



Religious tradition of conservation associated with greater abundance of a keystone tree species in rural Western Rajasthan, India



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ABSTRACT

Land-use and land-cover change in the Thar Desert region of Rajasthan threatens the persistence of many ecologically and economically important species. The Bishnoi people of Rajasthan have religiously protected a keystone tree species, *Prosopis cineraria*, locally known as the Khejeri tree, for over five centuries. We conducted the first comparative study that tests the widely held assumption that Bishnoi presence is positively associated with *P. cineraria* abundance in nineteen villages in rural Rajasthan. We also evaluated the influence of land area type, human and livestock population, and income on measured Khejeri tree abundance. Villages with Bishnoi had significantly more *P. cineraria* and had significantly higher incomes than villages without Bishnoi despite no significant differences in land area, human population, or livestock population between village classes. We found no direct associations between Khejeri tree abundance and village demographics suggesting *P. cineraria* abundance is a function of environmental and socio-economic factors. Within this context we discuss the role of Bishnoi protection of Khejeri trees in maintaining important ecosystem functions and supporting human prosperity.

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1. Introduction

The role of local ecological knowledge (LEK) in addressing issues of species conservation is increasingly recognized among conservation scientists and practitioners (Agrawal and Gibson, 1999; Chalmers and Fabricius, 2007; Ford and Martinez, 2000; Steele and Shackleton, 2010). Traditionally human inhabitants of regions of conservation concern have not been included in the planning and decision making process, particularly in the developing world (Steele and Shackleton, 2010; Stevenson, 1996). Studies have shown that inclusion of local people and their knowledge of the environments they inhabit can have measurable benefits to conservation outcomes (Brooks et al., 2006; Bryce et al., 2010). Local populations are often in a favorable position to implement, enforce, and maintain conservation agendas when compared to non-local researchers and/or regional authorities (Ancoren et al., 2007; van Eeden et al., 2006).

The Thar Desert region in India's largest state, Rajasthan, faces considerable environmental challenges brought about by human activity (Francis and Gadgil, 2009; Khan et al., 2004; Niyogi et al.,

2010). Land-use and land-cover change has led to noticeable and significant changes to local ecology and livelihoods (Ram and Chauhan, 2009; Tewari and Arya, 2005). Over the last fifty years efforts to increase agricultural productivity through massive irrigation infrastructure (Maitra, 1987) has begun to change the ecological dynamics of this desert region. While humans stand to benefit economically from these efforts (Government of India, 2010) other species that share the landscape are under increased pressure to adapt (Government of India, 2006; Hall et al., 2012). Moreover, the change brought about by increased irrigation has seen the proliferation of an invasive plant species that threatens to impede the agricultural goals of human populations (Government of India, 2006). At the center of Rajasthan's rural ecology and economy is a tree species that is widely used by human and wildlife species. *Prosopis cineraria*, locally known as the Khejeri tree, supports agricultural productivity through soil retention and nutrient cycling, is an essential source of fuel wood for rural households, provides food to livestock from leaves and fruit of branches lopped off by humans, and provides nesting habitat for a wide variety of bird species including critically endangered vultures (Goyal et al., 1988; Hall et al., 2012; Pasiecznik et al., 2001; Sharma and Dakshini, 1998). Increases in human and livestock populations and the subsequent increased harvesting of Khejeri branches (Government of India, 2006) combined with the proliferation of the aforementioned invasive *Prosopis juliflora* threaten to displace *P.*

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cineraria from its native landscape (Government of India, 2006; Sharma and Dakshini, 1998).

The Bishnoi, a particular caste group that inhabits Northwest India, have been practicing a religion since the late 1400 s that requires they protect and preserve Khejeri trees even at the cost of their lives (Jain, 2011). Khejeri are considered particularly sacred to the Bishnoi ever since the founder of their religion recognized *P. cineraria* as essential to the survival of people in a region plagued by frequent drought and famine (Brockmann and Pichler, 2004; Jain, 2011). Khejeri's ability to thrive in arid regions and support human livelihood is likely why it was singled out by the Bishnoi as important for conservation (Brockmann and Pichler, 2004; Jain, 2011). Since then the Bishnoi have earned a reputation among other castes, local managers, and scientists as effective and important environmental advocates and conservation practitioners (one particularly dramatic example being a protest in 1730 of the cutting of Khejeri ordered by Maharaja Abhay Singh that resulted in the death of 363 Bishnoi that refused to let go of trees as the Maharaja's men cut them down (Brockmann and Pichler, 2004; Jain, 2011)). Despite their reputation and assumed positive influence on the environment no studies have systematically investigated whether or not the Bishnoi have a positive influence on or are positively associated with Khejeri abundance. The fact that the Bishnoi may effectively conserve important species as a matter of cultural practice dovetails with other species conservation efforts and is worth investigating.

Here we report our results from a comparative study that pursued two lines of inquiry related to Bishnoi and Khejeri trees. First, we tested the prediction that Bishnoi presence and Khejeri tree abundance were positively associated in village areas. Second, we determined which village characteristics thought to influence Khejeri tree abundance was associated with our observed abundance figures. The overall goal of this work was to begin to test the veracity of a positive Bishnoi effect on a keystone species and orient any associations within the changing ecological context of the region.

2. Methods

2.1. Study area

Our study area included villages within 50 km of Jodhpur (26°18'N, 73°08'E) bordering the Thar Desert (Fig. 1). The semi-arid landscape is dominated by farmland primarily punctuated with *P. cineraria*. The climate of northwestern India is hot and dry. Temperatures 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 crops, drinking water, and feeding livestock and therefore local people face considerable economic and subsistence challenges during drought (Fisher, 1997; Tewari and Arya, 2005).

Fieldwork was conducted in 19 villages covering approximately 312 km² that were chosen based on logistical feasibility and preexisting research infrastructure 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 fifteen 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 travel to and across village lands would not have been

permitted without some type of pre-existing relationship with researchers.

All villages in the study area were organized in the roughly the same way, with a centralized housing area and 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 nineteen villages also varied, ranging from 13% to 78% (Hall, unpublished data).

2.2. Study species

P. cineraria, locally known as the Khejeri tree, occurs in north-west India and across the Thar Desert region (Pasicznik et al., 2001; Sharma et al., 2010). Khejeri trees have thin leaves, thorny branches, and yellow flowers. They are well adapted to arid environments and thrive on cultivated land (Pasicznik et al., 2001). Trees in the study area were as tall as 10 m, but the majority were less than 7 m and had very similar girth. Khejeri trees are central to the ecology and economy of rural Rajasthan (Fisher, 1997; Pasicznik et al., 2001). Human populations use Khejeri for fuel wood, building material, fencing, and fodder for livestock. Several studies have shown that Khejeri also support agriculture through soil retention and nutrient cycling (Sharma and Dakshini, 1998; Yadav et al., 2008). Wildlife species also use Khejeri trees for shelter, nesting habitat, and a source of food (Chhangani, 2005; Goyal et al., 1988). In our study area, Khejeri trees grew almost exclusively on village farmland presumably because of the known agricultural benefits they provide.

2.3. Khejeri tree transects

We sampled Khejeri trees on farmlands within a 1 km radius (covering a maximum of 3.14 km²) of the reported village center in each of the nineteen villages in our study area. Each transect began 500 m from the village center (mostly housing areas devoid of any trees) in each cardinal and sub cardinal direction. We counted all Khejeri trees within 10 m of the 500 m transect line. Numbers of other tree species on farmland in both Bishnoi and non-Bishnoi areas were too scarce to analyze in a meaningful way and thus we did not record their numbers. Because the proportion of farmland within 1 km of village centers varied between villages the total number of transects run in each village varied from five to eight. Five transects was the minimum number we were able to run in each village due to logistical constraints. As such we account for the difference in total transects per village in our analysis.

2.4. Village demographic data

We collected village demographic data from four sources; the 2001 Rajasthan census (Sharma, 2011), district officials (called *patwaris*) who keep written demographic information of villages, demographic data collected by the School of Desert Sciences during their various projects in 2007, and semi-structured interviews (Bernard, 2001) we conducted for this study. Each interview consisted of a group of 3–18 adult male (18 years or older) residents who voluntarily gathered to be interviewed (cultural constraints limited the participation of women). Interviews lasted from half an hour to one and a half hours. Collecting information from multiple sources allowed us to verify reported information for the demographic characteristics we were interested in. We chose to focus

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