
2009	0.3684 (0.1107)	1.0
2009_B	0.3495 (0.1174)	1.0
2010	0.3863 (0.1168)	0.7847 (0.0744)
2010_B	0.3947 (0.1202)	0.9305 (0.0882)

Years	Model	Ψ (se)	p (se)	e (se)
2007-2009	Constant p	0.3684 (0.1107)	1.0	0.0
2009-2010	Seasonal p	0.3684 (0.1107)	$p_{2009} = 1.0$	0.0
			$p_{2010} = 0.7714$ (0.0710)	

Table 3 : A) Blackbuck and Bishnoi status of each village during 2010 biological census. Seven total villages reported having blackbuck. B) Summary statistics of blackbuck census organized by village class. Three-fold difference in total number of blackbuck counted and two fold difference in average number per village and average number per sample between village classes.

Village	Bishnoi present?	Blackbuck present?	Blackbuck counted (2010)	Blackbuck/sample (4 Samples)
Golia	Yes	Yes	10	2.50
Guda-Bishnoi	Yes	Yes	94	24.75
Khejarli Kallan	Yes	Yes	47	11.75
Khejarli Kurd	Yes	Yes	38	9.50
Baniawas	No	Yes	57	14.25
Mortuka	No	Yes	0	0
Phitasani	No	Yes	6	1.50
		Total Blackbuck	Avg/Village (sd)	Avg/Sample (sd)
Villages w/Bishnoi		189	47.25 (34.93)	12.13 (9.29)
Villages w/o Bishnoi		63	21.00 (31.32)	5.25 (7.83)

questionnaires in 2010 and the subsequent biological census (a period of two months) the blackbuck population in Mortuka village disappeared from its reported site. Among the potential reasons for the absence of a blackbuck population from a village – poaching, predation by feral dogs, disease, or moving to another site – we consider the later to be less likely than the former reasons given the stability of reported presence/absence across years and the author's confirmation of said reports in 2009. It should be noted that the Bishnoi people are not present in Mortuka village (Table 3). The absence of blackbuck in Mortuka village during the 2010 biological census likely explains why a seasonal detection probability was the best model for estimating blackbuck detection from 2009 to 2010. We did not ask villagers to count animal signs (tracks and/or pellets) as presence. This is a limitation of our findings, but we think, given the flat, open, and sparsely vegetated landscape combined with repeat surveys of villages that we effectively captured blackbuck presence in our study area.

Possible reasons for differences in observed blackbuck populations

Because blackbuck persisted exclusively on community lands (as reported by villagers in questionnaires), are hunted and otherwise displaced by human populations, and compete for food and water resources with livestock one might suspect that a three fold difference in blackbuck populations would be accompanied by a significant difference in human and/or livestock population and/or village land type demographics. The lack of statistical difference in community land area, total village land area, human population, and/or livestock population suggests the cause of blackbuck population differences is not a function of these village characteristics alone and may be a matter of how potential blackbuck habitat space is utilized and how human populations interact with them. We did not include an analysis of environmental covariates due to the small sample size of villages in our study. Increasing the number of sites would allow for the investigation of environmental covariates that might further explain the trends in occupancy we've observed in this study. Karanth *et al.* (2009 and 2010) explore this question on a national scale, but information on whether or not these trends differ on a finer scale has yet to be investigated.

An important parameter to include in future studies concerning blackbuck occupancy should be availability of water resources, specifically the amount of surface water in village ponds. These data are not reported in government census and not precisely quantified by villagers from year to year, but likely do impact many species of wildlife including blackbuck.

Hunting is still prevalent in our study area (Jain, 2011) (*personal observation*) and would certainly impact the differences in blackbuck numbers we observed. There are many accounts of Bishnoi deterring poachers through direct confrontation and legal action (Jain, 2011). The specific nature of these confrontations (armed vs. unarmed) is not always known, but the outcomes, particularly in the case of Bollywood star Salman Khan's arrest, are often facilitated by the Bishnoi's political and financial status within society (Bishnoi are considered "middle caste" or *other backwards caste* (OBC [Jain, 2011]). During our biological survey in 2009 a Bishnoi man who mistook us for poachers aggressively confronted us (he was unarmed) thinking we were poachers. We were not allowed to continue our work until we explained what we were doing in his village and on his property. Given the Bishnoi's reputation for such actions it is plausible that

such behavior as we witnessed might explain (partially or completely) why blackbuck persist at higher numbers in the Bishnoi areas in our study and why no population of blackbuck disappeared from villages with Bishnoi populations during our study.

Broader Implications

A common response to threats to species persistence in India has been the establishment of protected areas where species are buffered from human contact and land development (Karanth *et al*., 2010). Recent studies have shown however, that this strategy alone may not save species threatened by human activity (Waite *et al*., 2007a; Waite *et al*., 2007b; Robbins *et al*., 2009; Cox and Underwood, 2011; Harich *et al*., 2013). In fact large mammals may be even more susceptible to large scale environmental factors (e.g. climate-induced drought) within protected areas (Waite *et al*., 2007b) and that despite prohibitions on entering and using resources in protected areas people still access them (Robbins *et al.,* 2009). Wildlife reserves present specific challenges in the developing world often do to the social and subsistence challenges they levy against local people that must adjust to a different landscape dynamic (Agrawal and Redford, 2009; Robbins *et al*., 2009). Identifying areas where blackbuck are likely to persist may ultimately be a question of identifying areas where blackbuck can co-exist on land being used by humans rather than identifying areas where humans are absent.

Previous research has shown that culturally informed tolerance combined with effective engagement of local communities can lead to community-based conservation that positively impacts threatened species (Agrawal and Gibson, 1999; Lepp and Holland, 2006; van Eden *et al*., 2006; Sommerville *et al*., 2010; Waylen *et al*., 2010; López-Arévalo *et al*., 2011). The Bishnoi have been practicing a form of community-based conservation that to this day is positively associated with greater abundance of a threatened species. Further engagement with Bishnoi and other communities that actively protect wildlife is needed to help mitigate the threats to ungulate species brought on by human activities, particularly in increasing human-dominated landscapes.

Acknowledgements

This research was supported by the Office of International Affairs and the Department of Evolution, Ecology, and Organismal Biology at the Ohio State University. We are grateful to the School of Desert Sciences in Jodhpur, and the people of Khejarli Kalla village, particularly Raju Singh Chohan and his family for their expertise, enthusiasm, and kindness. We are also grateful to the Katzner lab at West Virginia University for their thoughtful input, particularly Todd Katzner and Adam Duerr. Lastly, we are thankful to Professor Chandrakala Padia, Vice Chancellor of Maharaja Ganga Singh University, Bikaner for promoting collaborative research. This research was conducted in compliance with the Ohio State University's Office of Responsible Research Practices.

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