

# Assessing the Potential for Reintroducing the Cheetah in India



भारतीय वन्यजीव संस्थान  
Wildlife Institute of India



## **Assessing the Potential for Reintroducing the Cheetah in India**

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## Executive Summary

- 1) Reintroductions of large carnivores have increasingly been recognised as a strategy to conserve threatened species and restore ecosystem functions. The cheetah is the only large carnivore that has been extirpated, mainly by over-hunting in India in historical times. India now has the economic ability to consider restoring its lost natural heritage for ethical as well as ecological reasons. With this context, a consultative meeting of global experts was held at Gajner in September, 2009. A consensus was reached at this meeting for conducting a detailed survey in selected sites to explore the potential of reintroducing the cheetah in India. The Honourable Minister of Environment and Forests, Shri Jairam Ramesh, mandated the Wildlife Institute of India and the Wildlife Trust of India with this task.
- 2) In this report we assess 10 sites from seven landscapes located in the states of Rajasthan, Gujarat, Madhya Pradesh, Uttar Pradesh and Chhattisgarh, for their potential to harbour viable reintroduced cheetah populations. We conduct field surveys to collect data on prey abundances, local community dependencies on forest resources and their attitudes towards wildlife, and use remotely sensed data to assess habitat size. We compute current and potential carrying capacity of the sites to support cheetah as well as assess the long-term viability of the introduced population, using Population Habitat Viability Analysis.
- 3) Amongst the seven surveyed landscapes, the landscape that contained Sanjay National Park, Dubri Wildlife Sanctuary and Guru Ghasidas National Park was the largest, covering over 12,500 km<sup>2</sup>. It is in this landscape that the cheetah continued to survive till after India's Independence. However, today this landscape is characterised by low prey densities, probably due to poaching by tribal communities that reside within the protected areas. The three protected areas were currently estimated to have the capacity to support about 14 cheetah. With restorative and managerial inputs under the Project Tiger scheme available for Sanjay National Park and Dubri Wildlife Sanctuary, these protected areas are likely to improve and could potentially support over 30 cheetah, while the landscape could hold upto 60 individuals We recommend that Guru Ghasidas National Park in Chhattisgarh also be considered under the Project Tiger scheme as it is well connected with Sanjay National Park and Dubri Wildlife



Sanctuary. We recommend that this landscape be restored and re-evaluated before considering cheetah reintroduction here in the future.

- 4) Kuno Palpur Wildlife Sanctuary is a part of the Sheopur-Shivpuri forested landscape, which had the second largest area (6,800 km<sup>2</sup>) amongst the surveyed sites. This site was rated high on the priority list for considering the reintroduction of the cheetah, because a lot of restorative investment has already been made here for introducing the Asiatic lions. The Protected Area was estimated to have a current capacity to sustain 27 cheetah, which could be enhanced to over 32 individuals by addition of some more forested areas (120 km<sup>2</sup>) to the Kuno Sanctuary and managing the surrounding 3,000 km<sup>2</sup> forested habitat as a buffer to the Kuno Sanctuary. Once a cheetah population establishes itself within the Sanctuary, dispersers would colonize the landscape and potentially hold over 70 individuals. This would not preclude the reintroduction of the lion once the cheetah population is established and the two introductions would complement each other. Indeed, Kuno offers the prospect of all the four large forest felids of India to coexist as they did in the past.
  
- 5) The Nauradehi Wildlife Sanctuary (1197 km<sup>2</sup>) in Madhya Pradesh is part of a forested landscape of 5,500 km<sup>2</sup>. Cheetah prey densities were reasonable in this area and the site was considered favourable to be considered for a reintroduction. Based on current prey densities the area could support 25 cheetah. We recommend the designation of 750 km<sup>2</sup> as a core area of the sanctuary and relocate about 23 human settlements from the core with generous and adequate compensation. Our assessment indicates that the local communities would prefer to relocate for better livelihood and modern facilities. The site could then support over 50 cheetah as a source population, while the Nauradehi landscape could harbour over 70 individuals.
  
- 6) Kaimur Wildlife Sanctuary, Uttar Pradesh and Bagdara Wildlife Sanctuary, Madhya Pradesh formed a continuous habitat. However, potential cheetah habitat in this area was small (less than 500 km<sup>2</sup>), as much of the land is under agriculture. Though the prey densities were reasonably high due to good management and law enforcement, the site was not considered further due to its small size and it was likely to have a high level of conflict with an introduced cheetah population.

- 7) The Shahgarh landscape on the international border in Jaisalmer district of Rajasthan was found to be suitable for introducing cheetah. As the area is fenced along the international border, we propose to additionally fence off the bulge area by constructing another 140 km long chain-link fence, so as to encompass about 4000 km<sup>2</sup> of xerophytic habitat. Within this area about 80 seasonally used human settlements, each having 5-10 households, would need to be relocated with adequate and generous compensation and alternate arrangements provided. Though the prey species diversity was less (primarily chinkara) in Shahgarh, the area could currently support about 15 cheetah and had the potential to sustain 40 cheetah with habitat management within the large fenced ecosystem.
- 8) Desert National Park in Jaisalmer, Rajasthan, was reasonably large (3162 km<sup>2</sup>) with a fairly good prey availability. However, the area is heavily grazed by livestock and is the last stronghold for the great Indian bustard. The introduced cheetah are likely to come into severe conflict with local communities and may be a potential threat to the endangered great Indian bustard. For this reason the Desert National Park was not considered ideal for cheetah reintroduction.
- 9) Banni grasslands and Kachchh Wildlife Sanctuary in Gujarat cover a vast arid landscape of which over 5800 km<sup>2</sup> could be considered as potential cheetah habitat. The wild prey abundance was extremely low with no current potential for considering introduction of a large carnivore. However, the area has potential and with restoration, livestock grazing management and law enforcement the area could bounce back and could potentially support over 50 cheetah. If the Gujarat Government takes serious steps to restore this landscape, then the site could be re-evaluated at a later date.
- 10) Based on the above assessment, we recommend that cheetah could potentially be reintroduced at 1) Kuno-Palpur Wildlife Sanctuary, Madhya Pradesh 2) Shahgarh Landscape in Jaisalmer, and 3) Nauradehi Wildlife Sanctuary, Madhya Pradesh. All the three sites require preparation and resource investments to commence an introduction program. Long-term commitment of political will, resources and personnel is required from the Central and State Governments to implement this project successfully.

- 11) Depending on the availability of suitable animals and a continued supply, we propose to source cheetah from sites in Africa. We also propose collaboration with the Government of Iran and the world conservation community in assisting with the conservation of the Iranian cheetah, so as to reduce its risk of extinction and to re-establish viable wild populations.
- 12) Cheetah reintroduction would greatly enhance tourism prospects, especially at the sites, the cascading effects of which would benefit the local communities. Cheetah as a flagship would evoke a greater focus on the predicament of the much abused dry-land ecosystems and the need to manage them, which would benefit pastoralism in India where the largest livestock population in the world resides, the large majority of it being free-ranging.
- 13) As a way ahead, we propose that the Government of India and the concerned State Governments approve of the sites recommended in this report and commence allocation of resources, personnel and restorative actions for a reintroduction program. Once approved, a more detailed study of the selected sites and of the costing of the project would have to be undertaken and project implementation could there after commence.
- 14) The venture must be viewed not simply as an introduction of a species, however charismatic it may be, but as an endeavour to better manage and restore some of our most valuable yet most neglected ecosystems and the species dependent upon them.

# 1

## Introduction

The world today is witnessing the highest concern society has ever shown towards conservation of large carnivores and their ecosystems (Mech 1996; Schaller 1996; Weber & Rabinowitz 1996). Yet, the numbers and range of most large carnivores continue to decline (Dinerstein *et al.* 2007; Karanth & Chellam 2009). A major effort to stall and indeed try to reverse this declining trend has been through reintroduction efforts across the range of extirpated large carnivores (Breitenmoser *et al.* 2001). Successful reintroductions as well as failures have marked such reintroduction efforts (Smith & Bangs 2009; Johnsingh & Madusudan 2009). The successful recovery of the wolf in Greater Yellowstone Ecosystem, Idaho, and Banff National Park are perhaps the best examples of human induced re-establishment of the functional role of a large carnivore in an ecosystem (Bangs *et al.* 2001; Hebblewhite & Smith 2010). However, increasingly, such vast areas are no longer available for carnivore reintroductions across the globe and establishment of carnivore populations on fenced-off game reserves and private ranches is becoming an important component for the survival of several species in many landscapes (Smith 2006). Scientific planning and management using the established principles of conservation biology is the key to enhancing the value of these small populations in conserving the species (Hayward & Somers 2009).

## ***Why the cheetah?***

Despite the immense and ever mounting demographic pressure, India has lost only one large wild mammalian species since the country's independence in 1947. And if the Javan (*Rhinoceros sondaicus inermis*) and the Sumatran (*Dicerorhinus sumatrensis lasiotis*) rhinoceroses, which in any case had peripheral existence in the eastern extremity of the country, be excluded, India has not lost a large mammalian species in historical times, barring one – the cheetah (*Acinonyx jubatus venaticus*). The animal, charismatic in its own right, therefore, also has a very special significance for the national conservation ethic and ethos.

The reintroduction of cheetah, important in itself, would have equally important conservation ramifications. In saving it one would have to save not only its prey-base comprising certain threatened species, but also other endangered species of the grasslands, some of which are on the brink of extinction. Amongst these are the caracal (*Caracal caracal*), the Indian wolf (*Canis lupus pallipes*) and three endangered species of the bustard family- the Houbara (*Chlamydotis undulata macqueenii*), the lesser florican (*Sypheotides indica*) and the most endangered of all, the great Indian bustard (GIB) (*Ardeotis nigriceps*). The grassland-dependent species, both avifaunal and faunal, have suffered a more drastic decline than any other species adapted to other biomes, simply because the grasslands have undergone the most qualitative and quantitative decimation of all ecotypes in the sub continent.

Cheetah restoration will be part of a prototype or model for restoration of original cheetah habitats and their biodiversity, helping to stem the degradation and rapid loss of biodiversity now underway. Lessons learnt from this process will benefit the management of these eco-types, the most overused, least managed and yet the most productive biomes in the country.

Dry grasslands and open forests are under-represented in the national network of protected areas. The national Wildlife Action Plan calls for appropriate bio-diversity representation in the Protected Area Network. The National Forest Commission of Government of India also strongly recommends further protection of grasslands and associated flagship species. This is particularly

relevant to India, which has the largest livestock population in the world, almost all of which is free-ranging.

Among large carnivores, cheetah are likely to present the lowest level of conflict with human interests, as they are not a threat to human life and are most unlikely to predate large livestock. Bringing back a top predator restores historic evolutionary balance, which leads to:

- a) Better management and restoration of cheetah habitat (grasslands, scrublands and open forest ecosystems),
- b) Conservation of cheetah's prey and sympatric endangered species
- c) A top-down effect of a large predator that enhances and maintains the diversity in lower trophic levels of the ecosystems.

In our effort to reintroduce the cheetah in India we aim to achieve both the biological objectives i.e. a) re-establish the ecosystem function role of the cheetah in representative areas of its former range and b) contribute to the global effort towards the conservation of the endangered cheetah as a species as well as preserve its genetic diversity. Simultaneously, we are hopeful that the project will boost and enhance the livelihood options and living conditions of the local communities in and around the landscapes where the cheetah is likely to be introduced.

A two day workshop was held at Gajner, Rajasthan, India, on September 9th and 10th to deliberate the possible re-introduction of cheetah into India. This meeting was attended by experts from across the world and officials of the Government of India from the Ministry of Environment and Forests and representatives of the state governments of the range states, being Chief Wildlife Wardens of Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh.

The experts were of a considered opinion that re-introduction of the cheetah into India was feasible, taking into account the presentation made by the Wildlife Institute of India and others. It was opined that further detailed surveys and analyses be carried out in the areas short listed to confirm this and, to determine the modalities and the inter-se priority of possible release sites.

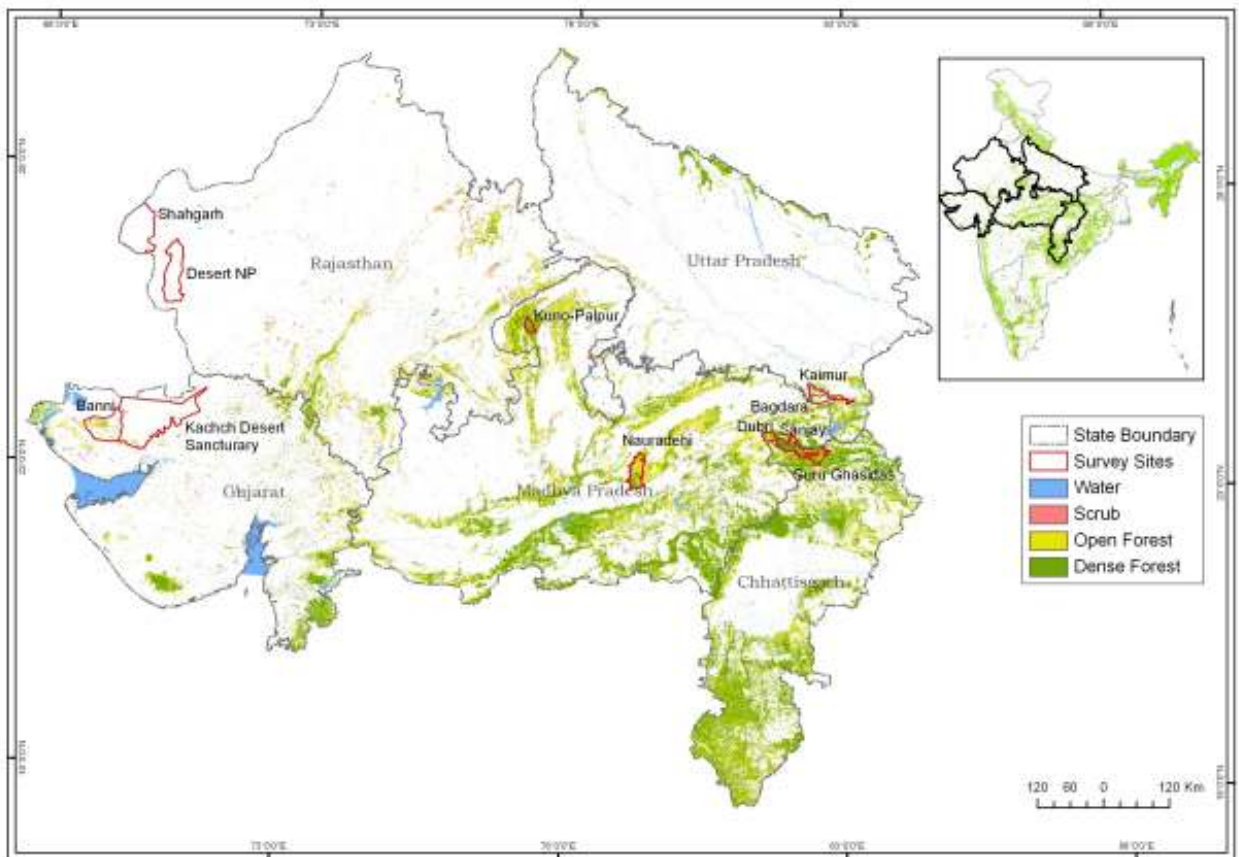
Keeping in view the genetic similarity between the Iranian and the African cheetah, the assembly was of the opinion that the African cheetah would be genetically suitable for re-introduction into India. It was also opined that there should be collaboration and synergy between India and Iran in the conservation of the cheetah in Asia and India should learn from the experience of Iran.

The assembly also gave, inter-alia, valuable recommendations with regard to sourcing and translocation, for the pre-release, release and post-release considerations and for health screening and quarantine, which will all be taken into account at the appropriate time.

Participating experts and organizations involved with cheetah reintroduction pledged support in sourcing, translocation, rehabilitation and monitoring, including training of their Indian counterparts.

On receipt of the report of the consultative meeting at Gajner, Shri. Jairam Ramesh, Honourable Minister of State, Ministry of Environment and Forests, Government of India gave directions to Dr. M. K. Ranjitsinh to prepare a detailed road map for the reintroduction of the cheetah, which should include a detailed analysis of different potential sites, to be carried out by the Wildlife Institute of India in collaboration with Wildlife Trust of India, the state forest departments concerned and others. In pursuance of the decisions taken at Gajner and the directions of MoEF we surveyed ten sites within seven landscapes situated in Chhattisgarh, Gujarat, Madhya Pradesh, Rajasthan and Uttar Pradesh (Plate 1).

1. Chhattisgarh: Guru Ghasidas National Park
2. Gujarat: Banni Grasslands
3. Madhya Pradesh: Dubri Wildlife Sanctuary, Sanjay National Park, Bagdara Wildlife Sanctuary, Nauradehi Wildlife Sanctuary and Kuno-Palpur Wildlife Sanctuary
4. Rajasthan: Desert National Park and Shahgarh Grasslands
5. Uttar Pradesh: Kaimur Wildlife Sanctuary



**Plate 1:** The location of potential cheetah re-introduction sites surveyed in the states of Rajasthan, Gujarat, Madhya Pradesh, Uttar Pradesh and Chattisgarh



The important factors that govern the occupancy and abundance of large carnivores are a) availability of habitat, b) availability of prey and c) attitudes of local communities towards conservation and their livelihood dependencies on natural resources (Sanderson *et al.* 2006, Hayward *et al.* 2007). In our feasibility assessment we address each of these factors by collecting field data (between March to May 2010) at all ten potential sites within the seven landscapes, analysing the information and making site specific recommendations in terms of the potential of the site for reintroducing the cheetah, the long-term strategy, commitment and likely costs involved in attempting a successful establishment of a viable cheetah population.

Criteria of long-term success for the conservation of a species has often been the establishment of a “minimum viable population” which is extremely stringent, especially in the case of a newly introduced endangered carnivore, as it translates to numbers in excess of 500 (Gilpin & Soule 1986, Shaffer 1981). A more pragmatic approach to assess success of reintroductions is proposed by Hayward *et al.* (2007a, b) and Gusset (2009) wherein three objectives need to be met: a) survival of the released generation, b) breeding by the released generation and their offspring and c) persistence of the re-established population which could be assessed by population viability models. We conducted traditional Population Viability Analysis (PVA) (Lacy 2005) to determine population sizes that need to be achieved for long-term persistence of introduced cheetah in a landscape. The PVA analysis also explores alternative management strategies of managing geographically isolated populations as “artificial meta-populations” (Gusset 2009).

## 2

# Methods

### Field survey design

Field sampling was conducted across all sites from March to May 2010. Sampling protocols designed to assess tigers, co-predators, prey and habitats across tiger landscapes in India (Jhala *et al.* 2009) were followed in this study.

**2.1 Estimation of prey densities:** Line transect method was used to estimate population density of prey (Buckland *et al.* 2001). The methodology varied between forested ( $n=6$ ) and arid ( $n=4$ ) study sites. Within forested areas a beat was considered as the sampling unit and a fixed transect with length varying from 2 to 4 kilometers was walked. Since beats are spread out across the entire protected area, this transect layout design allows for sampling across all habitat types within the Protected Area (Jhala *et al.* 2009).

Most semi-arid and arid sites covered large areas often outside the existing protected area network. Thus, in order to adequately sample these areas, vehicle transects were used. Each transect varied in length from 4 to 10 kilometers and measures were taken to ensure that transects were randomly distributed over the entire area, encompassing differing vegetation and terrain types for the study site.

Starting and end locations of each transect were recorded using an e-Trex GARMIN<sup>®</sup> GPS unit. In case of vehicle transects perpendicular distance to sighted prey was recorded with the aid of a laser range finder (Bushnell 800 pro). All ungulates and potential cheetah prey detected along with their group sizes were recorded.

**2.2 Density estimation of ungulate pellets:** Ungulate pellets and livestock dung can be used as indicators of herbivore abundance (Acevedo *et al.* 2010; Campbell *et al.* 2004), particularly in areas where ungulates are shy of humans due to high levels of anthropogenic disturbances.

After a line transect was completed, the observers sampled the same line, stopping at intervals of 400 m. At each such location, observations were recorded of vegetation type, human-disturbance covariates and presence of pellet groups or dung. Pellet plots were taken alternatively on left and right side of a transect perpendicular to it at each 400 m interval. In each case a strip transect of 20 m length and 1m width on either side was thoroughly searched for presence of pellets or dung. All pellet groups and dung encountered were identified to species level and their numbers recorded. Pellets <50 were recorded as actual counts while >50 were categorised as A: 50-100, B: 100-200 and C: >200 (Jhala *et al.* 2009). Pellet counts were conducted at all sites other than Kuno-Palpur Wildlife Sanctuary.

**2.3 Socio-economic survey to assess attitudes of people towards wildlife and calculate poverty index:** A questionnaire based survey was employed at each study site to obtain data about attitudes and perceptions of people towards wildlife, socio-economic conditions of people and occupational patterns in the area.

The study aimed to cover a minimum of 4% households in each village of the protected area. However this was not possible at all sites due to time and logistic constraints. Table.1 contains a list of total households interviewed. Since all villages from within Kuno-Palpur Wildlife Sanctuary have been relocated outside the park, interviews were conducted in villages within 5 km of the park boundary.

The structured questionnaire used was divided into 5 different sections. The first section required a visual assessment of the interviewee. The following three sections dealt with socio-economic questions pertaining household characteristics, livestock owned and occupation. The last section comprised of questions pertaining attitudes and perceptions of the respondents towards wildlife found in the area. A copy of the questionnaire is provided in Appendix 5.

Households sampled were chosen randomly with an aim of interviewing an equal number of people from both sexes. All respondents were over the age of 18 years and were questioned only if they agreed to answer the questions and participate in the survey. Interviews were conducted in the manner of a conversation by memorizing the questions and leading the discussion to acquire the desired information. In some politically sensitive sites with Naxal presence like Guru Ghasidas National Park and Kaimur Wildlife Sanctuary, questions pertaining ownership of weapons were not asked.

**Table 1.** No. of persons interviewed at each site

<b>Site</b>	<b>No. of interviews</b>
Kuno- Palpur WLS	98
Bagdara WLS	223
Kaimur WLS	202
Sanjay NP	64
Dubri WLS	121
Guru Ghasidas NP	77
Shahgarh	20
Nauradehi WLS	181
Desert NP	67
Banni	42

## 3

### Analytical methods

**3.1 Estimation of prey densities:** Animal sightings from the line transect data were analysed using DISTANCE 6.0 software (Thomas *et al.* 2009). Distance enables the computation of detection probability for the sightings obtained during transects (Buckland 1985; Buckland *et al.* 1993; Karanth & Nichols 2002). This detection probability enables estimation of animal abundances without the influence of biases in detection of animals that may arise due to varying habitat types, animal sizes or group sizes.

**Categories for prey estimation:** Since the number of sightings for each species of ungulates was relatively low, potential cheetah prey data was combined and three distinct categories were formed:

- (i) All potential prey species: all ungulate species, peafowl, hare and langur
- (ii) Potential prey species: all ungulate species, peafowl and hare
- (iii) Ungulate prey: all wild ungulates

**Model selection:** For DISTANCE analysis several models were used with varying group intervals and truncations to select a model that best fit the data. Detection function was usually fitted using half normal, hazard rate or uniform models as key functions with cosine series expansion. Outliers from the data were truncated. AIC values, goodness of fit tests, visual inspection of the detection function and variances associated with the estimates obtained were used to select the most appropriate model for each prey category (Buckland *et al.* 2001).

Small number of prey sightings at Guru Ghasidas, Sanjay and Dubri made it necessary to combine data for the entire region to obtain a common detection probability, which in turn was used to separately calculate abundances for each site. This was considered acceptable since the three protected areas are contiguous with each other and share the same bio-geographic zone and habitat types.

In case of Banni grasslands, total number of animals encountered was too few to enable DISTANCE analysis. Thus an encounter rate was generated for sightings/ km and ungulates/ km.

**3.2 Estimating densities of small-stock and large stock:** Cheetah-human conflict in most parts of the existing cheetah range is usually a consequence of livestock depredation (Marker *et al.* 2003). Thus, it was important to assess the potential for such conflict in the proposed reintroduction sites. In order to obtain information on livestock structure and composition for all study sites, we used an index of livestock density generated from responses to the questionnaire survey.

Responses from the structured questionnaire pertaining number of livestock owned per respondent were extrapolated to obtain approximate livestock densities for an entire study site. This included small stock (sheep and goat) and large stock (cattle and buffalo). While we did get density indices for other livestock (camel and donkey) from our data, this was not considered for further analysis since the latter two species were unlikely to be predated upon by cheetah.

**3.3 Estimating cost of relocating people:** The number of households in each site was determined using census data (2001). Each household was considered a single family unit and the minimum cost of relocation was determined by allocating a relocation cost of rupees ten lac per household as per the norms for core areas of Tiger Reserves (Gopal *et al.* 2009).

**3.4 Estimation of pellet/dung densities:** Pellet densities were calculated based on number of pellets and livestock dung encountered for each species of herbivore in the strip plots sampled. In case direct count data was not available, mid-point value for each category was used for density calculations. Thus densities of herbivore pellets per hectare were calculated. These were used as indices of ungulate abundance across study sites.

**3.5 Assessing economic socio-economic status of people and attitudes towards wildlife:** Responses from the questionnaire survey were used to analyse the economic well being index,

primary source of livelihood in an area and the attitudes and perceptions of people towards wildlife at the site.

***Economic well-being index:*** To make it possible to compare data across sites, it was important to get all the answer categories into a uniform system. Therefore, the responses were at first put into categories. Each question was then assigned a weight and the categories multiplied by the assigned weight to get a reliable index, which could be used to compare people's lifestyles across all sites. Questions like the land holding and the type of house ('*kuccha*' or '*pucca*') were given maximum weightage, while lower weightage was given to questions like the interviewee's appearance i.e., clothes, footwear and ornaments. The total score (after adding the weightage), for all the questions was calculated and then an average score for each site was calculated to indicate the economic well-being of people in the particular area. The combined weighted score for all sites was then represented in a graph for better visual comparison across all sites. The statistical comparisons were limited to a simple 95% confidence interval bands.

***Source of livelihood:*** The livelihood sources of people were categorized into 5 major groups- Agriculture, Daily wages, Livestock farming, Service (Government/private) and 'Others'. In almost all the places, people were dependent on more than one source of livelihood, especially in belts where agriculture is practiced, since there is a great dependency on availability of water for irrigation. Category 'Others' included professions like potter, shop-keeping, blacksmith, etc.

***Attitudes and perceptions of people towards wildlife in the area:*** Attitudes of people were taken into consideration by studying both- effect of wildlife on people's lives and the effect of people's lifestyles on the wildlife in the area. The impact of wildlife on human life was assessed by getting responses for two traits that have a direct impact on human life: crop raiding and livestock depredation. On the other hand, the impact of human presence in wildlife areas was assessed by assessing responses for indicators like - whether or not people eat meat and how often do they eat meat, can people trap or snare and do people own weapons. It was not possible to ask all of the above questions to all respondents at sites like Guru Ghasidas, owing to the

presence of 'Naxals' in the area and people's reluctance to answer such questions. Bar chart of each parameter was made, showing the standard deviation, for better comparison across the sites.

**3.6 Carrying capacity:** Once ample habitat is available, it is the appropriate prey density that determines large carnivore abundances (Carbone *et al.* 2001; Karanth *et al.* 2004; Hayward *et al.* 2007, 2009). In our computation of carrying capacity for cheetah at different potential reintroduction sites we follow the following approach:

(i) Determine current field densities of potential cheetah prey using distance sampling (Buckland *et al.* 2001). All categories of prey species that were below modal weight of 60 kg class were considered potential cheetah prey (Hayward *et al.* 2007; Lurenson *et al.* 1995). Amongst primates we consider only 10% of langurs as potentially available and amongst large ungulates like nilgai and sambar we consider only their young (weight class below 80 kg) as potential cheetah prey.

(ii) Considering the average prey weight at each of the potential reintroduction sites, we convert the available prey biomass to chinkara units (taken as 20 kg). We assume an intrinsic rate of increase ( $\lambda$ ) for prey to range between 1.25 and 1.18 (Jhala 1993; Owen Smith *et al.* 2005).

(iii) We use consumption rates and kill rates of cheetah as reported by Eaton (1974) and Caro (1994), which translate to 5-6.5 kg per cheetah per day or a chinkara unit killed and consumed at (80% utilization rate) per 3-4 days (Jethva & Jhala 2003).

(iv) We use Keith's model ( $k/(\lambda-1)$ ) (Fuller 1989) to estimate the number of chinkara units required to sustain a cheetah population of certain size (K) without causing declining trends in the prey population.

$N = k/(\lambda-1)$ ; where

$N$  = number of ungulates needed per cheetah to maintain stable ungulate population,  $k$  = number of ungulates killed/cheetah/year and  $\lambda$  = intrinsic growth rate of the prey.



(v) We evaluate the carrying capacity of 1) current situation based on available prey densities within the proposed site, 2) potential carrying capacity of the proposed site when offered appropriate protection, restoration inputs in the form of reduction of anthropogenic pressures, and habitat management and 3) landscape level carrying capacity wherein we consider that cheetah would disperse from the introduced site into potential habitat available within the landscape. For this last computation, we use realistic prey densities that are 60% of the current densities observed at Nauradehi, Sanjay-Dubri-Guru Ghasidas Protected Areas and for Kaimur-Bagdara Protected areas, while for the Kuno-Sheopur-Shivpuri landscape we use 30% of the current prey density observed in Kuno Wildlife Sanctuary, for the extrapolation to the larger landscape. This was because Kuno Wildlife Sanctuary has had a chance to recover from anthropogenic pressures and the observed prey densities are likely to be substantially higher than those achieved in the larger landscape, even with management inputs.

We believe that our computations for the carrying capacity are conservative, as we use kill and consumption rates from Africa where cheetah are forced to kill more often due to kleptoparasitism by other large predators (Hayward *et al.* 2006). At the potential reintroduction sites there would be less competition to cheetah during feeding in comparison to Africa. Since potentially competing carnivore densities (e.g. wolves (*Canis lupus*) and wild dogs (*Cuon alpinus*)) are low (Jhala *et al.* 2008), while there would be little temporal overlap between the leopard (*Panthera pardus*) and striped hyena (*Hyaena hyaena*). Besides, we vary the intrinsic growth rate of prey within a naturally observed range and kill rates of cheetah. This provides us with a best and worst case scenarios that are likely to be observed at the potential reintroduction sites (IUCN 1998). Besides, the carrying capacity computations are based solely on wild prey densities. Cheetah will undoubtedly also predate on livestock at most sites, and this additional food resource would further enhance the carrying capacity.

**3.7 Population Viability Analysis:** We used estimates of demographic parameters of cheetah obtained from literature (Caro 1994; Eaton 1974; Laurenson 1995) for a population viability analysis in VORTEX 9.93 (Lacy *et al.* 2005). All scenarios were run with the default inbreeding depression and density dependence option provided in VORTEX 9.93. We evaluated population

persistence (probability of extinction), stochastic rate of increase ( $r$ ), and population size for a period of 100 years. We ran 1000 simulations for each of the following scenarios:

(i) We modeled scenarios by varying the carrying capacity between 15 to 100 cheetahs. Carrying capacities were also modeled with an increasing trend to model the effect of reduction of human/livestock pressures in case the prescribed recommendations of the report are implemented.

(ii) We modeled a mild catastrophe frequency of one in 10 years, wherein reproduction was depressed by 40% and survival by 30%. This catastrophe could depict scenarios wherein severe drought that occurs often in Rajasthan, Kuno and Kachchh regions and possibility of occasional disease outbreaks in other areas.

(iii) We model artificial “meta-population” wherein two or possibly three populations are established in India and managed as metapopulations (e.g. Shahgarh-Kuno-Nauradehi and Kuno-Nauradehi) with conditions set as above. We modeled that 1-2 cheetah are exchanged between these populations per year to simulate a meta-population structure (model inputs and results are appended in Appendix 2).

## 4

### Site Evaluations

#### 4.1 Shahgarh Landscape

The southern Shahgarh Grasslands (27° 18' to 26° 47' N and 69° 37' to 69° 29' E) cover an area of over 4000 sq. km in Jaisalmer district of western Rajasthan. These grasslands lie in the Desert-Thar (zone 3A) bio-geographic zone of India (Rodgers *et al.* 2002) and form the eastern limit of the great desert that extends from Sahara eastwards (Sharma & Mehra 2009). Since this region is situated close to the international border of India and Pakistan, most of the area is under the control of the Border Security Force and the Indian Army. A fence that is impenetrable to most animals and people demarcates the international boundary. The total proposed area of the Shahgarh landscape is about 4200 km<sup>2</sup>. However, similar habitat albeit with lower prey and high potential for human conflict, exists contiguously for another 12,000 km<sup>2</sup>.

**Temperature and Rainfall:** This area experiences high variation in diurnal and seasonal temperatures. Summer temperatures during the day can exceed 45° C, while night temperatures can be as low as 20° C. Winters are cold with temperatures often going down to -2° C (Sharma & Mehra 2009). Rainfall is erratic and ranges from 100-400 mm (Sharma & Mehra 2009).

**Vegetation:** Vast areas dominated by *Lasiurus indicus* is a prominent feature of this area. Other prominent vegetation species are *Calligonum polygonoides*, *Leptidinia pyrotechnica* and *Crotolaria burhia*. Areas with higher levels of sub-soil water have *Salvadora oleoides* and *Prosopis cineraria* thickets that provide shelter to the wildlife.

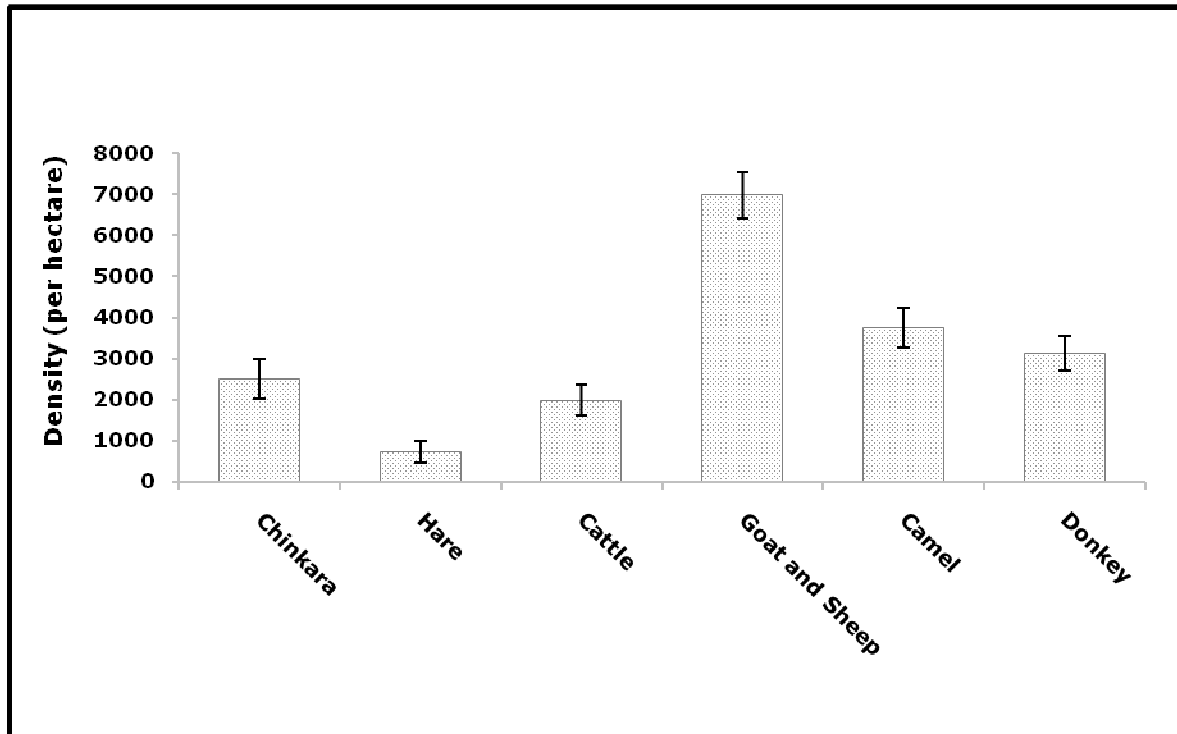
**Wildlife:** The only wild ungulate species currently found in this area is chinkara (*Gazella bennettii*), which can survive on very low quantities of water or can meet its water requirements from the vegetation it forages upon (Dookia & Goyal 2004). Desert fox (*Vulpes vulpes pusilla*) is

common and is the only known wild carnivore. Feral dogs are also common and are responsible for chinkara and livestock depredation.

**Human communities:** Scarcity of water makes life difficult in this region and thus few nomadic settlements exist in this area. Most of these settlements are small comprising of a cluster of 7-8 thatch houses which are seasonally occupied by nomadic Muslim communities. These communities were traditionally engaged in trade across the border with Sind. However, since the partition of the two countries they depend entirely on pastoralism to generate revenue. Goat, sheep, camel and donkey are owned in large numbers. Grassland degradation due to over-grazing in the region leading to starvation appears to be a common cause for livestock mortality. Cattle are also owned, though in small numbers. Alternate sources of livelihood and public facilities like schools and hospitals do not exist. There are no permanent settlements. Small hamlets called 'dhanis' are seasonally occupied by 5-8 households. There are close to 80 such 'dhanis' in the 4200 sq. km. area. During times of tension between the two neighboring countries, local communities are not permitted to reside in majority of this region, especially within 10 km from the border. Oil and gas exploratory activities also occur at a few locations.

**Prey densities:** Ungulate densities in this area, comprising entirely of chinkara were estimated to be  $2.44/ \text{km}^2 \pm 0.36$ , while those for all potential prey species (inclusive of prey weighing <5 kg) were  $2.50/ \text{km}^2 \pm 0.37$ .

**Pellet densities:** Eighty three percent of pellets encountered in Shahgarh were those of domestic livestock (Fig. 1), with small stock pellet densities ( $6,979/ \text{ha} \pm 558$ ) being much higher than those of cattle ( $1,979/ \text{ha} \pm 379$ ). Camel and donkey pellets were also commonly encountered. Amongst wild herbivores, chinkara pellet densities ( $2,500/ \text{ha} \pm 475$ ) were high compared to those of hare ( $729/ \text{ha} \pm 261$ ).



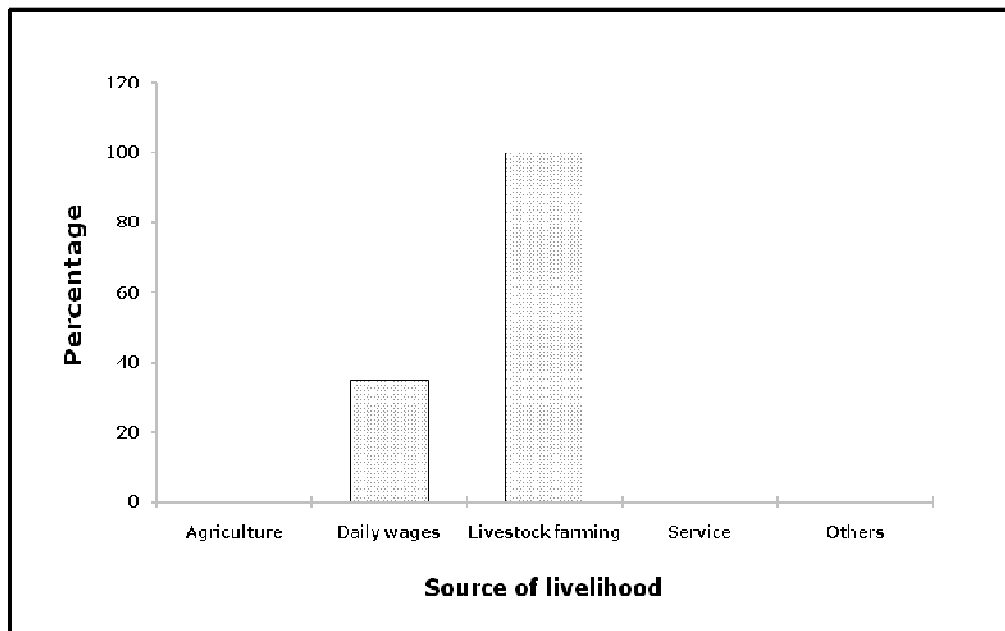
**Fig. 1 Herbivore pellet densities (per hectare) in Shahgarh area**

**Carrying capacity:** With its present prey densities comprising predominantly of chinkara, this area can sustain 15 cheetah. However, with reduced livestock-wild ungulate grazing competition and with minor habitat and water management, chinkara densities should increase, while other prey species like wild pigs and nilgai could potentially re-colonize. Under such conditions, chinkara density of this area could easily parallel the existing chinkara density of Desert National Park (6.45 chinkara/ km<sup>2</sup>) and even exceed it, providing the capacity to sustain upto 40 cheetah.

**Human densities:** The area sampled during this study had a density of 14 households/ 100 km<sup>2</sup> with 80 nomadic settlements. These settlements are seasonal and do not have any ownership of land. During times of tension between India and Pakistan, people living in this region are not permitted to reside within most of this area.

**Economic well-being index:** People in Shahgarh area make temporary settlements or ‘*dhanis*’ and move between the areas as per the season. They rely on the rains for good fodder for their

livestock, and shift between settlement areas accordingly. However, there is no cost incurred by them in maintaining the huge livestock numbers, since they leave their animals for grazing freely in the entire area and do not follow them. Each person on an average owns about 200-300 goat and sheep, which actually serve as liquid-cash and are easily renewable wealth resources. The tough desert conditions do not permit agriculture in the area, and therefore people in this area depend solely on livestock as means of income (Fig. 2). Since these people have been pastoralists for centuries, they do not prefer taking up any other activity and are cut off from most mainstream activities. The people in this region rank the highest on the economic well-being index, due to their high livestock numbers. However, they have no regular contact with the main markets, and trade in livestock takes place, when merchants visit them in their ‘*dhanis*’.



**Fig. 2 Percentage of people involved with each occupation type in Shahgarh area**

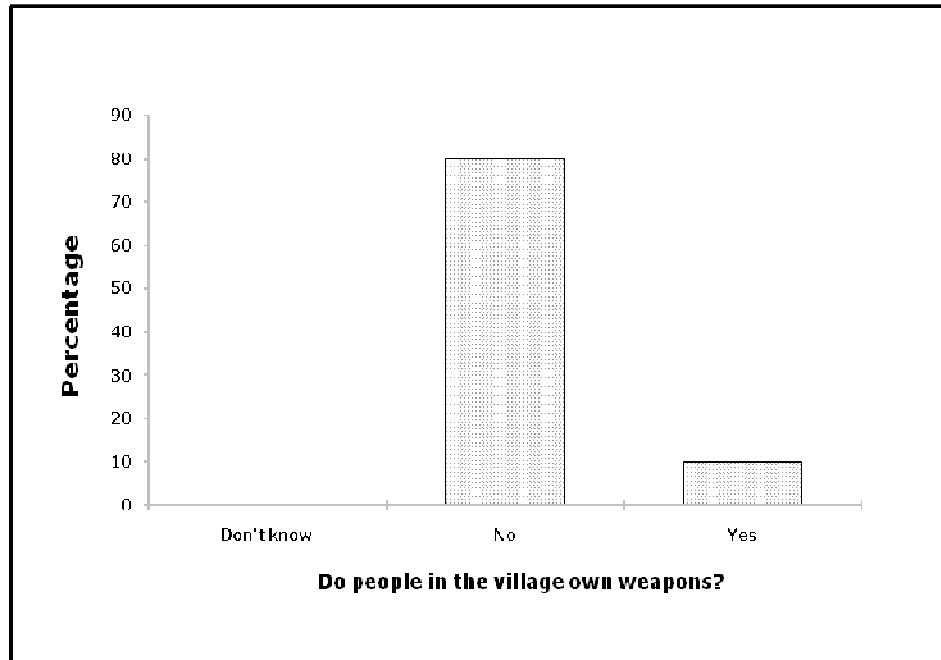
**Livestock densities:** As per the livestock density index based on the questionnaire survey, Shahgarh had amongst the lowest cattle densities (2.74/ 100 km<sup>2</sup>) while, sheep (9.86/ 100 km<sup>2</sup>) and goat (31.24/ 100 km<sup>2</sup>) densities were high. The region also had camel and donkeys, though in relatively low densities.

**Perceptions and attitudes:** People in Shahgarh area mainly eat meat from domesticated animals like goats and poultry, as clarified by 98% of the interviewees. All the people interviewed ( $n=20$ ) were non-vegetarian and consumed meat at least once a month. However, the interviewees' answered in negative when questioned about bush meat in their diet. The shyness of chinkara and depressed densities of wild prey compared to other similar habitats with vegetarian communities suggests that hunting may be a depressing factor on chinkara numbers.

According to the respondents, people here can trap and snare animals (Fig 3) and also own weapons (Fig 4). Since there is no agriculture in Shahgarh, there is no real threat or loss from wild animals due to crop raiding. Also, since predators are missing from this landscape, there is no serious threat of livestock depredation and therefore, all respondents responded in the negative. However, feral dogs in the area were reported to kill goats and sheep and sometimes even chinkara.



**Fig. 3: Percentage of respondents from Shahgarh area providing information on expertise available to set traps and snares for poaching of wildlife.**



**Fig 4: Percentage of respondents from Shahgarh area providing information on awareness about people owning weapons in the Shahgarh area.**

### **Potential and Strategy for Shahgarh Landscape**

a) This area was found to have the best potential for a successful reintroduction of cheetah in India, provided the following recommendations are implemented: The current carrying capacity of the region is close to 12-15 cheetah. This by itself is not a viable population in the long-term. Besides, introduced cheetah would come into conflict with local pastoralists who rear sheep and goats. To enhance the carrying capacity of the area and to reduce conflict, it is imperative that this area is made totally free of livestock. This could be achieved by compensating the migratory livestock herders that periodically use this area from some 70-80 'dhanis'. Each 'dhani' is composed of 5-10 households usually occupied only periodically. Thus, the magnitude of compensation required would be for about 800 families. Since these people do not own land but seasonally graze their stock on public lands and that too with the approval of the Border Security Force (BSF) and are often displaced due to tensions between neighboring countries, the compensation costs may not be high. But it is important that the local communities are more than adequately compensated and provided alternatives for their livelihoods or grazing lands. This

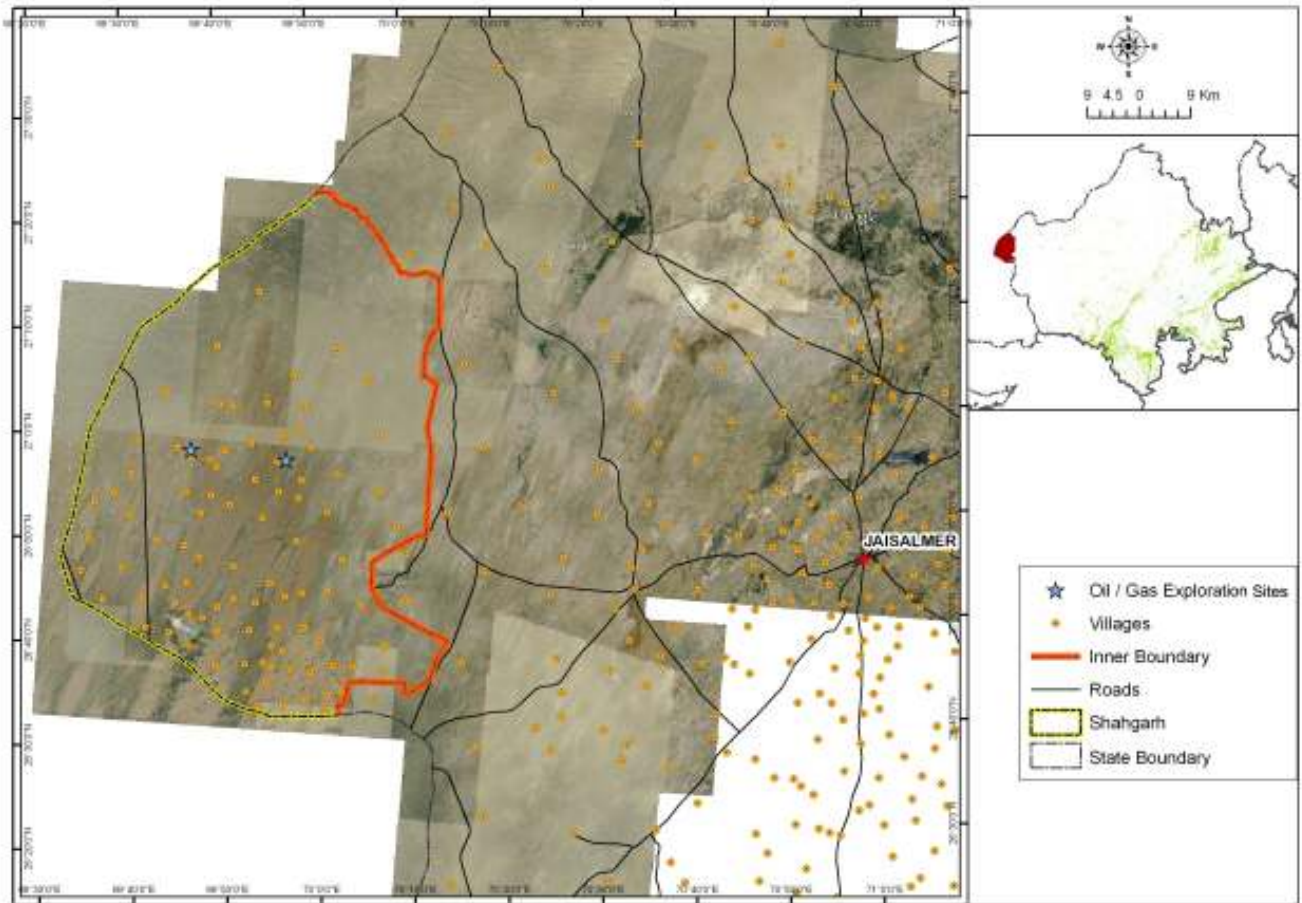


could be made possible by providing bore wells and alternative water sources north-east of Shahgarh.

b) The selected area of about 4220 km<sup>2</sup> is already demarcated and fenced by the International Border fence on the south and west along the Shahgarh bulge. We propose that a chain link fence of 7 ft above ground and 1 ft below ground be erected for a total length of 140 km, roughly running west to east and north to south as shown in Plate 2 so as to enclose the bulge area. The fence will serve two purposes i) to keep the introduced cheetah inside the bulge area and ii) keeping the livestock out of the area. Once the livestock is removed from the area and kept out by the fencing, and the poaching would cease, the chinkara population are most likely to increase rapidly and achieve a minimum density of what is currently observed in the Desert National Park or more. With such densities the carrying capacity of the area would be close to 40 cheetah.

c) We also propose management inputs to enhance the habitat quality by providing surface water for wildlife: The water table in this region is relatively high (30-50 ft) and windmill driven pumps can be installed throughout the region, so as to facilitate habitat utilization by wildlife. Once surface water is made available, a more diverse prey community can also be supported in this region and re-introduction of nilgai and wild pigs could also be considered to further enhance the carrying capacity for cheetah.

d) Since the region is near the border and sensitive in nature, the management and jurisdiction of the area should be a joint project between the Border Security Force, stakeholders and the project management authorities. Assistance, technical advice and population management should be provided by WTI and WII. Considering the situation and the sensitivity of the area, it will not be accorded a Sanctuary or National Park status.



**Plate 2:** The location of shahgarh area within the state of Rajasthan. The proposed fencing is denoted with an orange boundary

## 4.2 Desert National Park

Desert National Park covers an area of 3162 km<sup>2</sup> (Rahmani 1989), and is located partly in both Jaisalmer and Barmer districts of Rajasthan. Since the park boundaries are poorly marked and enforcement of park rules rarely implemented, the park is heavily grazed by livestock. The Forest Department has created small enclosures at 12 different sites inside the National Park. Even though most of these enclosures are in very bad condition, others like Sudasri have developed into good grasslands and support great Indian bustard and populations of other allied desert grassland species. This area is classified under the Desert – Thar (zone 3A) biogeographic zone (Rodgers *et al.* 2002).

**Temperature and rainfall:** The temperatures in parts of the Thar desert (that includes Jaisalmer) range from 0 degrees in winter to 50 degrees in summer. Rainfall in the Jaisalmer side of Thar is often less than 150 mm. (Rahmani & Soni 1997).

**Vegetation:** The plant species found in this area include- *Prosopis cineraria*, *Zizyphus nummularia*, *Capparis decidua* and *Calotropis gigantia*. However, trees are highly scattered in this landscape which is mostly dominated by grass species. *Salvadora* sp., are also found in the area, which provide for as good shade trees in the heat of the summer. *L. indicus* (Sewan) is the dominant grass, which is favored by great Indian bustards and other species dependent on grassland ecosystems.

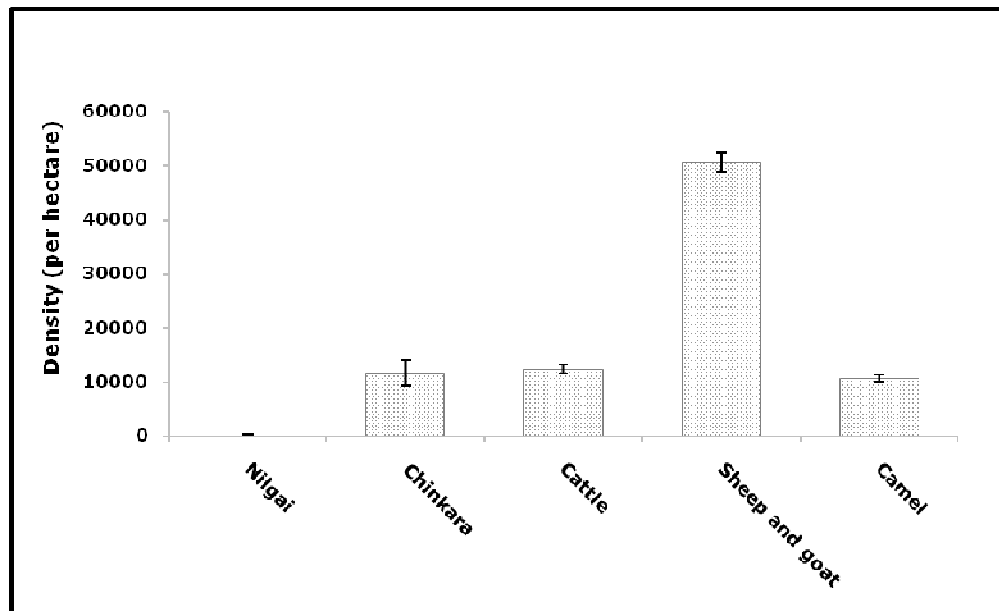
**Wildlife:** Chinkara (*G. bennetti*) are found in good numbers in the Desert National Park, especially in the enclosures where the habitat is better than the ones outside, since livestock grazing is restricted in these enclosures. Nilgai (*Boselaphus tragocamelus*) are also found in small groups. Two species of fox- Indian fox (*Vulpes bengalensis*) and the desert fox are found here in good numbers. The spiny tailed lizard (*Uromastix hardwickii*) is also abundant here.

**Human life in the area:** Previously, agriculture was highly restricted to monsoon cultivation. But, now there are plans of extending the Indira Gandhi Nahar Project (IGNP) right upto the end

of Jaisalmer district on the southern side, which will facilitate availability of water to the area. However, this will prove to be highly detrimental to the wildlife of this area (Rahmani 1989). On an average, people in this area came across as hostile in their attitudes towards the National Park.

**Prey densities:** Chinkara is the most frequently encountered ungulate in the region with densities of  $6.45/ \text{ km}^2 \pm 1.55$ . Apart from chinkara, the other potential cheetah prey in the region is peafowl. A combined density for both these species in the area designated as the National Park is  $7.18/ \text{ km}^2 \pm 1.71$ .

**Pellet densities:** Livestock pellet densities encountered at this site (Fig. 5) with  $50,528 \pm 1,727$  small stock pellets/ ha and  $12,324 \pm 773$  cattle pellets/ ha were higher than those encountered at any other study site during this study. However, this is not unexpected since pastoralism is a common way of life in this region which traditionally had large pastures and no other source of livelihood. Among wild herbivore pellets, chinkara pellet densities were relatively high ( $11,620/ \text{ ha} \pm 2,343$ ) compared to those of nilgai which is more common around areas irrigated by the Indira Gandhi canal.

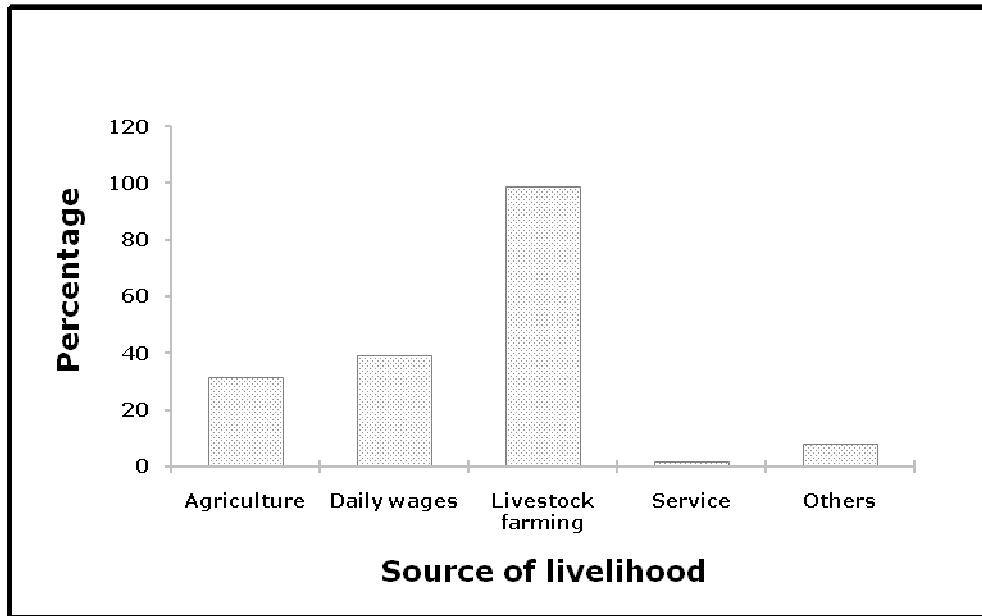


**Fig. 5 Herbivore pellet densities (per hectare) in desert national park**

**Carrying capacity:** This designated park area with its present prey densities can support around 31 cheetah. However, with the high levels of human disturbance and livestock grazing pressures, it would be challenging to increase the potential of this area to support any higher number of wild ungulates and subsequently cheetah.

**Human densities:** There are around 47 villages inclusive of small hamlets “*dhanis*” within the park, with a household density of 169/ 100 km<sup>2</sup> based on 2001 census. These villages are of varying sizes with some like Khudi being large with predominantly concrete houses and tourist lodges. Tourism potential of the area and the proposed extension of the Indira Gandhi canal have brought rapid development and urbanization into this part of the Thar in recent times. Several state highways and associated infrastructure crisscross the National Park (Plate 3). These, along with lack of legal enforcement and potential for high conflict, make the area less suitable for reintroduction in the current state of affairs.

**Economic well being:** The Desert National Park is close to Jaisalmer city and the people benefit by the developmental activities carried out here. A lot of people in this area are employed by mining companies, few others work as tourist guides and there is also some recruitment by the oil and gas exploration companies that work in the desert area of Jaisalmer and Barmer districts. Since the productivity of the agricultural land is highly reduced in this area, most people depend on livestock farming as the primary source of income. (Fig. 6)



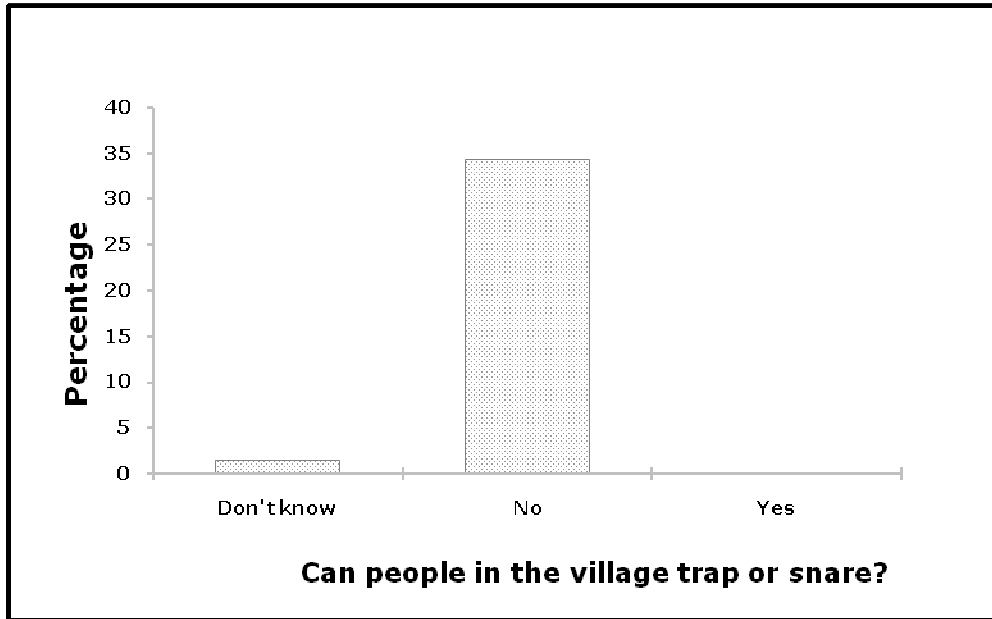
**Fig 6: Percentage of people involved with each occupation-type in Desert National Park.**

**Livestock densities:** As also indicated by the pellet density data, small stock densities in the region were very high with 251 sheep and 60 goats per 100 km<sup>2</sup>. Cattle were also kept by people but in relatively low numbers (15/ 100 km<sup>2</sup>). However, most of the small stock migrates out of the area around September-October and returns only after the first rains in June-July.

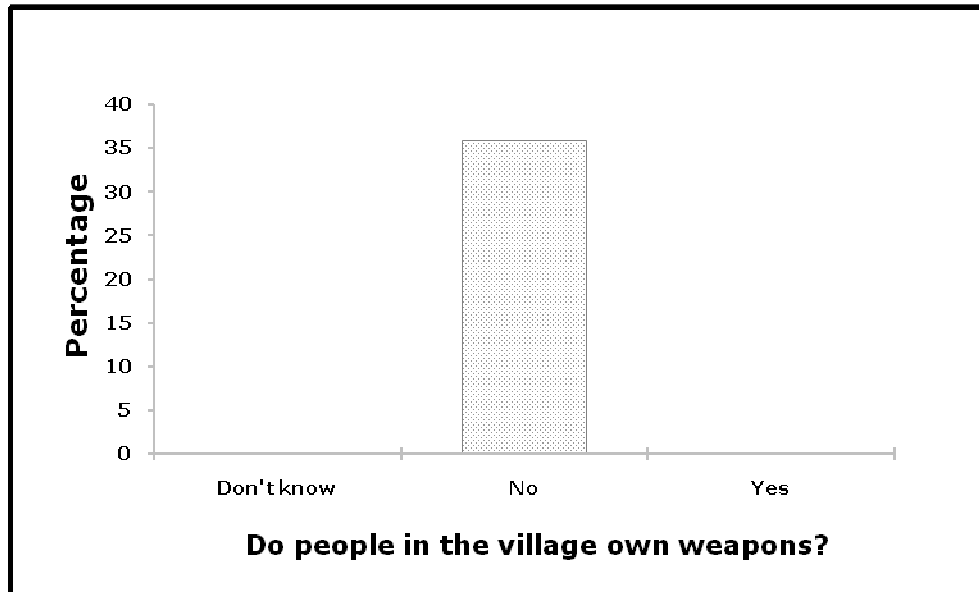
**Attitude and perception about wildlife in the area:** The source of meat in this area is mainly domesticated animals like goats and poultry. On an average most people eat meat once in a month, although there are some households that eat meat every day. The interviewees' responses indicate that people here can neither trap nor snare animals, nor do they own weapons (Fig. 7 and 8).

People do face problems with crop raiding by chinkara, however, livestock depredation is not experienced. It is due to the fact, that there are no large carnivores in this landscape since large carnivores like the wolf were extirpated from this area.

In general, people in Desert National Park were found to be hostile towards the Protected Area and the wildlife and most people we met wanted the park to be de-notified so that developmental activities could be carried out in the area.



**Fig 7 Percent of respondents from desert national park providing information on expertise available to set traps and snares for poaching of wildlife**



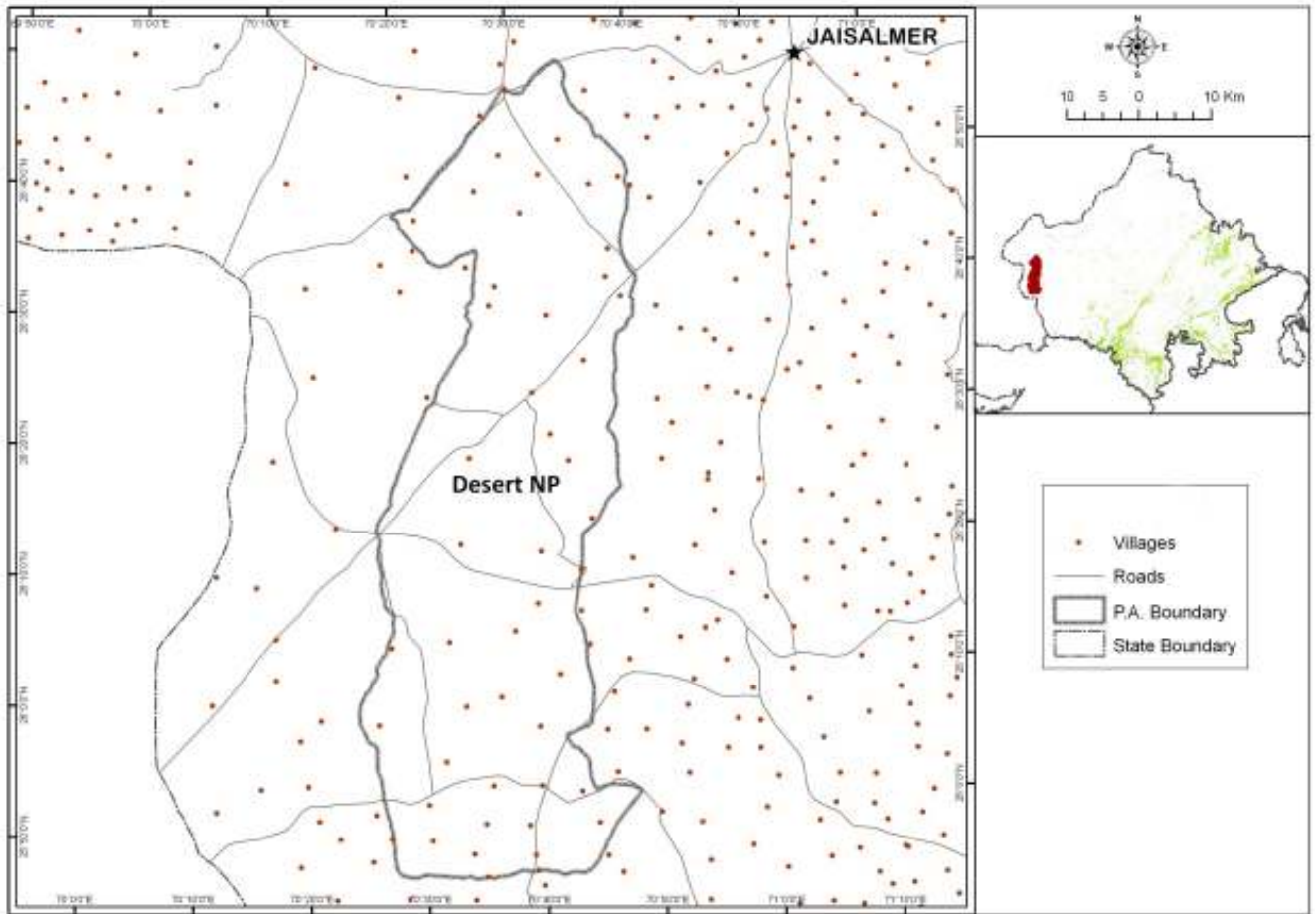
**Fig. 8 Percentage of respondents from desert national park providing information on awareness about people owning weapons in the area**

### **Potential and proposed strategy for the Desert National Park**

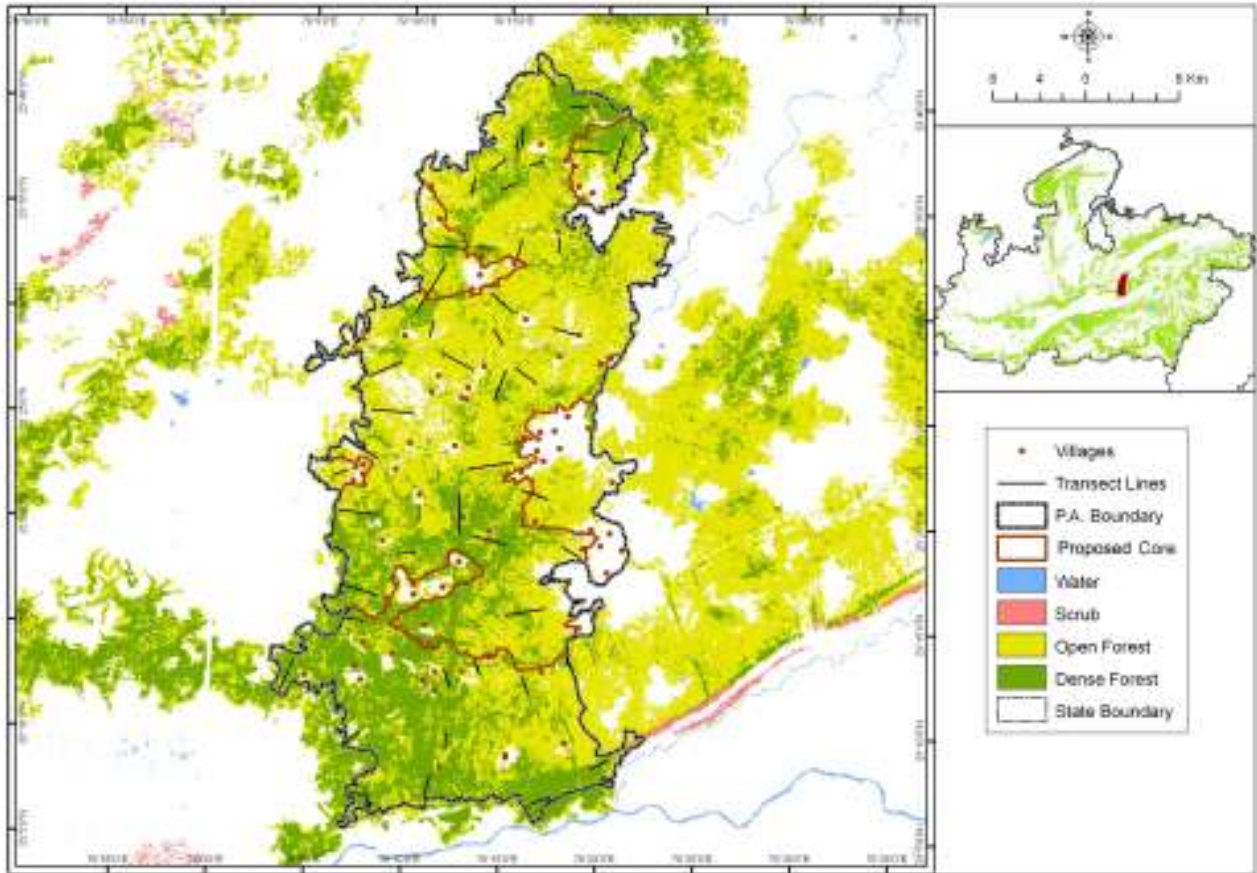
The Desert National Park is large (3162 km<sup>2</sup>) with reasonable chinkara densities. Considering just these two important criteria the area should score high on our priority for reintroduction. However, the Desert National Park does not meet the required criteria of minimal conflict between local communities and the introduced cheetahs. The area of the National Park is currently used as a common resource by local communities for livestock grazing and some agriculture as well. Several large villages are within the National Park which is also crisscrossed by state highways (Plate 3). Since livestock in the form of sheep and goats graze within and around the National Park area and there are no means of containing the introduced cheetah within the confines of the Protected Area, the reintroduction would result in high levels of conflict. Few small patches within the National Park are fenced off, these are the main refuges for wildlife including the critically endangered great Indian bustard. Due to the highly K selected life history of the GIB, and its critically low numbers, it would not be wise to introduce a potential predator within their last remaining stronghold. A potential conservation strategy to restore the conservation objective of this National Park would be to enclose the park within a



fence. However, this may be difficult due to the high cost and opposition from local communities and politicians. An alternative strategy would be to enclose large areas (over 10 km<sup>2</sup>) spaced within 5-10 km apart throughout the National Park and make them truly inviolate. This would be extremely beneficial for the GIB and may be an essential strategy to prevent their eminent extinction. If in the future several of these enclosures could be joined to cover a large area over 700 km<sup>2</sup> and the GIB have recovered to reasonable numbers so as to be able to sustain occasional losses to predation, then this area could be considered for a potential reintroduction of the cheetah. Until such conditions prevail we do not recommend considering this site further.



**Plate 3:** The location of Desert National Park within the state of Rajasthan showing villages and roads within the National park and its adjoining areas.



**Plate 4:** The location of Nauradehi wildlife sanctuary within Madhya Pradesh, showing village locations, transect lines and forest cover. The proposed core is denoted with a brown boundary.

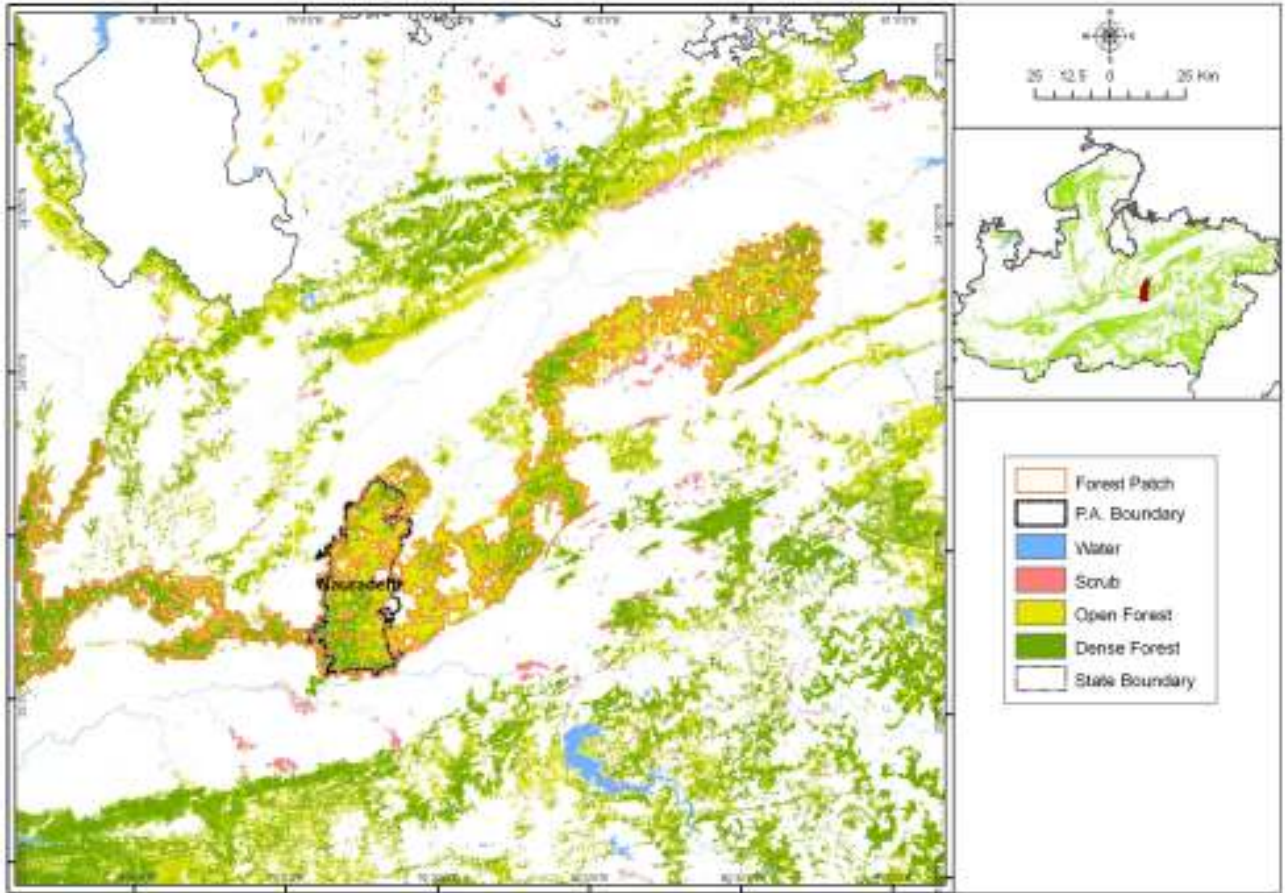
### 4.3 Nauradehi Wildlife Sanctuary

Nauradehi Wildlife Sanctuary is one of the largest sanctuaries in India, which covers 1197.04 km<sup>2</sup> area in three districts, viz., Sagar, Damoh and Narsinghpur, of Madhya Pradesh (Shukla 2007). The entire Sanctuary is situated on a plateau, forming part of upper Vindhyan range. The hills rise from the north to south with a gentle slope and terminate with steep slopes into the Narmada valley (Shukla 2007). It has a connecting forest patch with Veerangana Durgawati Sanctuary in Damoh district towards east which extends up to Bandhavgarh National Park. Nauradehi Wildlife Sanctuary is classified under Deccan peninsula- (zone 6A) bio-geographic zone (Rodgers *et al.* 2002).

**Temperature:** The average maximum summer temperature is reported as 40° C, while the lowest winter temperature is reported as 12° C (Shukla 2007). The annual rainfall in the area ranges from 914 mm to 1552 mm (Shukla 2007).

**Vegetation:** According to the revised classification of forests by Champion and Seth (1968), the flora of the Sanctuary can broadly be identified into southern tropical dry deciduous forests (type 5A). *Tectona grandis* is the dominant species covering 25-40% of the area. Other species comprise of *Terminalia* spp., *Phyllanthus emblica*, *Diospyros melanoxylon*, *Madhuca* spp., and *Acacia catechu* resulting in heterogeneous forest composition. Most of the northern part of the Sanctuary has good undergrowth with species like *Helictoris isora*, *Carissa spinulatum*, *Holorrhina antidicentrica* and *Woodfordia floribunda*. Some parts on the southern boundary have regeneration upto 90% but most of the Sanctuary is severely affected by low regeneration of tree species. Middle part of the Sanctuary is comprised of almost open woodland with grasses.

**Wildlife:** The ungulate species found in the area include nilgai, chital (*Axis axis*), sambar (*Cervus unicolour*), chinkara, barking deer (*Muntiacus muntjac*), blackbuck (*Antelope cervicapra*), chowsingha (*Tetracerus quadricornis*), and wild pig (*Sus scrofa*). Barking deer are present only in the southern part of the Sanctuary, while blackbuck are rare as they live in the



**Plate 5:** The landscape of central India showing the location of Nauradehi Wildlife Sanctuary with a contiguous forest patch of 5500 sq. km

agriculture fields on the periphery of the Sanctuary. Concentration of ungulates is higher in northern part. Among carnivores, tigers (*Panthera tigris*) were known to frequent this area until 7-8 years ago. In March 2010, a tigress was sighted in the Shahpur range of the territorial forest north of this Sanctuary. Last reports of leopards from this area also date back to early years of 2000. However, the present status of leopard in the region is unknown. Wolf and wild dog are the main carnivores here and cause a lot of conflict due to predation upon livestock.

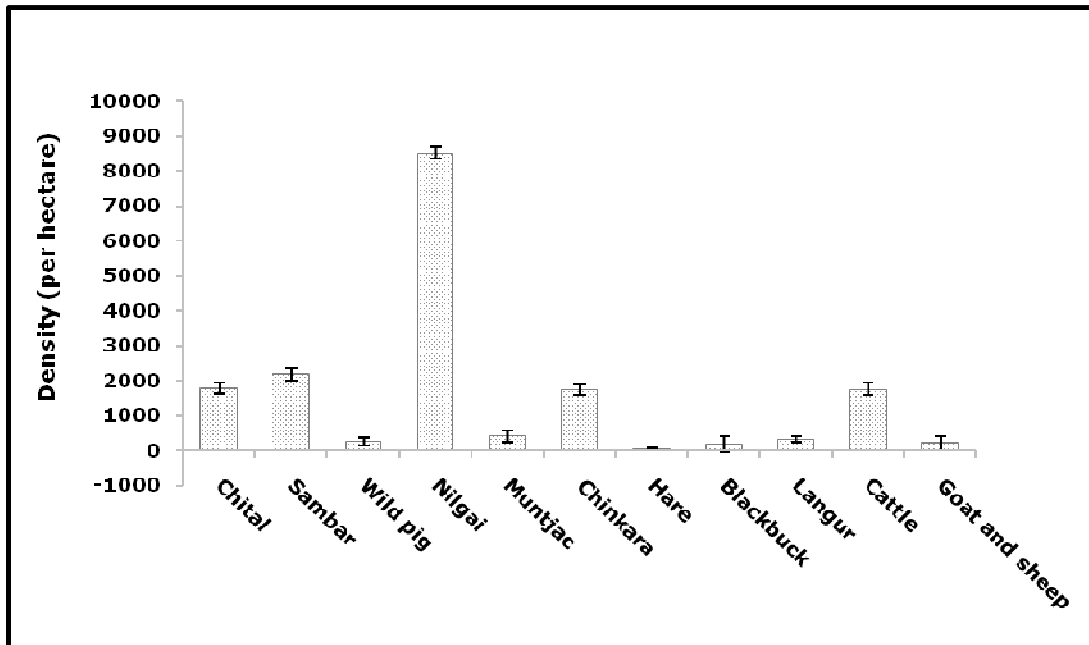
**Human Life in the area:** Most of the population is living below poverty line. Though the economy is largely agriculture based, the area does not seem to have fertile land and people cannot afford chemical fertilizers. People usually do not own much livestock due to shortage of fodder and water in summer.

The area had a mixed community structure with predominantly people from the Gond tribe. People generally are not hostile to wildlife and forest department because of a few effective activities by local eco-development committees, but the area has a lot of pressure of illegal and commercial timber extraction by the outsiders. National highway no. 12 lies along the southern boundary and two important roads (Sagar to Jabalpur via Mohli and Tendukhera to Devri) also bring in a lot of disturbance. Most of the villagers of northern and western parts expressed their wish to be relocated outside of the Park.

**Prey densities:** This area supports a high ungulate diversity with a density of 6.34/ km<sup>2</sup> ± 1.9. Nilgai is the most common ungulate, followed by chinkara, wild pig, chital, sambar and blackbuck. Chowsingha is also reported from the area but was not sighted on transect walks. The potential cheetah prey base in this site has a density of 15.83/ km<sup>2</sup> ± 3.5.

**Pellet densities:** Wild herbivore pellet densities estimated in Nauradehi were much higher than those for livestock (Fig. 9). Within wild ungulates, nilgai pellets had the highest density (8,503 pellets/ ha ± 166) followed by sambar (2,173 pellets/ ha ± 173) while chinkara and chital pellets accounted for 20% of the pellets observed. Cattle dung and goat pellets within the Protected Area

were in much lower densities and contribute to only 11% of all pellets observed, suggesting that the area may not have high livestock grazing pressure.



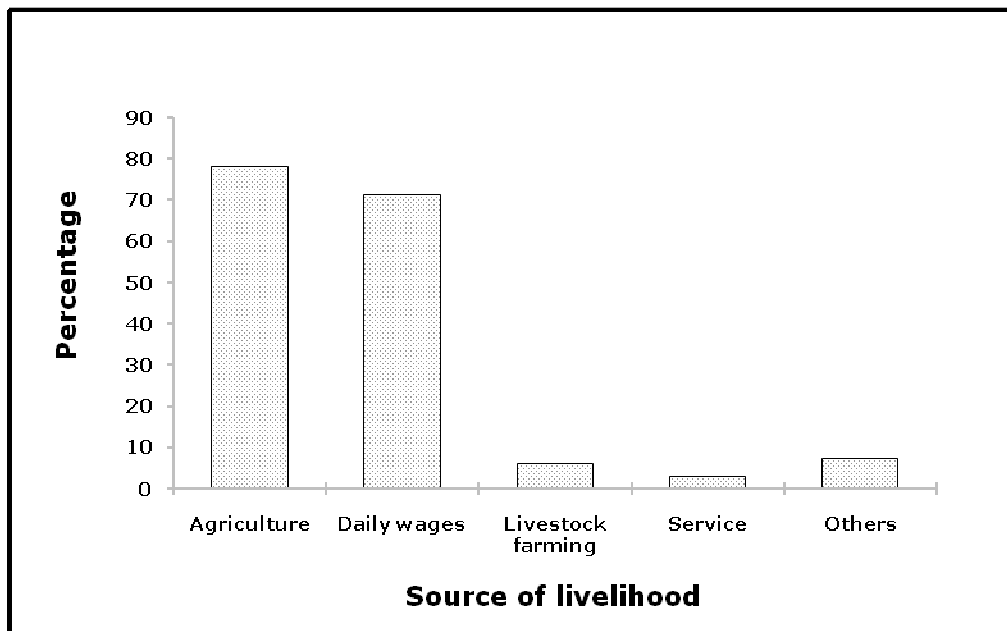
**Fig 9 Herbivore pellet densities (per hectare) in Nauradehi wildlife sanctuary**

**Carrying capacity:** This area holds immense potential for re-introduction of the cheetah with a present carrying capacity of 26 which can be increased to 52 with better management and reduced human pressures in the park. The entire Nauradehi landscape, encompassing the forest tracts of Veerangana Durgawati Sanctuary can support up to 71 cheetah in future with adequate habitat management of this area.

**Human densities:** Human densities within the protected area are high with 74 villages and 423 households/100 km<sup>2</sup>. There are seven forest villages within the protected area while all others are revenue villages. Poverty levels in the region are high with reduced employment opportunities and many respondents to the questionnaire wished to be relocated out of the area. Most people living within the Protected Area showed desire to move out of the forest so as to avail modern facilities of transportation, electricity, education and health care.

**Livestock densities:** Scarcity of water and fodder, particularly during summer causes high livestock mortality in the region. Hence, most people do not own large number of cattle or small stock. Goat densities are low at 1.8 animals/100 km<sup>2</sup> while large stock is constituted of 21% buffalo indicating that unproductive cattle in this region may be lower than those found in other sites.

**Economic well-being:** Agriculture and daily wages form the main sources of income in this area (Fig. 10), although the average land holding size is the lowest, after the desert area sites of Banni and Desert National Park. Even when the general appearance of the interviewees was assessed, they scored amongst the lowest rankings.



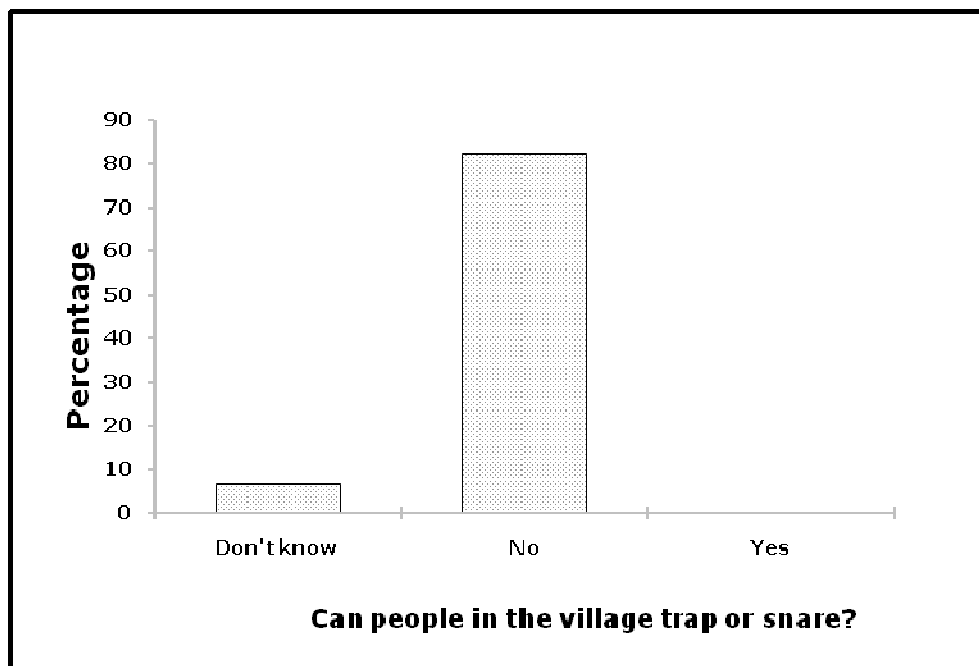
**Fig. 10 Percentage of people involved with each occupation-type in Nauradehi Wildlife Sanctuary, Madhya Pradesh**

**Attitude and perception of people towards wildlife:** Most people in Nauradehi consume meat once in a month on an average. However, there are a small percentage of people who consume meat weekly or even everyday. The main source of meat is domesticated animals in this area, but a small percentage of people take fish from the river Narmada and its tributary Biarma, which flow on the southern and eastern boundary of the Sanctuary respectively.

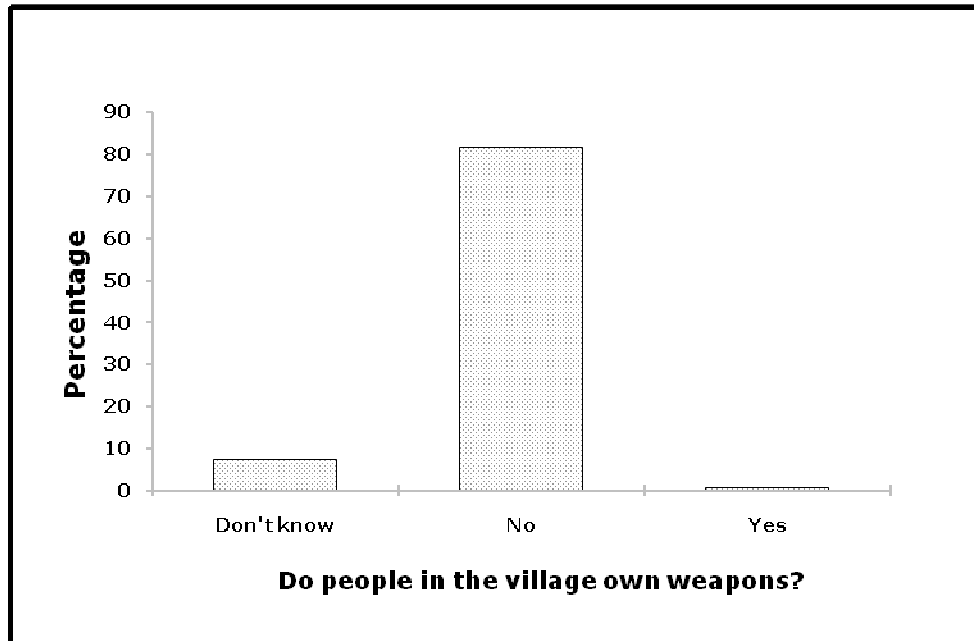


According to the respondents we interviewed during the survey, people in the area do not know how to lay traps and snares for animals (Fig. 11), but there have been incidences in the past wherein the water sources were poisoned by the tribals in the area. A very small percentage of people own weapons in this area (Fig. 12). However, there is a small percentage of people who responded saying they do not know anything about people trapping or snaring for animals. This can be considered as an indirect indicator of their tendency to hunt and reluctance to admit that hunting is indeed a part of their daily lifestyle.

People face a major problem with crop raiding in the area, with wild pigs, nilgai and chital being mostly responsible. There are also incidences of livestock depredation, mostly by wolves and wild dogs.



**Fig. 11 Percentage of respondents in Nauradehi providing information on expertise available to set traps and snares for poaching of wildlife**



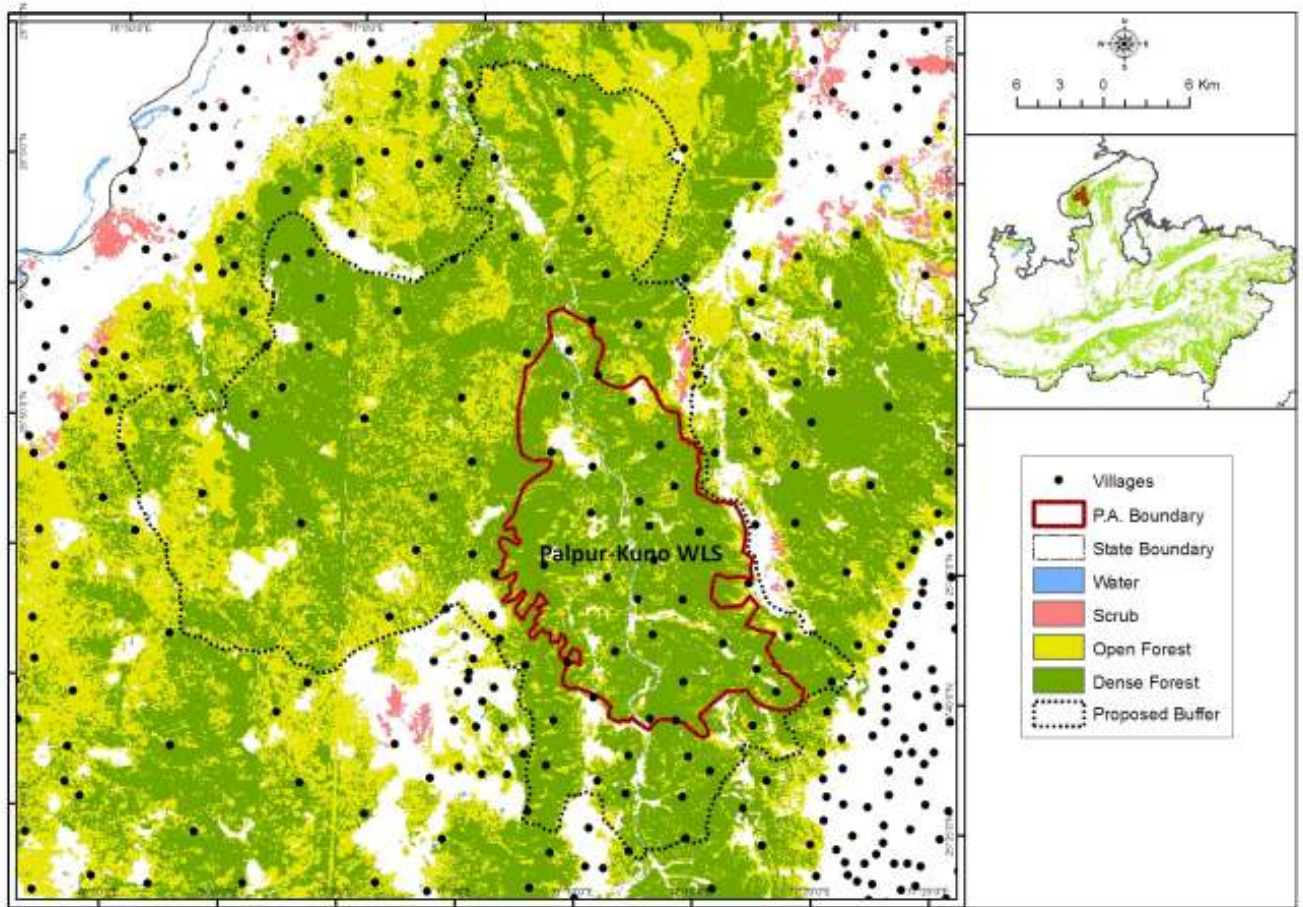
**Fig. 12 Percentage of respondents in Nauradehi providing information on awareness about people owning weapons in the area.**

### **Potential and Strategy for Nauradehi Landscape**

Surprisingly Nauradehi fared extremely well in our evaluation considering landscape features, patch size, prey availability and human pressures. The Nauradehi forest patch extends south till the Narmada banks and eastwards through Durgawati Sanctuary upto Nagod Tehsil and towards the west as a thin strip of forest in Bareli tehsil of Raisen district. This forested habitat is about 5500 km<sup>2</sup> and if provided the required resources for management inputs can bounce back to its pristine state. We propose that about 700 km<sup>2</sup> of the Nauradehi Wildlife Sanctuary be declared as core area for cheetah reintroduction and the remaining as buffer area (Plate 4). There are about 21 villages located within this proposed core area that would need to be relocated. Our interactions with the local communities in this area suggest that most people are keen to move out of the Sanctuary area to explore better livelihood options and to avail modern amenities. As per the approved guidelines for core areas of Tiger Reserves the cost of relocating these villages (about 800 families is likely to be Rs. 80 Crore). Currently, Nauradehi can support close to 27 cheetah, if the above recommendations are implemented. The Sanctuary itself should be able to

support close to 55 cheetah and the total capacity of the landscape would be close to 70 individuals.

Qualitative improvement in the Nauradehi Sanctuary and the proposed core within it, can only occur through a much better management regime. The Sanctuary, bereft of any unique or mega species and off the beaten track, has always been a neglected Protected Area in Madhya Pradesh. It would now have to be managed by handpicked staff, from the forest guard upwards. Being dry-deciduous open forest with a sizeable number of *D. melanoxylon* and *Madhuca sp.* trees, fire has been a serious bane of Nauradehi. Repeated fires are set each year periodically by *B. lanzan* collectors, graziers, mahua pickers and tendu leaf collectors. This will have to stop. Being close to cities like Sagar and even Jabalpur, illicit extraction of teakwood and fuel wood are also problems. As mentioned above, water sources dry up in summer, leading to poaching over waterholes, which will have to be counteracted and more water availability provided. Eco-development activity would also have to be undertaken on a large scale to wean away the people from their dependency upon the forest, especially those within the Sanctuary.



**Plate 6:** The location of Kuno wildlife sanctuary within Madhya Pradesh showing village locations and forest cover. The proposed buffer is denoted with a dotted black boundary.

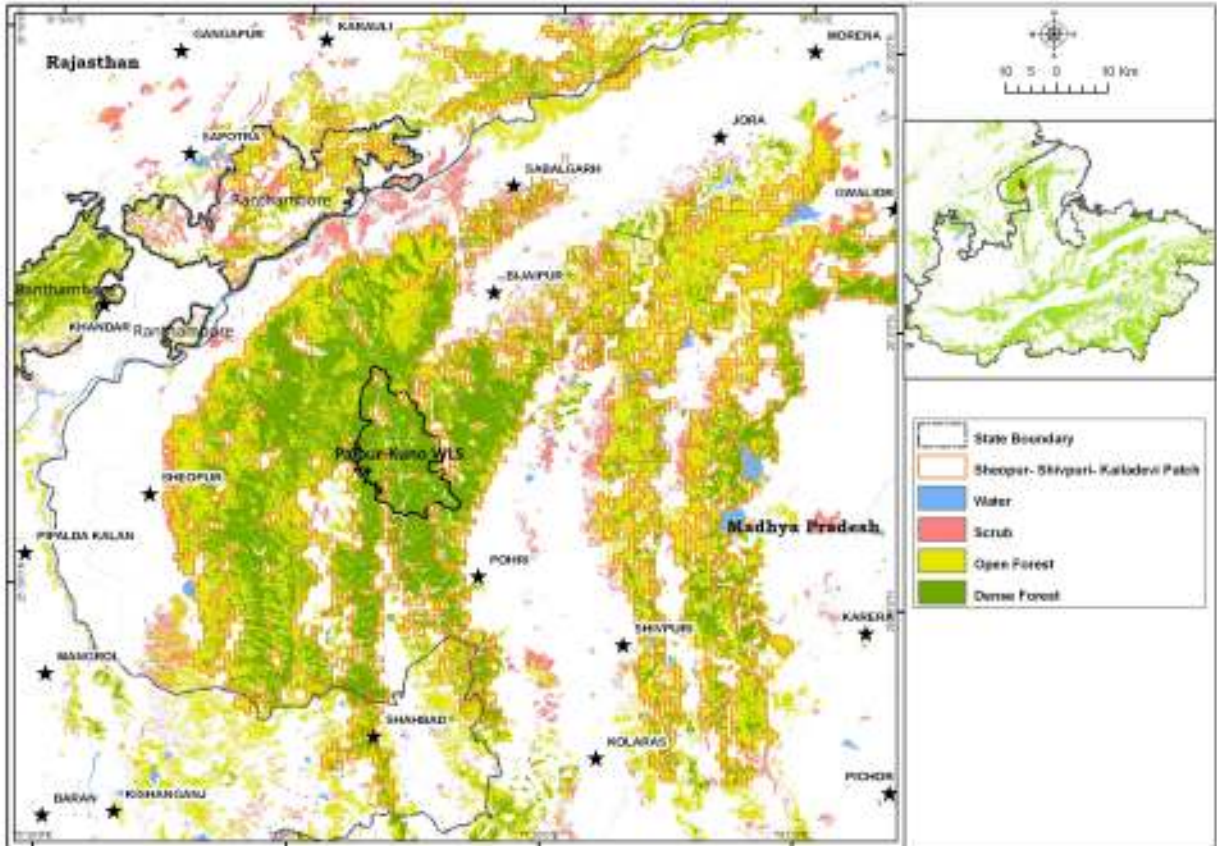
#### 4.4 Kuno-Palpur Wildlife Sanctuary

Kuno-Palpur Sanctuary covers an area of 346.68 km<sup>2</sup> and is located in the Sheopur district of Madhya Pradesh. The river Kuno flows through the Sanctuary. The western side of the river is dominated by high hills with medium to steep slopes while the eastern bank falls towards the valley and therefore has more flatter terrain with gentle-medium slopes (Chaudhary 2001). On its south-eastern side of the boundary, Kuno forms a contiguous forest landscape with patchy connectivity to Panna Tiger Reserve through the Shivpuri forest area. On the other hand, the Ranthambhore National park and Keladevi Wildlife Sanctuary (both part of the Ranthambhore Tiger Reserve) are connected with Kuno- Palpur through good forest patches towards the north-western boundary from across the river Chambal (Jhala *et al.* 2008). The contiguous habitat patch is about 6800 km<sup>2</sup> with a potential for cheetah occupancy in over 3200 km<sup>2</sup>. Kuno-Palpur Wildlife Sanctuary is classified under the Semi-arid – Gujarat Rajputana (zone 4B) biogeographic zone (Rodgers *et al.* 2002).

**Temperature and Rainfall:** The average maximum summer temperature has been reported as 42.3° C, while the lowest winter temperatures are between 6 and 7° C (Chaudhary 2001). The average annual rainfall in the area is about 760 mm (Banerjee 2005)

**Vegetation:** The Sanctuary falls under the northern tropical dry deciduous forest as per the revised classification of forest types of India (Champion & Seth 1968). The dominating trees in this landscape are *Anogeissus pendula* and *Boswellia serrata*, while the middle story is dominated by *A. catechu*, *Acacia leucopholea* and *D. melanoxylon*. *Zizyphus sp.* makes the lowest part of the canopy cover. Kuno is probably one of the only wildlife sites in the country where there has been a complete relocation of villages from inside the park. These village sites inside the Sanctuary have now been taken over by grasses and scrub, forming a savannah-type grassland habitat.

**Wildlife:** The ungulate species found in the area include nilgai, sambar, chowsingha, chital and wild pig. There is one small group of blackbucks consisting of 5-6 individuals that is present in



**Plate 7:** The location of Kuno wildlife sanctuary is shown within the contiguous landscape of sheopur-shivpuri forest of 6800 sq. km.

the north-eastern part of the park. Carnivores present in the area include Leopard, hyena, jackals and fox. The village sites left after relocation of their human population outside the park, that now have grasslands and scrub form ideal habitat for the chinkara, and it is at one such site that the only group of blackbuck inside the Sanctuary now calls its home.

**Human life in the area:** There is a lower village density in this area, due to a long history of dacoits in the area. Tribal communities like the Mogiyas who are known for their hunting skills reside very close to the northern and eastern boundaries of the park. Sahariya, a sub-caste within the Gonds, are the most dominant of the tribes and their populations are settled in villages all around the Sanctuary. The Bhils, have settled on the south-western parts of the park, and are considered one of the most troublesome tribes by the Forest Department personnel, since they continue encroaching on forest land and resources (Chaudhary 2001). People from the Kachchh in Gujarat have also settled in the area nearly 30-35 years back, and have been given the right to cultivate (*'patta'* land) by the forest department. Almost every village has 'baniya' families who own provision shops and operate small-scale money-lending business within the village, while 'thakurs' in these villages continue to own some of the largest agricultural land holdings in the area.

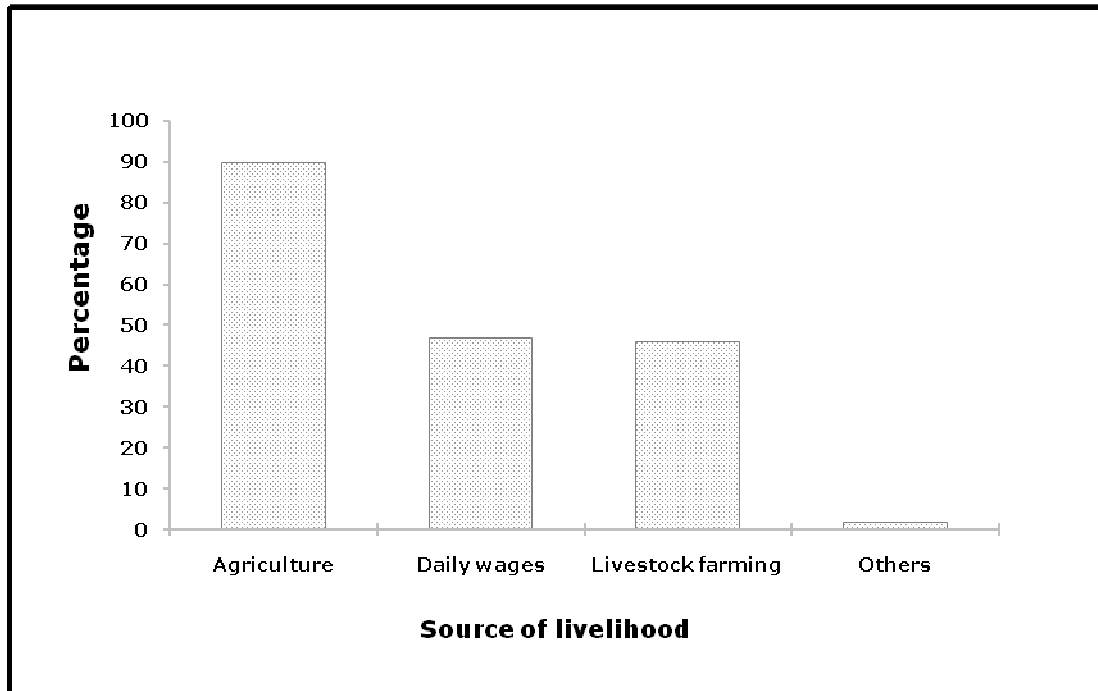
**Prey densities:** We use density estimates from an earlier study (Banerjee 2005) which uniformly sampled all habitat types within the study area. Since this study was conducted five years ago, we assume that with adequate management and reduced human disturbance, the prey densities in this area would have increased at the rate of 5% per annum (based on growth rates recorded in Gir Protected Area (Dave 2008)), providing ungulate densities of 13.59/ km<sup>2</sup> and 26.11/ km<sup>2</sup> for all potential cheetah prey species.

**Carrying capacity:** The protected area of Kuno Wildlife Sanctuary with its reduced human pressures after the relocation of villages from within the park holds potential to sustain up to 27 cheetah based on its existing prey base. Based on carrying capacity estimates the entire Kuno landscape covering over 3000 km<sup>2</sup> could provide prey base for up to 100 cheetah, making this one of the most suitable landscapes for cheetah in terms of prey availability.

**Human and livestock densities:** The protected area of 346 km<sup>2</sup> within the Sanctuary is free of human settlements and domesticated livestock. All 24 villages that were located within the Sanctuary were relocated outside the boundaries of the Protected Area in 1998 (Kabra 2009). Also, the Sanctuary has an approximate 2042 feral cattle (Banerjee 2005) left behind by people when they moved out. This population of feral animals forms part of the prey base for any large carnivore inside the park. The Kuno Sanctuary area is devoid of human settlements due to the rehabilitation program undertaken by the Forest Department of Madhya Pradesh. The potential cheetah habitat of 3200 km<sup>2</sup> has 169 villages within it.

**Economic well-being index:** The villages that were inside the Sanctuary have mostly been shifted out barring a few houses that are still under the procedure of moving out. Each family unit was allocated 2 ha of land outside the Sanctuary area when they agreed to move out. The relocation site is now located about 10-12 km further on the north-eastern side from the core area of the Sanctuary. There are a lot of livestock moving into the area from Rajasthan for a few months of the year, putting additional pressures on the resources in the area. Agriculture is the main source of income for most people in this area, followed by daily wages and livestock farming (Fig. 13). On the economic well-being index, the people of Kuno rank as the 4<sup>th</sup> wealthiest group.





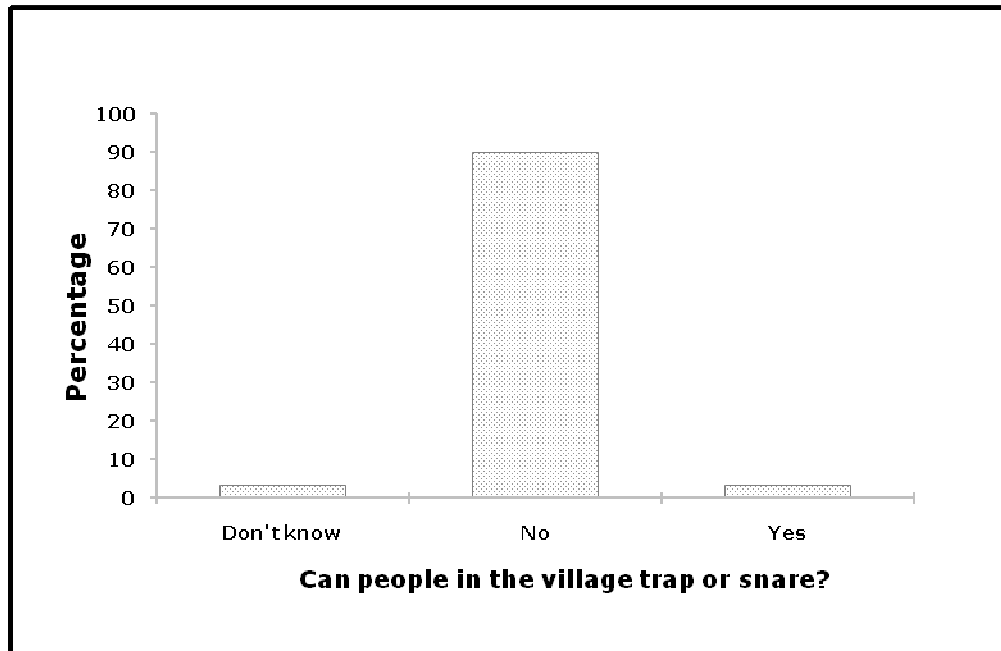
**Fig 13 Percentage of people involved with each occupation-type in Kuno**

**Attitude and perception of people towards wildlife:** Kuno has people who eat meat once a week or once a month on average. There is also a significant percentage that eats meat everyday; although none of the interviewees' has responded saying that bush-meat is consumed in the area. The main source of meat was stated to be from domesticated animals while some people take fish from the River Kuno.

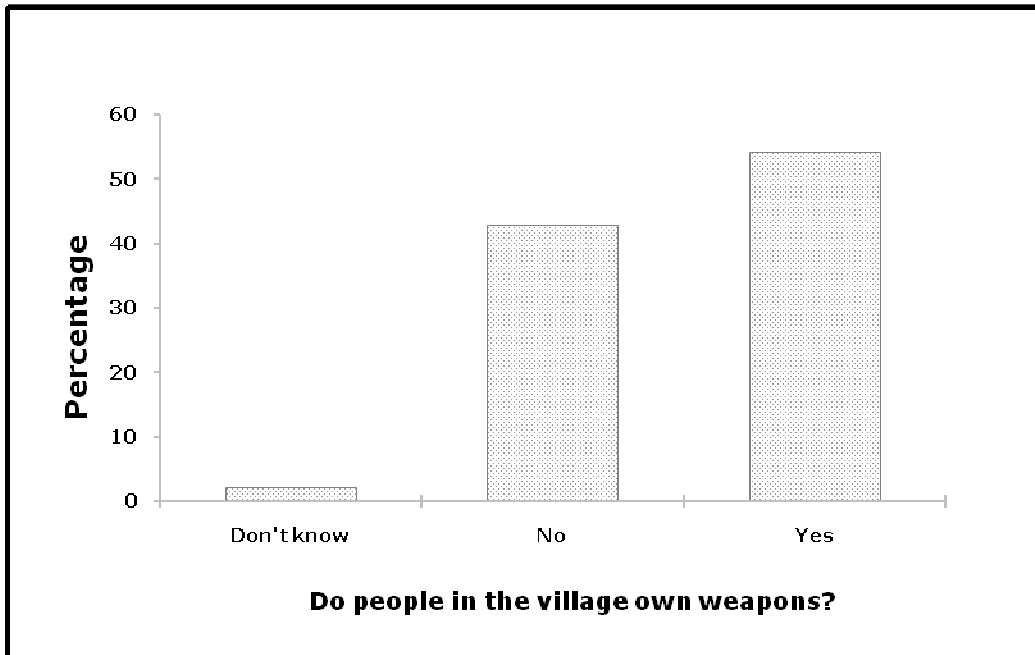
There is a very small percentage of people who confirmed having knowledge of laying traps and snares for animals (Fig. 14). However, we suspect this could be misleading information given by the people who were interviewed, since there were people who seemed reluctant to answer the question and said they did not know anything about traps and snares. A majority of people in the area also own weapons (Fig. 15). Some guns have been legally issued, but there are others who own country-made guns, bows and arrows and catapults (mainly for birds).

A majority of people have problems with crop raiding by ungulates in the area. Wild pigs and nilgai have been reported to be the highest damage-causing species. However the incidences of

livestock depredation were low in the last one year in the area. This is probably due to the high levels of poaching of large carnivores in this area.



**Fig. 14 Percentage of respondents in Kuno providing information on expertise available to set traps and snares for poaching of wildlife**



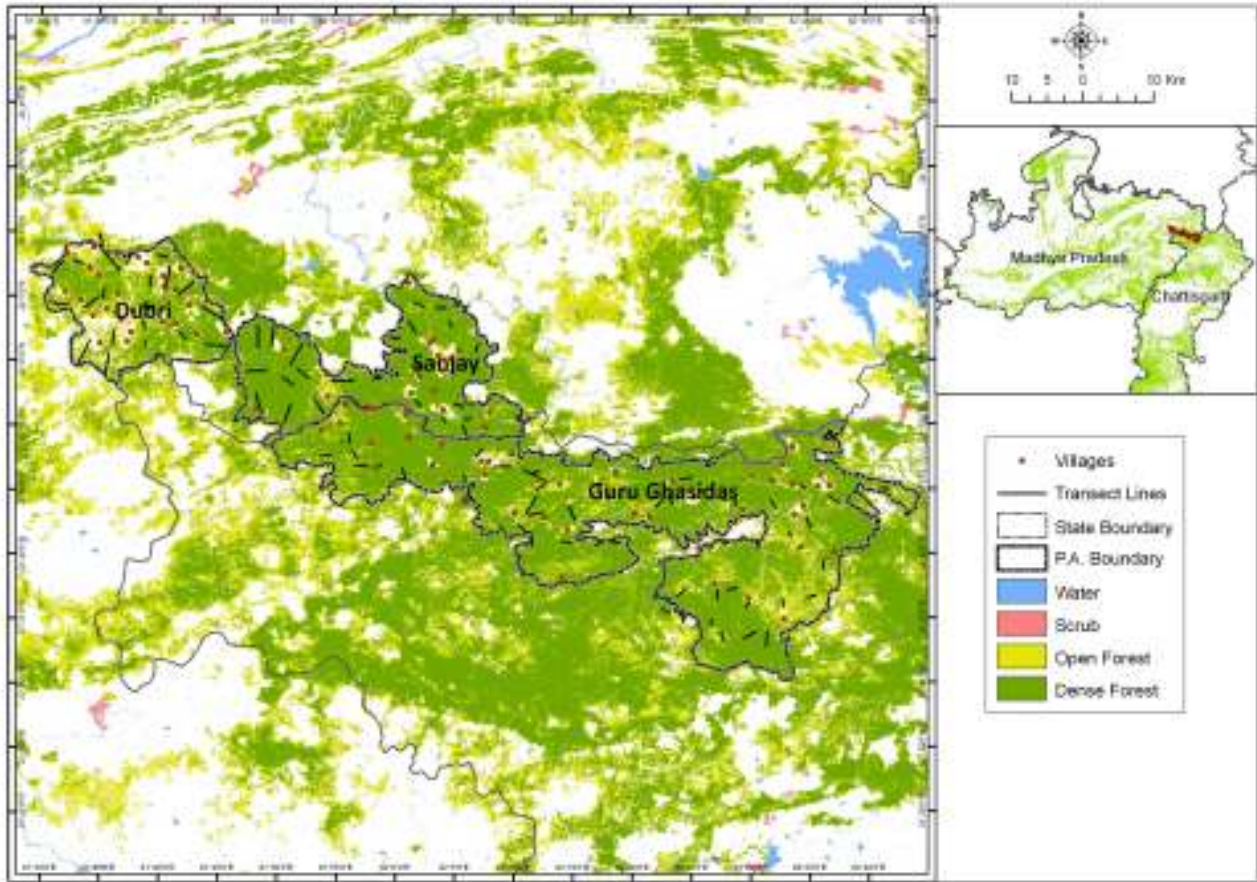
**Fig. 15 Percentage of respondents in Kuno providing information on awareness about people owning weapons in the area.**

### **Potential and Strategy for Kuno-Sheopur Landscape**

The Kuno Wildlife Sanctuary was developed as an alternate site for reintroducing the Asiatic lion. However, the possibility of acquiring wild lions from the Gir Forests of Gujarat seems remote due to political debate. In preparation for the lions, all the human settlements from the Sanctuary area have been relocated. The Sanctuary area has shown remarkable recovery in terms of vegetation and prey. The current carrying capacity of the Sanctuary area is close to 27 cheetah which is likely to increase with time. However, the size of the Kuno Sanctuary area is only 346.68 km<sup>2</sup>, but the size of the forested habitat is over 6830 km<sup>2</sup> extending from Kailadevi part of Ranthambore Tiger Reserve, through the forests of Sheopur to Madhav in Shivpuri. Of this landscape we propose that the area tentatively demarked by the polygon (Plate 6) covering 3200 km<sup>2</sup> be considered as the buffer of Kuno Sanctuary and managed with restorative habitat and eco-development inputs. About 3 settlements (from the north western part in Vijaipur tehsil in Sirhoni north and Aggra West Forest Ranges) may additionally be considered for relocation from

this proposed buffer and included within the core area of Kuno which would enhance the core area by about 150 km<sup>2</sup>. With proper law enforcement after providing due incentives to the local communities, poaching is likely to reduce and subsequently prey densities in this buffer area increase. Assuming that the buffer area achieves just 30% of the prey densities currently recorded in Kuno Wildlife Sanctuary this region can then support over 100 cheetah.

As in the case of all dry deciduous forests undergoing serious demographic impact, fire is a hazard in Kuno, reduced due to the re-settlement of villages, which has also led to a reduction in the extent of grazing, though it does occur more than is warranted, especially on the periphery and would have to be further reduced. The forests are rich in khair (*A. catechu*), prized for its 'katha' contents and mercilessly poached. Further, the area is populated by communities which are traditional hunters, who still practice their wares. If the prey population is to be enhanced, these poaching proclivities will have to be controlled. Again without a set of dedicated personnel at all levels, the goals cannot be attained. Pro-active eco-development activity for the neighboring people, particularly those who have moved out of the Sanctuary and who now move out, and for those who are dependent on forest produce for their livelihoods, would need to be undertaken.



**Plate 8:** The location of Sanjay national park, Dubri wildlife sanctuary and Guru Ghasidas national park showing village locations, transect lines and forest cover.

#### 4.5 Sanjay-Dubri-Guru Ghasidas Landscape

This landscape comprises of the Dubri Wildlife Sanctuary, Sanjay National Park and Guru Ghasidas National Park in the states of Madhya Pradesh and Chhattisgarh. The area is categorized as bio-geographic zone 6: Deccan Peninsula - Central Highlands (Rodgers *et al.* 2002) and has north Indian most deciduous forest type (Champion & Seth 1968). This landscape is connected to Bandhavgarh on the west and Palamau on the east through a series of small unconnected forest patches (Jhala *et al.*, 2008). These forest patches act as ‘stepping stones’ for wildlife movement across this region.

##### a) Dubri Wildlife Sanctuary

Dubri Wildlife Sanctuary (23° 50’ to 24° 5’ N and 81° 25’ to 81° 50’E) covers an area of 364.6 km<sup>2</sup> in Sidhi district of eastern Madhya Pradesh.

**Temperature and Rainfall:** The annual temperature ranges from 41.5° C in summer to 7.5° C in winter with an annual average rainfall of 1168 mm, most of which comes from the south-west monsoon.

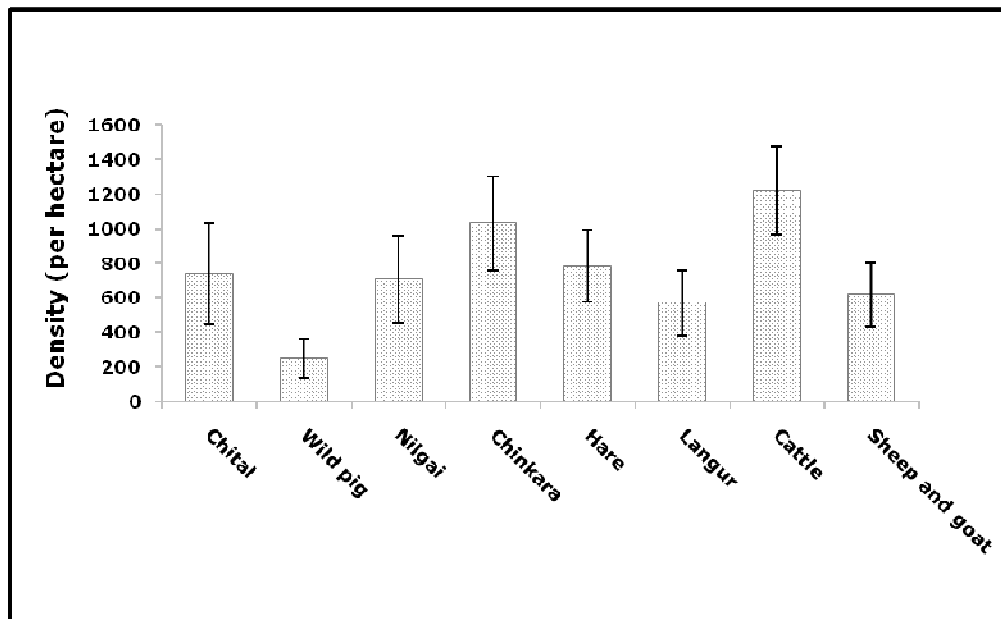
**Wildlife:** With 29 revenue villages within the precincts of the Sanctuary, human-disturbance levels are high supporting low abundances of ungulate species like chital, nilgai, chinkara, wild pig and few carnivores like leopard, sloth bear, hyena , Indian fox, jungle cat and jackal. Hanuman langur (*Semnopithecus entellus*) and rhesus macaque (*Macaca mulatta*) are relatively common.

**Vegetation:** Flora of the region comprises chiefly of deciduous species like *Shorea robusta*, *Madhuca sp.*, *Terminalia tomentosa*, *Anogeissus latifolia*, *Buchanania lanzan* and *Diospyros melanoxylon*.

**People and occupation:** Most communities living within the protected area belong to Gond, Baiga or Kol tribes with restricted employment opportunities and depend heavily on the forest for fuel, fodder, small timber and NTFP collection. Agricultural potential of the area is low with poor quality, low depth soil which requires high quantities of manure. To meet manure requirements of the soil, most inhabitants of the area own large herds of unproductive cattle that graze freely within the protected area accentuating pressures on the park.

**Prey densities:** Within the Sanjay-Dubri-Guru Ghasidas landscape highest ungulate densities are found in this area ( $2.74/ \text{ km}^2 \pm 1.0$ ). When other potential cheetah prey species like the langur and other species weighing  $< 5 \text{ kg}$  are added to the species pool, potential cheetah prey densities for this area increase to  $24.84/ \text{ km}^2 \pm 7.99$ .

**Pellet densities:** The most frequently sighted ungulate in this region was chinkara, thus the high density of chinkara pellets ( $1034/ \text{ ha} \pm 273$ ) in the sampled area can be explained. Chital was the next most common species based on pellet densities. Cattle dung and goat pellets were frequently encountered suggesting that the area supports high livestock densities (Fig. 16).

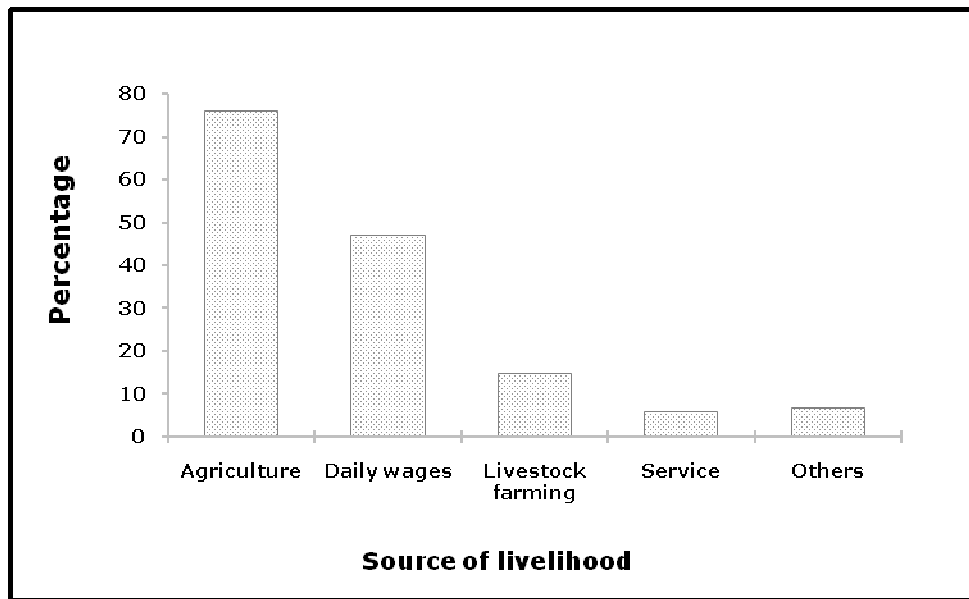


**Fig. 16 Herbivore pellet densities (per hectare) in Dubri Wildlife Sanctuary**

**Human densities:** While the number of villages within this area is relatively few, the area supports high human densities of 789 households/ 100 km<sup>2</sup>. Most villages within the protected area are large with basic facilities like shops and well established road networks.

**Livestock densities:** Livestock densities within the Protected Area are relatively high with cattle constituting 63% of domestic herbivores in the region. However, most of the cattle comprises of indigenous breeds that are unproductive and cause much damage to the forest. Dubri also supports high densities of buffaloes (8.6/ 100 km<sup>2</sup>) and goats (11.6/ 100 km<sup>2</sup>).

**Economic well-being:** The lifestyle of the people in Dubri is quite similar to that in Sanjay National Park. The average land holding is almost the same as Sanjay, i.e. between 6 and 8 acres. Even on the economic well-being index, both these areas score almost equally, and are dominated by tribal communities. The conflict levels with wildlife were found to be really high in this area.

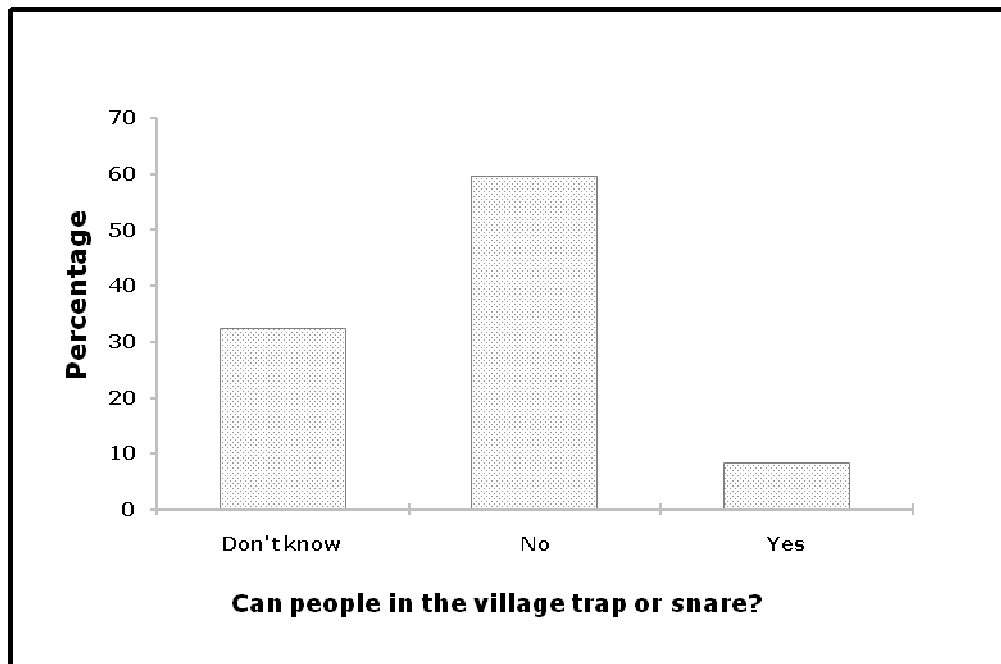


**Fig. 17** Percentage of people involved with each occupation-type in Dubri wildlife sanctuary.

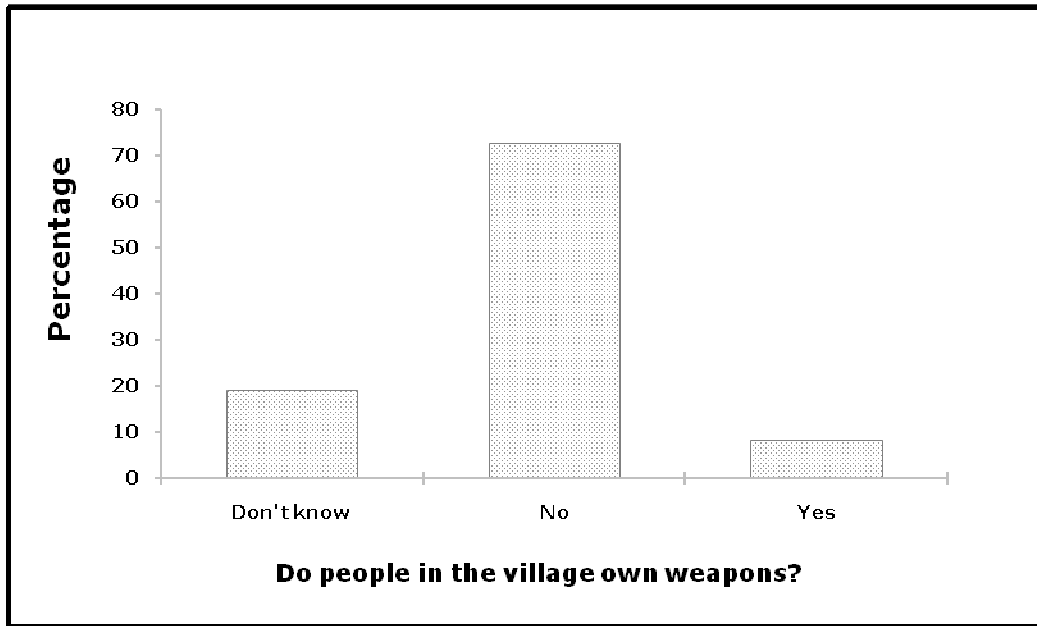


**Attitudes and perceptions of people towards wildlife:** Most people in Dubri eat meat at least once a month on an average, but there are people who eat more frequently like once a week or even everyday. The respondents said that the source of meat is from domesticated animals only. However, we think bush meat may be forming a part of their regular diet. We believe that this is the case as 14.05% of the respondents ( $n=121$ ) said that they do not know what the source of meat is or how often people eat it, but they did say that people do eat meat. This is a veiled response that indirectly agrees to people consuming bush meat. Few respondents also admitted to people in the village having expertise of trapping and snaring wildlife (Fig. 18). There are also a few people who own weapons in these villages (Fig. 19).

Crop raiding is a matter of concern for people in this area, with wild pigs, nilgai, chital and chinkara, forming the highest percentage as species raiding crops. A significant number of people (27%) also said that they faced a problem with depredation by carnivores, and identified leopards and wolves as the biggest predators of livestock.



**Fig. 18 Percentage of respondents in Dubri providing information on expertise available to set traps and snares for poaching of wildlife**



**Fig. 19 Percentage of respondents in Dubri providing information on awareness about people owning weapons in the area**

## **b) Sanjay National Park**

Sanjay National Park (23° 30' to 24° 11'N and 81° 46' to 82° 13' E) is contiguous with Dubri Wildlife Sanctuary on the eastern side. It covers a highly undulating area of 466.7 km<sup>2</sup> of eastern Sidhi district of Madhya Pradesh with altitudinal gradient varying between 425 to 732 m.

**Temperature and rainfall:** Annual temperature ranges from 45° C in June to 7.4° C in winter with an annual average rainfall of 1168.40 mm concentrated mainly between July and October.

**Vegetation:** The moist deciduous peninsular forest (Champion & Seth 1968) of this region is dominated by *S. robusta* with 500 other recorded plant species comprising chiefly of *Madhuca sp.*, *T. tomentosa*, *T. chebbula*, *D. melanoxylon*, *B. lanzan* and *A. latifolia*. The 'pats' have rich forests of *Dendrocalamus strictus*.

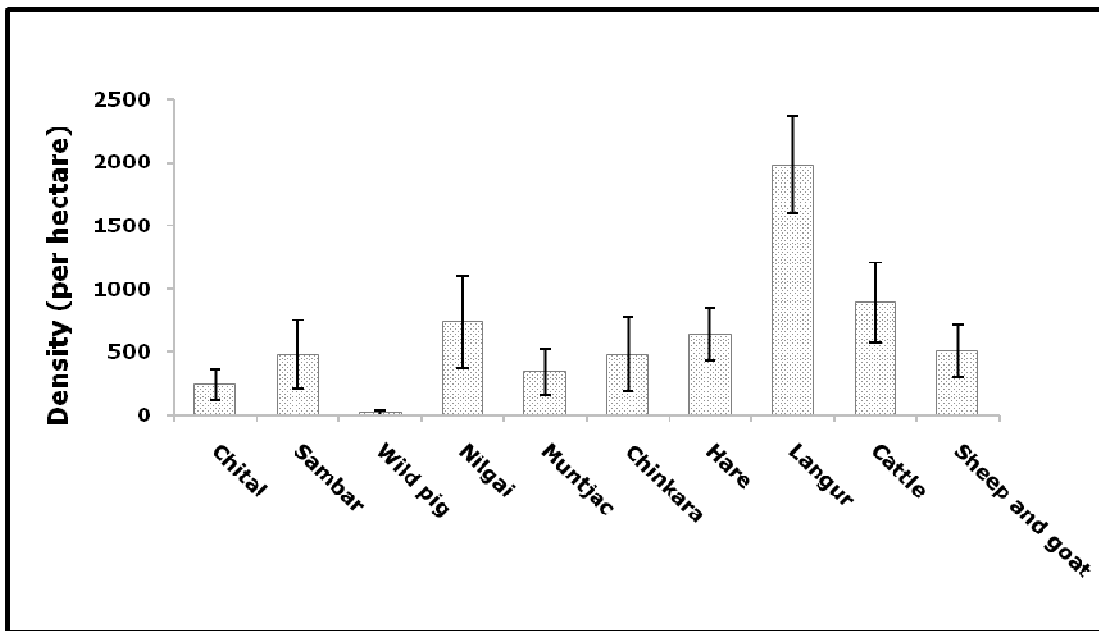
**Wildlife:** The protected area comprises of several plateau like features locally called 'pats'. These host many ungulate species like chital, sambar, muntjak, chinkara, nilgai and wild pig. Elephants (*Elephas maximus*) have also been seasonal migrants to the area in recent times. Carnivores like tiger, leopard, sloth bear, hyena, wolf, jungle cat and jackal occur in the region but in low numbers. The famous 'white' tiger of Rewa was captured in Mohan block of this park in 1951.

**Human life in the area:** The protected area is situated in a part of the Rewa plateau from Mahadeva series of the Gondwana formation. Soils emerging from the ferruginous Mahadeva series breach easily and thus give rise to poor quality, low depth soils. These soils make agriculture difficult. The predominant tribal communities of this area comprising of Gonds and Baigas thus depend on forest activities like NTFP collection for livelihood.

**Prey densities:** Sanjay had the lowest number of ungulate sightings during this study. Most wild ungulates in this region are restricted to the plateau tops where human disturbance is low. The

ungulate density estimate thus obtained for the area was  $1.58/ \text{ km}^2 \pm 0.88$  while the density of all potential cheetah prey for the area increases sharply to  $17.91/ \text{ km}^2 \pm 4.42$ .

**Pellet densities:** The most frequently encountered pellets during this study were those of langur (1983/ ha  $\pm$  384). Pellets of nilgai, chinkara, sambar, chital and wild pigs were also encountered but in very low densities (737/ ha to 26/ ha). Cattle dung and goat pellets were more frequent and constituted 22% of all pellets encountered during sampling (Fig. 20).



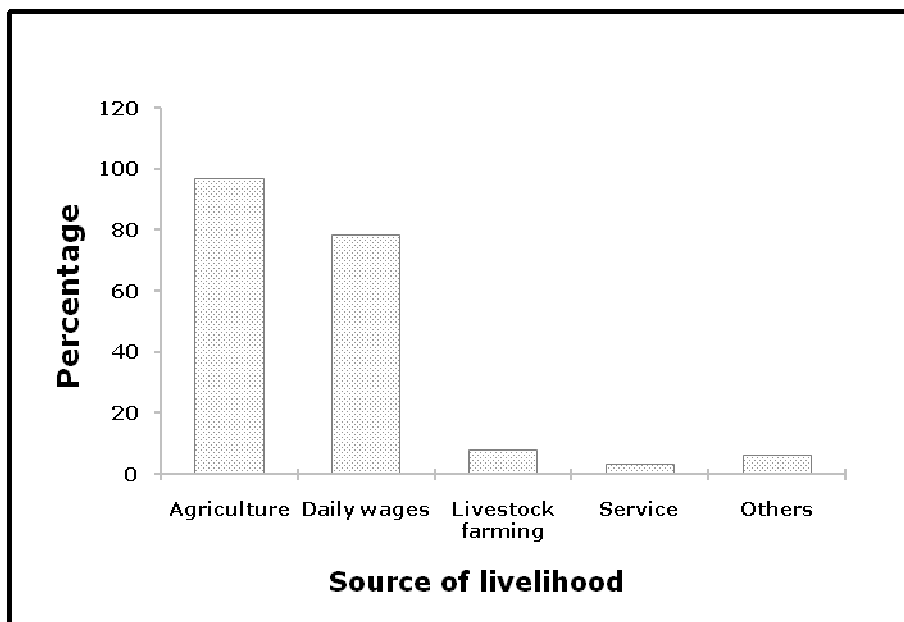
**Fig. 20 Herbivore pellet densities (per hectare) in Sanjay National Park**

**Human densities:** Human density in the region was low with 207 households/ 100 km<sup>2</sup>. The 18 villages located within the park have tribal population with most people depending on agriculture. Certain villages like Runda and Bhadaura located in valleys in the south-eastern part of the park are larger establishments but lack access to basic facilities like electricity and roads.

**Livestock densities:** Total livestock density of this area is low (25.88/ 100 km<sup>2</sup>) compared to most other sites surveyed in this study. Most cattle found in this area comprise of local breeds, domesticated not for milk but for manure which is required for agricultural use. Some people

keep buffaloes in the region; however, goats are more common with a higher density of 9.67/100 km<sup>2</sup>.

**Economic well being:** The main source of livelihood in the area is agriculture, followed by daily wages (Fig. 21). This area is dominated by tribal communities, with a strong resource dependency on the forests. The area also faces a problem of naxalism towards the southern part of the park, which shares its boundaries with Chhattisgarh. People in this area, own land ranging between 6 and 8 acres on average, which is due to encroachment into forest land.

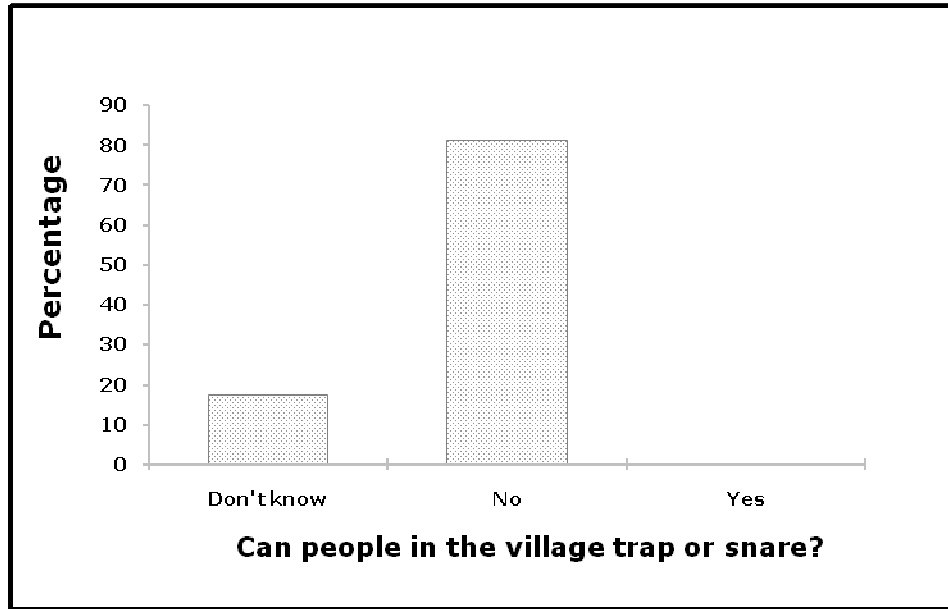


**Fig. 21 Percentage of people involved with each occupation-type in Sanjay National Park.**

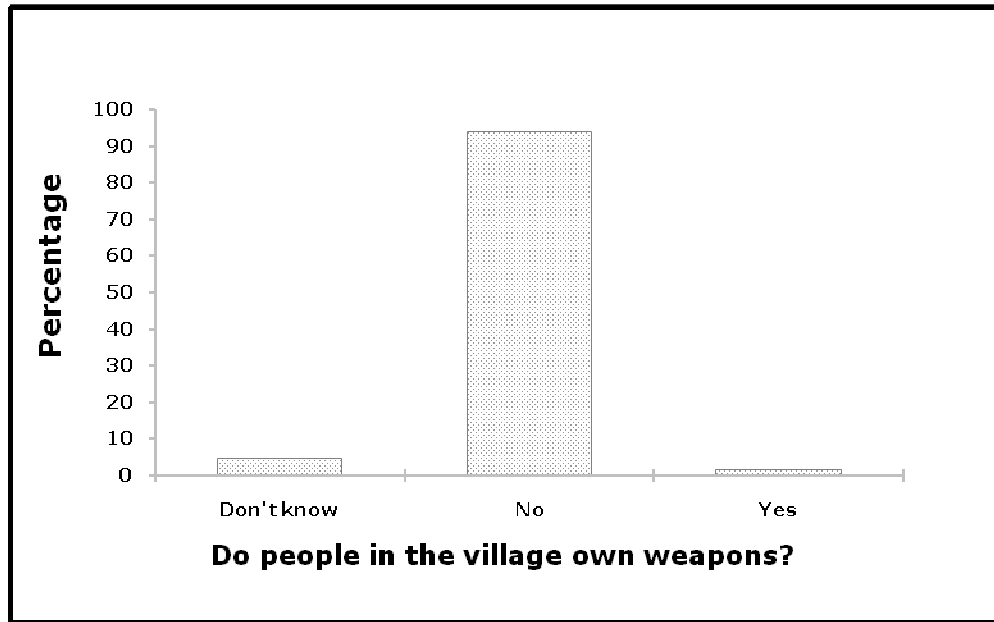
**Attitudes and perceptions about wildlife in the area:** There is an equal percentage of people who eat meat either once in a month or once in a year. And all the respondents ( $n=64$ ) confirmed the source of meat is from domesticated animals.

According to the respondents, there is no one in the area with an expertise on laying of traps and snares for animals, although there is a small percentage that said that they cannot comment on anyone else's way of life. There is a very small percentage who own weapons in the area.

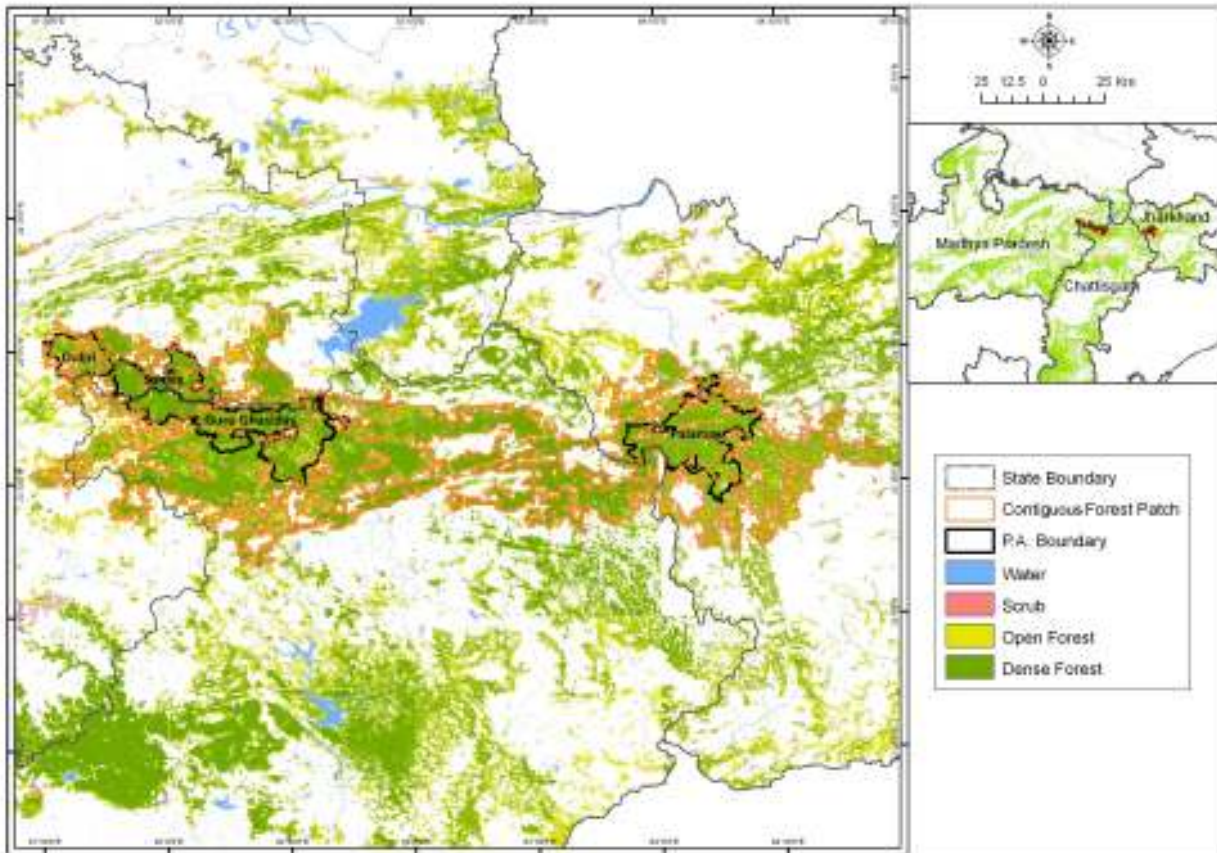
The conflict rate with wildlife is extremely high in this area, due to crop raiding and livestock depredation by wild animals. Nilgai, wild pigs and rhesus macaque were reported to be the highest damage-causing species due to crop raiding, while leopards and wolves scored as the biggest problem as livestock depredators.



**Fig. 22 Percentage of respondents in Sanjay providing information on expertise available to set traps and snares for poaching of wildlife**



**Fig. 23 Percentage of respondents in Sanjay providing information on awareness about people owning weapons in the area**



**Plate 9:** The location of Sanjay, Dubri and Guru Ghasidas in central India showing contiguous forest areas with Palamau tiger reserve in Jharkand



### c) Guru Ghasidas National Park

Guru Ghasidas National Park comprises of 1440.75 km<sup>2</sup> area and is the largest National Park in Chhattisgarh. It was a part of Sanjay National Park in Madhya Pradesh and attained its present independent status when Chhattisgarh was notified as a separate state in 2000.

Spread over parts of Koriya and Sarguja districts, most parts of the park are covered with highly undulating terrain with several peaks and plateaus attaining elevations of over 800 meters.

**Temperature and rainfall:** The mean maximum temperature in this area can be as high as 46° C in summer while winters are warm with temperature usually not plummeting below 10° C. Most of the average annual rainfall of around 1700 mm is received between June and September.

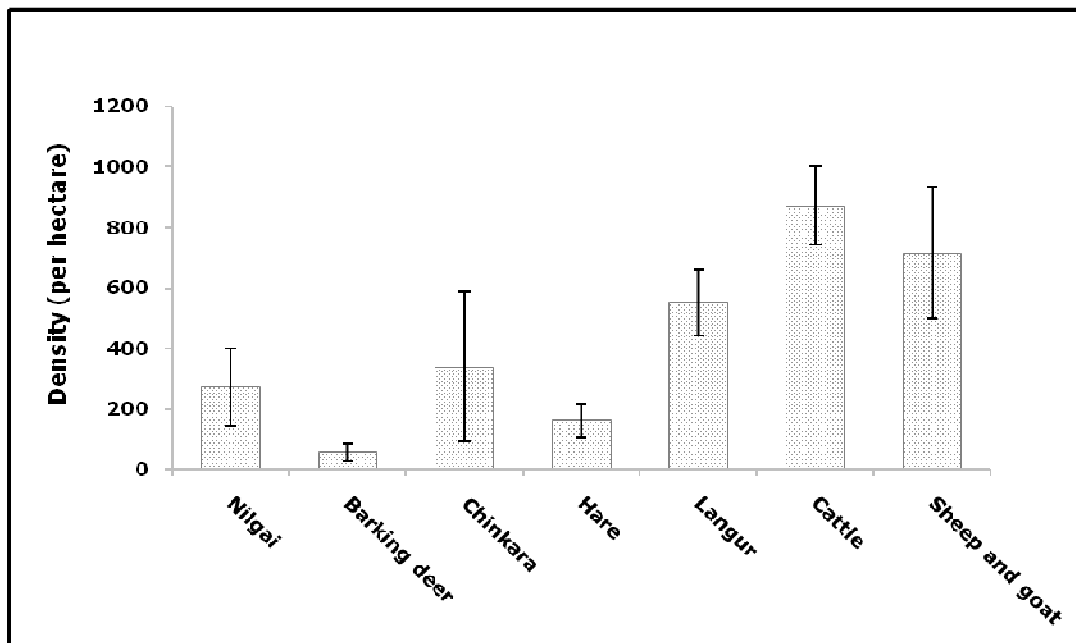
**Vegetation:** Flora of the park comprises chiefly of *S. robusta* with other deciduous species like *T. tomentosa*, *T. chebbula*, *D. melanoxylon*, *D. strictus*, *Madhuca sp.*, *Woodfordia sp.*, etc.

**Wildlife:** Ungulates like chinkara, nilgai, muntjac, sambar, wild pig are rare. Carnivores inhabiting the region include leopard, hyena, sloth bear, jungle cat and jackal. Tigers are known to occasionally visit the area. In recent years a herd of elephants has been seasonally visiting the protected area. Officially the last cheetah were killed near Ramgarh village in 1947, which lies on the periphery of the protected area (Divyabhanisinh 1999). Reports also exist of cheetah having been sighted in 1967 between Turripani and Ramgarh villages of this park (Divyabhanusinh 1999).

**Human life in the area:** Almost the entire human population in this area comprises of Gond, Pando, Panika, Baiga, Korwa and other tribes which depend heavily on the forest. Most of these people depend on NTFP collection as a source of livelihood. Leaves of *D. melanoxylon* and *B. vahii* and flowers of *Madhuca sp.* are collected on mass scale and are often the cause for forest fires. Other forest products commonly collected include *B. lanzan* fruits, *T. bellarica* fruits, *T. chebbula* fruits, *Woodfordia floribunda* flowers, etc.

**Prey densities:** Most people living in this area belong to tribal groups and exert high pressure on wildlife of the region. Thus, prey densities in the region are very low at  $1.77/ \text{ km}^2 \pm 0.58$ . Density estimates for potential prey inclusive of langur result in a density estimate of  $14.8/ \text{ km}^2 \pm 3.27$ .

**Pellet densities:** During this study, very low densities of wild ungulate pellets were seen with those of chinkara ( $339/ \text{ hectare} \pm 246$ ) and nilgai ( $273/ \text{ hectare} \pm 126$ ) being the highest. Livestock dung was observed in most plots with an estimate of  $871 \pm 130$  dung piles/ hectare. Almost 25% of the pellets encountered were those of small stock suggesting that grazing within the Park may be common (Fig. 24).



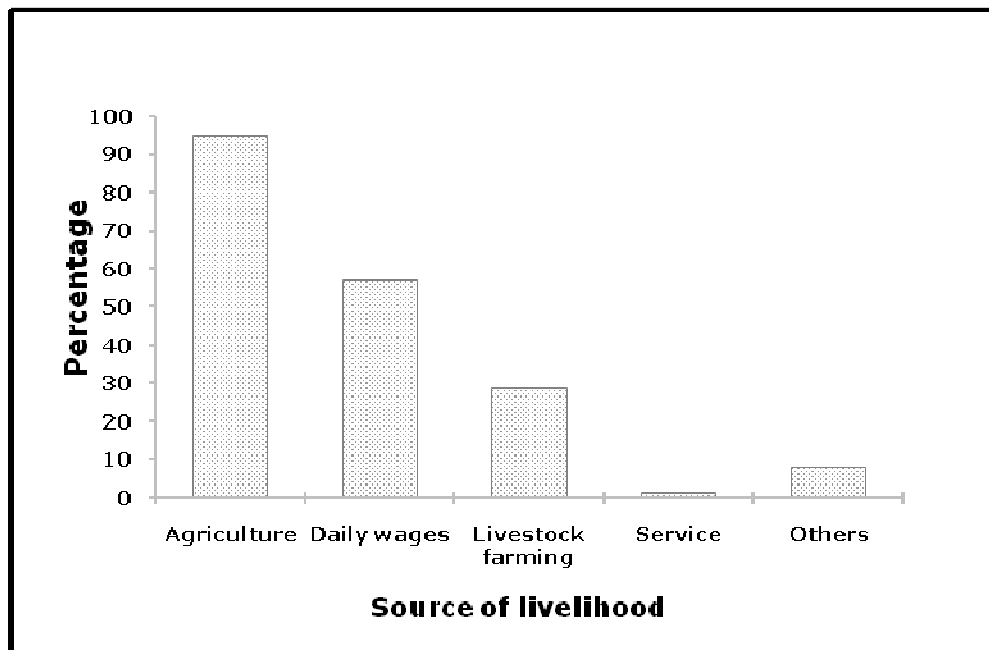
**Fig. 24** Herbivore pellet densities (per hectare) in Guru Ghasidas national park

**Human densities:** This area has a low household density with 79 households/  $100 \text{ km}^2$ . Most of the 40 villages located within the park are accessible by road and have facilities like solar lights. However, isolation from urban centres reduces employment opportunities and thus increases

dependence of people on forest products. The presence of naxal activities in the region also affects developmental initiatives.

**Livestock densities:** Guru Ghasidas has lower livestock densities than any of the other study sites. Total livestock density for the protected area is 11.4 animals/100 km<sup>2</sup> with cattle being the most common (6.3/100 km<sup>2</sup>). Goats are also kept by people and have a density of 4.2/100 km<sup>2</sup>.

**Economic well-being:** People in Guru Ghasidas National Park have been provided with solar electricity connections, also there are better roads connecting most villages as compared to Sanjay and Dubri. However, the area is difficult to live in due to the presence of naxals. Lifestyle wise, people in this area are very similar the ones from Sanjay and Dubri. During the flowering season of Mahua, there are regular incidences of people setting fires to the forest, resulting in high forest-people conflict in the area.



**Fig. 25 Percentage of people involved with each occupation-type in Guru Ghasidas**

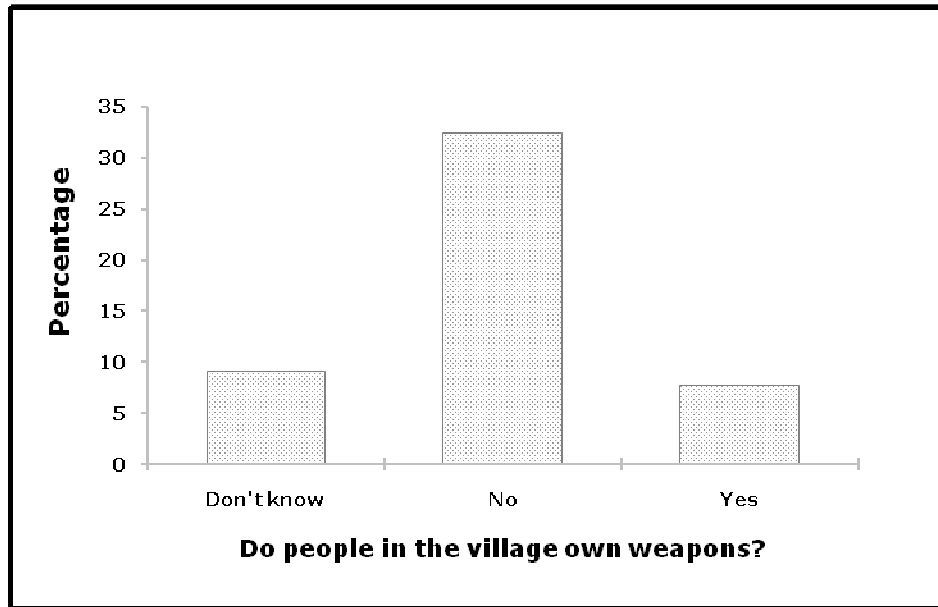
**Attitudes and perceptions of people towards wildlife in the area:** People in this area had mixed responses for the frequency of eating meat. Most people eat meat once a month; however there are people who eat meat once a year, once a week or even everyday. The main source of meat is from domesticated animals, but there is a small percentage of people who take fish from the rivers.

There is a small percentage of people who can set traps and snares for animals (Fig. 26), although a majority of the respondents ( $n=77$ ) replied in negative to the question. People in this area also own weapons (Fig. 27).

This area has a major problem of crop raiding by wild animals, mostly by wild pigs, chinkara and nilgai. Due to high incidences of livestock depredation by carnivores, mainly leopard and wolves, there is a high level of conflict and hostility between people and the Park.



**Fig. 26 Percentage of respondents in Guru Ghasidas providing information on expertise available to set traps and snares for poaching of wildlife**



**Fig. 27 Percentage of respondents in Guru Ghasidas providing information on awareness about people owning weapons in the area**

**Potential and Strategy for Sanjay-Dubri-Guru Ghasidas National Park Landscape:**

Sanjay National Park, along with Dubri Wildlife Sanctuary is part of the newly declared Tiger Reserve in Madhya Pradesh. Guru Ghasidas National Park in Chhattisgarh along with the two protected areas of Madhya Pradesh form a continuous chain of Protected areas. These protected areas lie almost at a central location in the tiger landscape from Bandavgarh in Madhya Pradesh to Palamau in Jharkhand. In early 1940's to 1960's these forests must have been continuous with Achanakmar Tiger Reserve in Chattisgarh. The sheer size of this landscape possibly was the single most important factor that permitted the persistence of the cheetah in this landscape till the 1960's (Divyabhanusinh 1999 ). Both Sanjay and Dubri would benefit immediately from the scheme under Project Tiger which makes it mandatory within Protected Areas to designate core and buffer zones and make the core inviolate by relocation of human settlements (Gopal *et al.* 2009). We further propose that Guru Ghasidas National Park also be brought under the scheme of the Tiger Reserve and be provided additional resources for management, law enforcement, and relocation of settlements from the core areas. Our assessment and interaction with the local communities suggests that the people in this area are most willing to move out of the forests to

be free of the Naxal menace and avail modern amenities of health care, education, power, and transportation. An in-depth assessment would be required to delineate the core areas of these proposed Tiger Reserves. Most communities residing in Guru Ghasidas National Park and Dubri Wildlife Sanctuary were willing to translocate. The prey densities in the region are highly depressed since the tribal communities traditionally hunt wildlife. In spite of these depressed prey density the current carrying capacity estimated for cheetah was about 14 individuals which could be enhanced to over 50 with the suggested policy and management inputs. The landscape could potentially support over 60 cheetah. The suggested inputs would be beneficial for recovering the area as a potential site for cheetah reintroduction; it will also serve to enhance the potential of the area to serve as a potential source for tiger populations. Currently tigers are occasionally recorded throughout this landscape; the major source for these tigers is likely to be Bandhavgarh Tiger Reserve located in the west. If cheetah populations are brought back in this landscape and suggested recommendations implemented the habitat would become conducive for tiger populations as well. Once cheetah populations are established they should be able to coexist with tigers as was the case in the recent historical past in the same landscape (Divyabhanisinh 1999).

#### 4.6 Banni grasslands

Banni grasslands along with the Kachchh Desert Sanctuary, cover approximately 5000 km<sup>2</sup> area in the Kachchh district of north-western Gujarat. Champion and Seth (1968) classify this area as Tropical thorn Forest and it falls within the bio-geographic zone 3b: Desert Kachchh (Rodgers *et al.* 2002). The region lies south of the Rann of Kachchh mud-flats and parts of it get inundated by sea water during the rainy season. However, the area sampled for this study covers mostly parts of the Banni, stretching from Hajipeer in the west to Dadar in the east and Khavda in the north, to Jura in the south. A small part of the Kachchh Wildlife Sanctuary around Kala Dungar on Pacham Island was also sampled.

**Temperature and rainfall:** Annual summer temperatures in the region can be as high as 50° C (Ferroukhi 1996), with high diurnal variations in temperature. Droughts are frequent, with less than 250 mm of annual average rainfall (Ferroukhi 1996). Almost all rain comes from the south-west monsoon between July and September.

**Wildlife:** During the monsoon, several non-perennial rivers drain into this area, giving rise to ephemeral wetlands, locally called ‘*dhand*’, that provide habitat to migratory waterfowl. Chaari Dhand is one such wetland in the region, designated as an IBA site and proposed as a Ramsar site, covering around 80 km<sup>2</sup> area.

Wild ungulate abundances are abysmally low, with very few chinkara, nilgai and wild pig. The region had low density blackbuck populations till 1960s, after which they were hunted out by the predominantly Muslim tribal communities (Williams, 1981). Carnivores found in the region include hyena, wolf, jackal, Indian fox, caracal and jungle cat. Great Indian bustard have been reported from the area but none are seen in recent times, the closest breeding population of GIB is in Abdasa grasslands about 40 km away. Lesser florican, and Houbara bustard are still seasonal visitors to the Banni and fringes of the Kachchh desert.

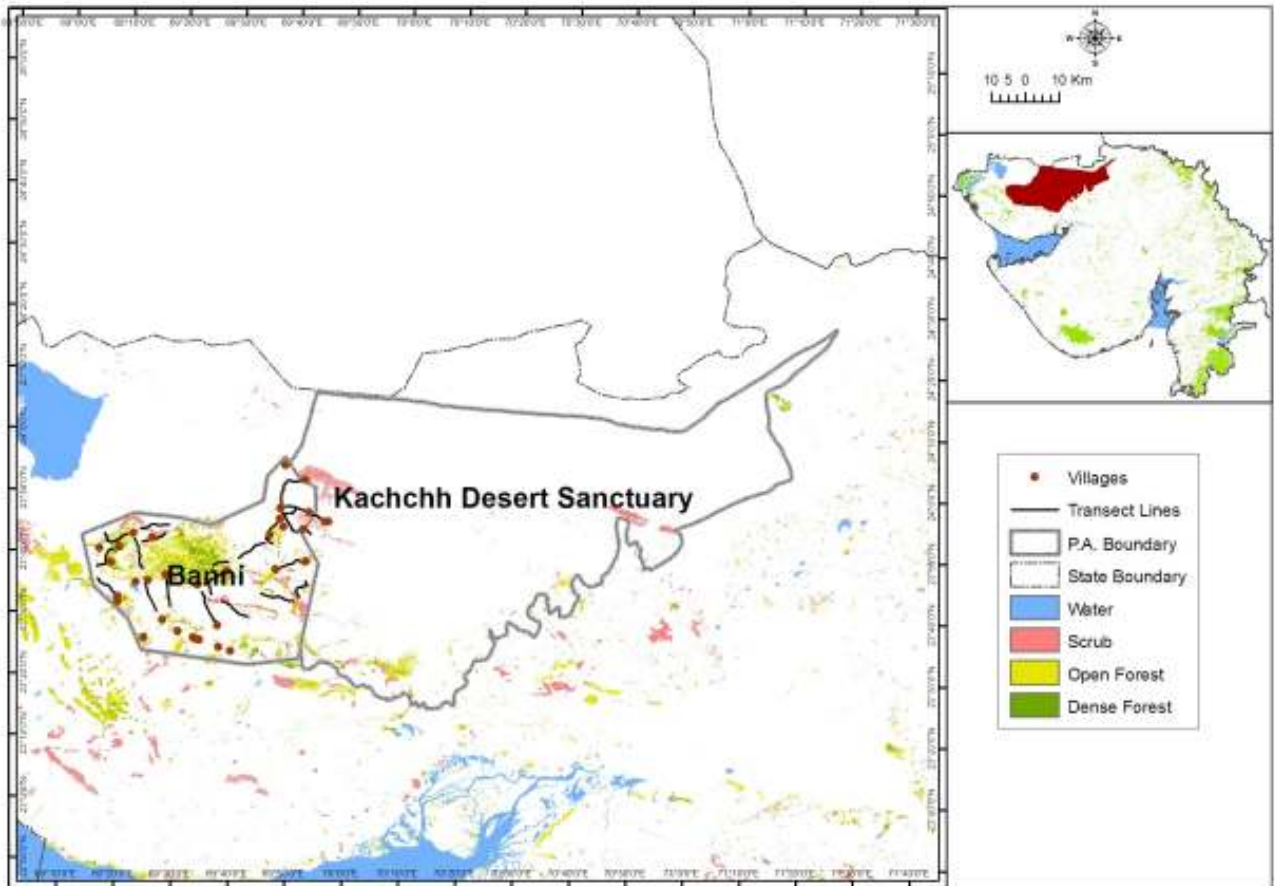
**Vegetation:** Around 32 species of palatable but salt tolerant grasses have been reported from the Banni (Das & Bhatti 2010). However, most parts of central Banni, east of Hajipeer to Ghadiyado are entirely choked up by *P. juliflora* that grows profusely in this area. Saline flats which are common in this region, are dominated by *Suaeda sp.* Further away from the saline flats species like *Salvadora oleoides* and *Calotropis procera* can be seen. The Kachchh Wildlife Sanctuary has scrub type vegetation comprising chiefly of species like *A. senegal*, *A. leucocephala*, *Zizyphus sp.*, etc.

**Human communities:** Present day Banni was preserved as a grazing zone by the erstwhile ruler of Kachchh, Maharao Khengarji and agricultural operations in the area were prohibited (Das & Bhatti 2010). This was mainly for the benefit of the pastoralist community found in this region called 'Maldharis'. Most 'Maldharis' even in the contemporary era depend almost entirely on revenue generated from livestock. They maintain a breed of buffalo, called the Banni buffalo that has high resistance to disease, and can survive on salt tolerant grass species and has a high milk yield (Das & Bhatti 2010). Banni is also famous for the Wagad breed of draught bullocks, the largest indigenous breed in India. Other than Maldharis, the region also has people from the Meghwal community. Most of the Meghwal families in this region make intricate embroidery and are known for their handicrafts.

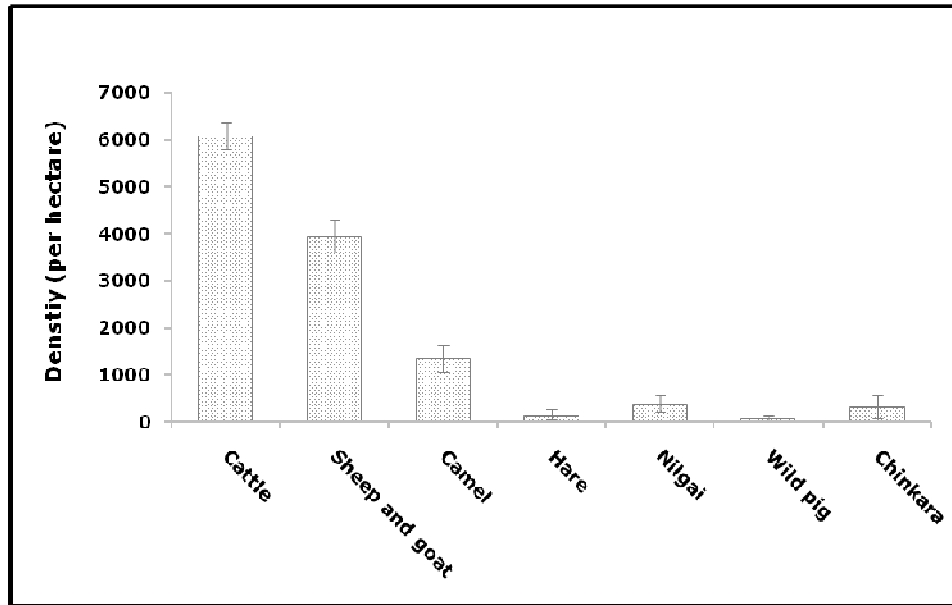
**Prey densities:** Low prey sightings in this region made it difficult to determine prey densities using the DISTANCE method. Thus, encounter rates for sightings were generated using data obtained during line transects. Encounter rate for sighting/ km was 0.05/ km  $\pm$  0.02 while encounter rate for ungulates was 0.03/ km  $\pm$  0.01.

**Pellet densities:** Livestock dung was frequently encountered in the sampled plots, with an estimated density of 6091  $\pm$  297 dung piles/ ha. Sheep, goat and camel pellet densities were also high indicating that livestock grazing in this region is common. Wild herbivore pellets were very few, with nilgai being the most frequent (396/ ha  $\pm$  172), followed by chinkara (316/ ha  $\pm$  249). As per responses to the questionnaire survey conducted in the area, wild pig is known to be common; however, frequency of wild pig pellets was low (Fig. 28).





**Plate 10:** The location of Banni grasslands and Kachchh Desert Wildlife Sanctuary in Gujarat. The sampled transects and villages in the Banni are shown.



**Fig. 28 Herbivore pellet densities (per hectare) in Banni Grasslands**

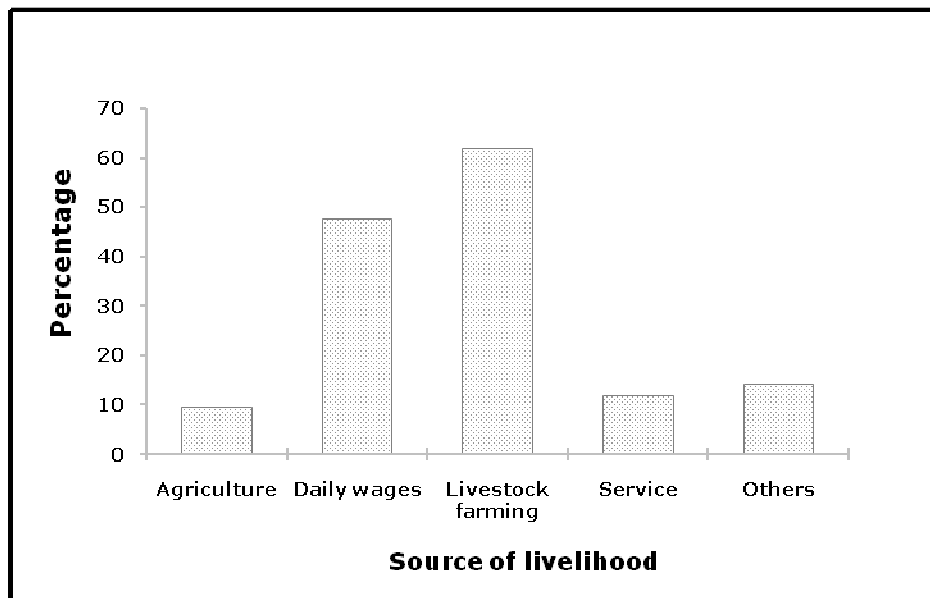
**Carrying capacity:** With the existing cheetah prey base, Banni grasslands can sustain only two cheetah. However, the Banni area is flanked by the Narayan Sarovar Wildlife Sanctuary on the west and the Kachchh Wildlife Sanctuary on the east, encompassing over 5000 km<sup>2</sup> of area. With proper management strategies and plans to restore the habitat in this presently degraded system, ungulate densities can increase substantially. Under such conditions it would be possible for this region to support as many as 55 cheetah, as per carrying capacity estimates.

**Human densities:** The sampled area had 31 villages with a household density of 978 households/ 100 km<sup>2</sup>, making this one of the most densely populated study sites in this study. Most of the people in this area are ‘Jatt’ Muslim Maldharis, depending almost entirely on pastoralism. The region is not very well connected with the mainstream, though developmental activities are fast changing this area.

**Livestock densities:** As per the livestock density index, livestock densities in the region are very high, with most families owning buffaloes. The total livestock density for the region was estimated at 207 animals/ 100 km<sup>2</sup>, with buffaloes being the most common (152/ 100 km<sup>2</sup>)

followed by sheep (30/ 100 km<sup>2</sup>). People in this area also own horses and donkeys of which horses are sold for a high price. While several camels were frequently sighted in this landscape, no respondent of the questionnaire survey owned any, thus making it difficult to compute a density index for the species in this region.

**Economic well-being:** This area is a completely flat terrain with salt encrustations, which makes agriculture an unviable option as a source of income for everyone. People in the area depend mainly on buffaloes and horses. Banni buffaloes are infact famous for their quality. After livestock farming, people depend mainly on daily wages as an alternate livelihood source (Fig. 29).



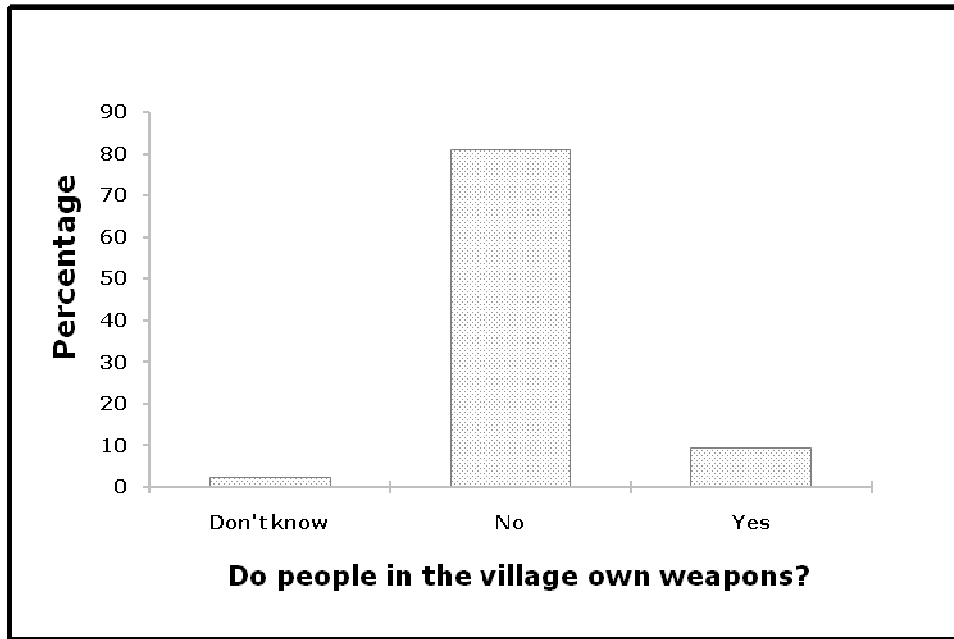
**Fig. 29 Percentage of people involved with each occupation-type in Banni**

**Attitudes and perceptions towards wildlife in the area:** People in Banni eat meat about once a month. However, there are people who ate meat more frequently, like almost everyday or even as occasionally as once a year. Majority of the people (69%) said that the source of meat came from domesticated animals, while the others chose not to answer.

There is a small percentage of people who confirmed that people in this area could lay traps and snares for animals (Fig. 30). There are also some people who own weapons (Fig. 31). Only a few people in the area (4 out of the 42 interviewees) own agriculture land. The area is highly unsuitable to harbor a number of predators, due to persecution and low prey densities. Therefore, instances of crop raiding, and livestock depredation are low. Only feral dogs are known to kill livestock, while crop raiding is mainly by nilgai and wild pig.



**Fig. 30 Percentage of respondents in Banni providing information on expertise available to set traps and snares for poaching of wildlife**



**Fig. 31 Percentage of respondents in Banni providing information on awareness about people owning weapons in the area**

### **Potential and Strategy for Banni-Kachchh Desert Wildlife Sanctuary**

The sheer size of the landscape available as a potential habitat for the cheetah is the plus point of this area. However, the current wild prey densities are extremely low. Even after a substantial effort our team did not obtain sufficient sightings of prey to do a computation of their densities. Prey species were sighted at great distances fleeing from the vehicle. Most communities living around the region are non-vegetarian. It seems likely that prey densities were depressed due to poaching. Both the principle investigators of this project have been visiting this site since the past several decades and can vouch for the potential that this area has in terms of supporting wild ungulates. A diversity of ungulate species existed and can potentially exist at reasonably good densities. These include chinkara, wild pig, nilgai, blackbuck, and Asiatic wild ass (*Asinus hemionus khur*). These ungulate species could be restored, but would require extreme commitment from the State Government in enforcing strict protection, evolving and implementing a policy of rotational grazing and reducing livestock density. Some areas (10%) strategically located within Banni and the Kachchh Desert Wildlife Sanctuary should be made

inviolate with no human activity including livestock grazing. If restored this area has the potential to support over 50 cheetah.

## 4.7 Bagdara-Kaimur Landscape

This landscape spans across the states of Madhya Pradesh and Uttar Pradesh and encompasses the Bagdara Wildlife Sanctuary and Kaimur Wildlife Sanctuary. The area is classified under the Deccan peninsula – Central highlands (Zone 6A) bio-geographic zone (Rodgers *et al.* 2002) and has northern mixed deciduous forest type (Champion & Seth 1968).

### a) Bagdara Wildlife Sanctuary

Bagdara Wildlife Sanctuary comprises a total area of 478 km<sup>2</sup> and is situated in the Sidhi district of Madhya Pradesh. It includes 231.05 km<sup>2</sup> as protected forest and 246.95 km<sup>2</sup> of revenue and other land. It is situated on the north-eastern boundary of the state and forms a boundary with Uttar Pradesh. The river Belan forms the northern boundary between Bagdara (M.P.) and Kaimur (U.P) wildlife sanctuaries, while the river Son forms the Sanctuary boundary towards the south. Bagdara WLS has plateaux with flat tops and the slopes of the hills are moderate to steep.

**Temperature and Rainfall:** The climate of Bagdara Wildlife Sanctuary is tropical in nature with temperatures in summer soaring to above 45° C. (Negi 2002). The average winter temperature is about 34° C. The annual average rainfall is between 777.2 mm to 1196.6 mm.

**Vegetation:** The mixed deciduous forest type of the region comprises of species like *Boswellia serrata*, *Haldina cordifolia*, *Madhuca longifolia*, etc. The middle story of the canopy is mostly dominated by *Butea monosperma*, along with *Acacia katechu*, while *Ziziphus sp.* and *Woodfordia fruticosa* make up the lowest canopy cover.

**Wildlife:** Bagdara Wildlife Sanctuary is famous for its blackbuck population. However, other ungulates like nilgai, chinkara, sambar, chital and wild pig are also seen. Carnivores found in the area include hyena, jackal, Indian fox and sloth bear. Langurs are seen in good numbers in the area.

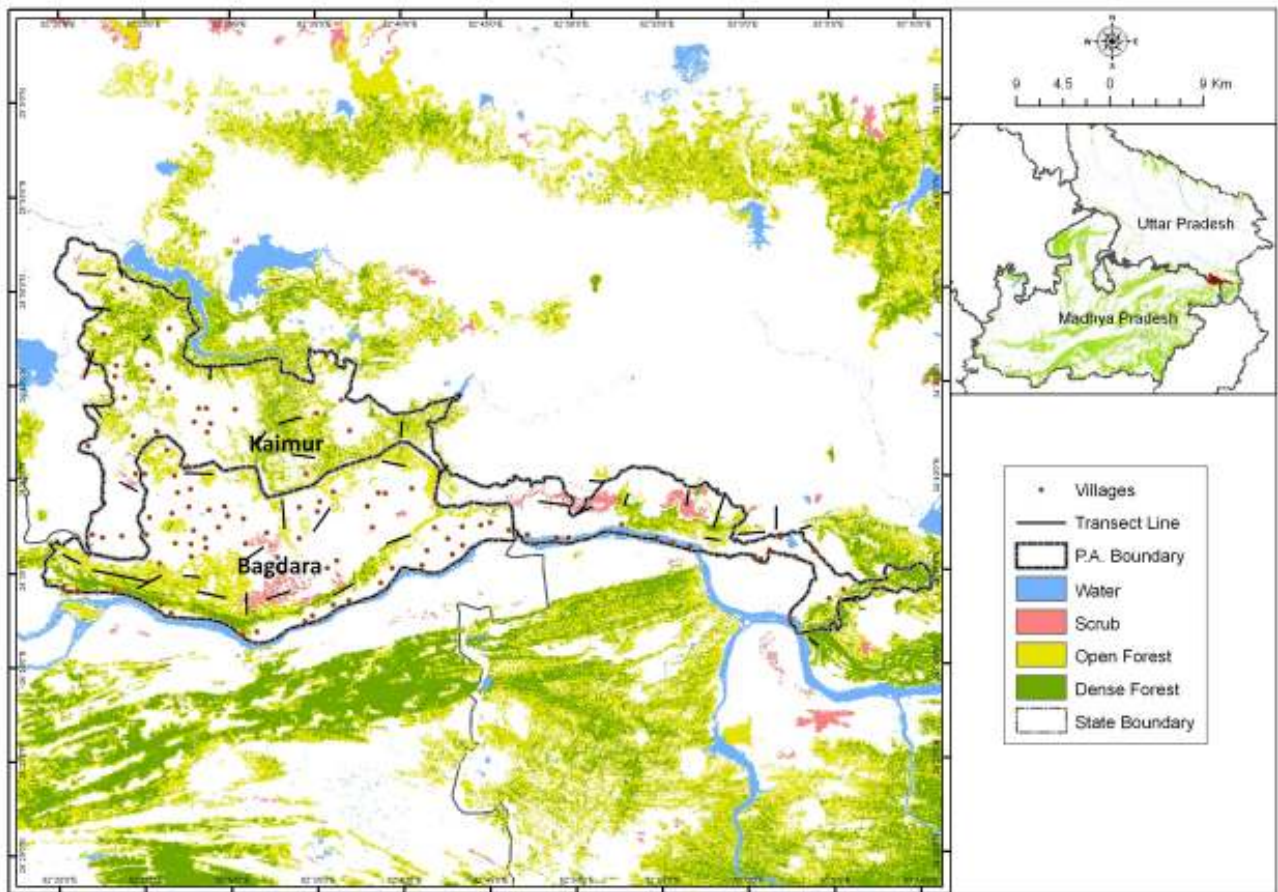
**Human life in the area:** Bagdara Wildlife Sanctuary is one of the most unique protected areas, considering the co-existence factor between man and wildlife. More than 50% of the park area is occupied by human habitation. It has tribal communities like Gonds, Kohls, and Baigas, which are traditional hunting communities. People belonging to the Kavar community, on the southern side of the park, are basically fishermen by occupation, although they have now also adapted their lifestyles to agriculture. Thakurs, found in most villages, are some of the most influential people in the area. They own large agricultural lands and in certain villages, the entire village population is employed to work on their farm.

People in the Forest Department are very strict in terms of law enforcement and, that coupled with the tolerance and resilience of the locals in the area towards wildlife has resulted in a good ungulate population within the Sanctuary.

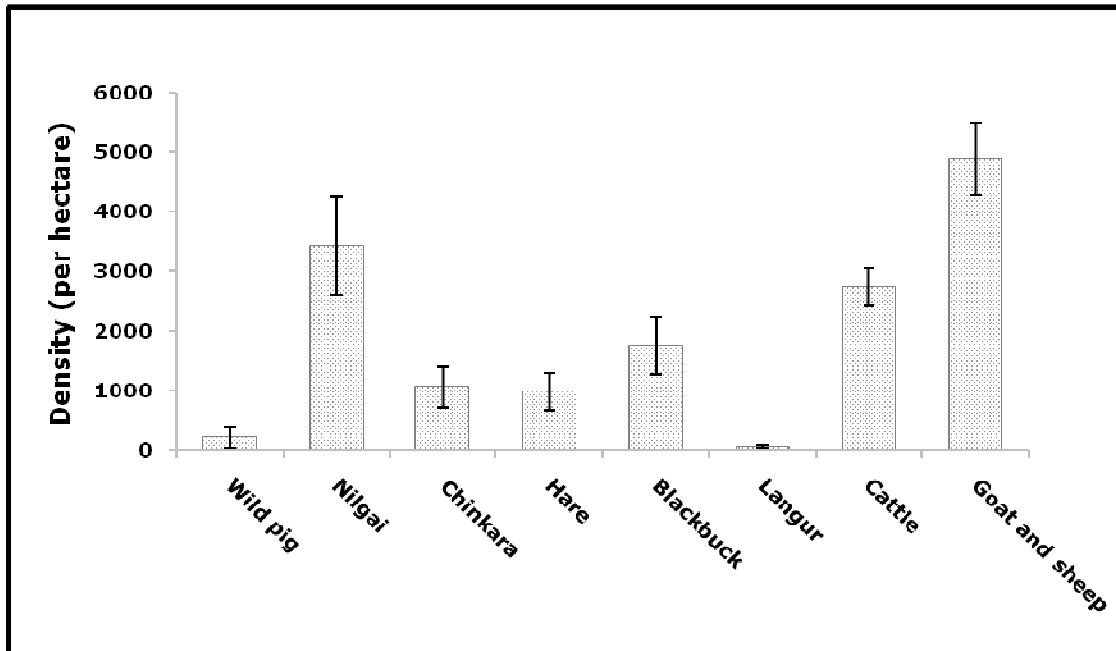
**Prey densities:** The Protected Area has high densities of ungulates ( $8.26/ \text{ km}^2 \pm 1.91$ ), with nilgai and blackbuck being the most common. Total prey densities inclusive of all potential cheetah prey species, are slightly higher ( $9.90/ \text{ km}^2 \pm 1.9$ ).

**Pellet densities:** Livestock pellet densities for this region are high, with small stock contributing to 32% of all pellets encountered during sampling. Amongst wild ungulates, nilgai pellets were most abundant ( $3433/ \text{ ha} \pm 819$ ), followed by blackbuck ( $1753/ \text{ ha} \pm 489$ ), in concurrence with the frequency of prey sightings on transects (nilgai ( $n=23$ ) blackbuck ( $n=18$ )). Chinkara ( $1062/ \text{ ha} \pm 352$ ) and hare ( $988/ \text{ ha} \pm 307$ ) pellets were also found in high densities within the sampled plots (Fig. 32).





**Plate 11:** The location of Bagdara and Kaimur wildlife sanctuaries showing village locations, transect lines and forest cover.



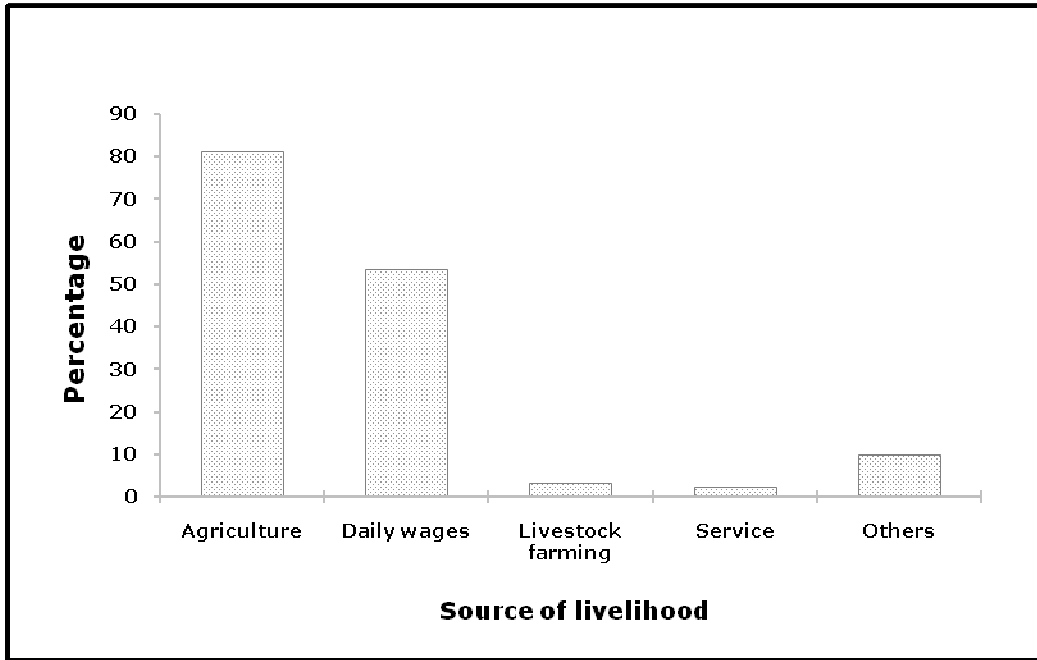
**Fig. 32 Herbivore pellet densities (per hectare) in Bagdara wildlife sanctuary**

**Human densities:** Human densities within this region are very high, with 1501 households/ 100 km<sup>2</sup>. There are 64 villages within the protected area boundary of the Wildlife Sanctuary. Most of these villages are scattered and cover large areas, making an almost continuous chain of human settlements over the region. The only area devoid of human settlements within this Sanctuary is the plateau ridge line, which is steep and difficult to access.

**Livestock densities:** As per the livestock density index based on responses to the questionnaire survey, this area has high livestock densities, with 130 animals/ 100 km<sup>2</sup>. Cattle comprises 73% of the domesticated animals while goats come next, with a density of 23.5 animals/ 100 km<sup>2</sup>. Buffaloes are also kept by the people.

**Economic well-being:** The main source of income for most people in the Bagdara Wildlife Sanctuary is agriculture (Fig. 33). However, there is a major water shortage in the area and, therefore, water sources for irrigation are highly restricted in the dry season. Since during the summer season the water table drops drastically in the area, people need to take up other means of income, such as daily wages. Also, the area faces a problem with illegal encroachments into

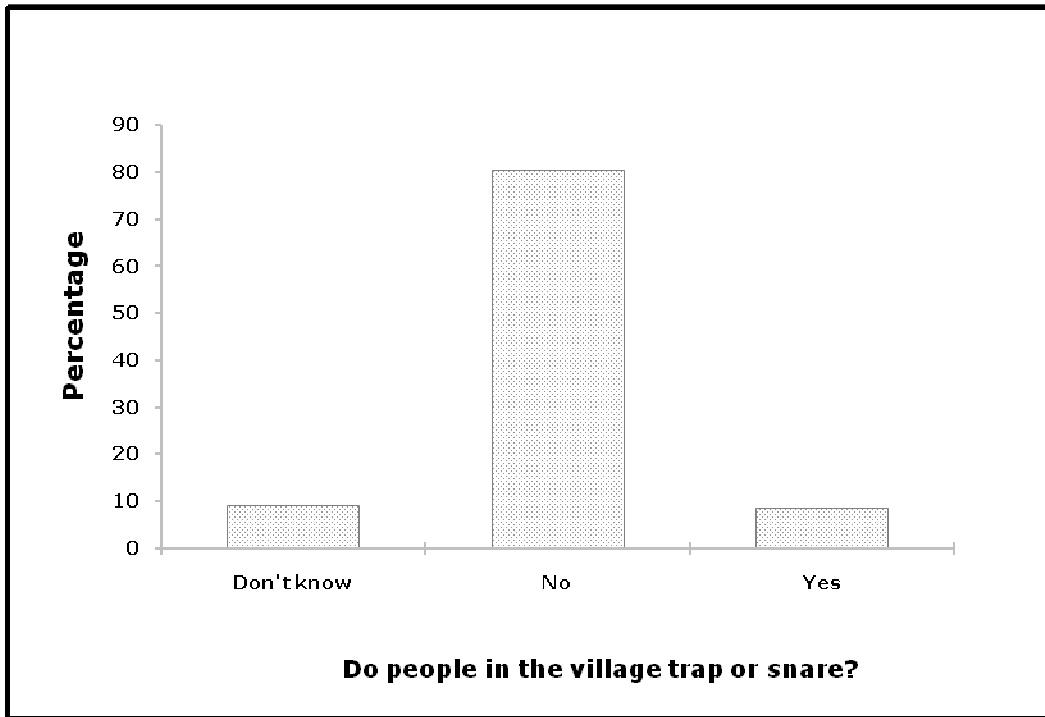
the forest area. Even though Bagdara ranks highest in terms of average land holding, the quality of life in general was found to be poor. However, people in the area show great understanding of and resilience to wildlife in the Sanctuary.



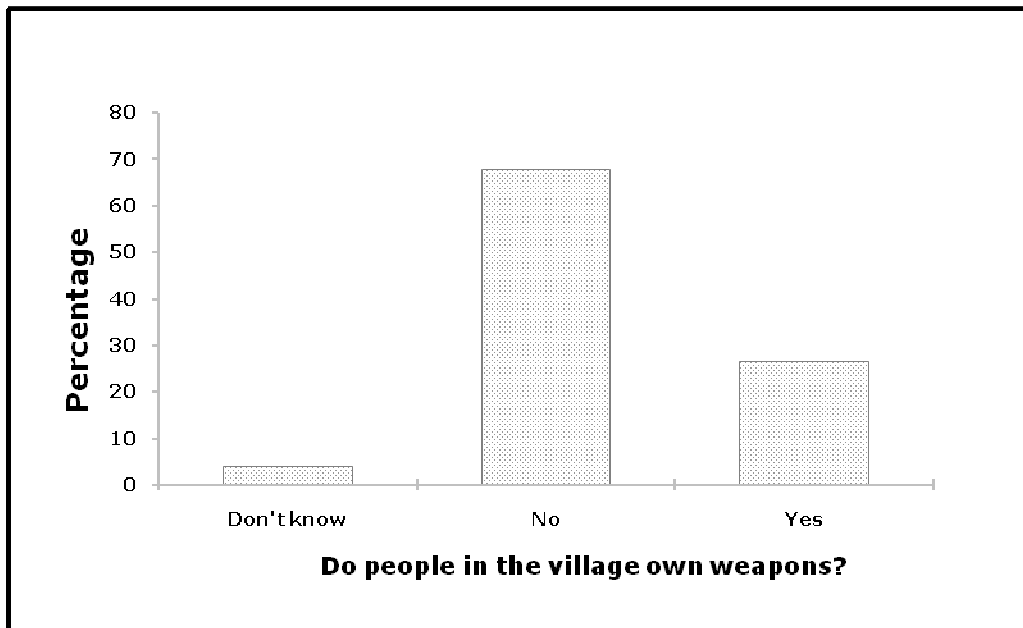
**Fig. 33 Percentage of people involved with each occupation-type in Bagdara**

**Attitudes and perceptions of people towards wildlife:** People in the Bagdara Sanctuary had mixed responses when it came to meat eating. This is directly related to the community structures and also to economic status of each household that influences their preferences of eating meat. Although most people eat meat from domesticated animals like goats and poultry, people living close to the river on the southern boundary of the Sanctuary take fish from the river Son regularly. A small percentage of people also eat bush meat.

There are people in Bagdara who know how to set traps and snares for animals (Fig. 34) and there is a significant number who own weapons (Fig. 35). This can be considered as an indirect indicator of their tendencies to hunt animals. Due to the high density of ungulates in the area, people experience a significant amount of crop-raiding.



**Fig. 34 Percentage of respondents in Bagdara providing information on expertise available to set traps and snares for poaching of wildlife**



**Fig. 35 Percentage of respondents in Bagdara providing information on awareness about people owning weapons in the area**

## **b) Kaimur Wildlife Sanctuary**

Kaimur Wildlife Sanctuary (24° 33' to 24° 73' N and 82° 12' to 82° 21' E) is situated in the Mirzapur and Sonbhadra districts of Uttar Pradesh, on the border with Madhya Pradesh. It covers an area of 500.73 km<sup>2</sup> as the core area Sanctuary, with an additional 146.85 km<sup>2</sup> area as reserve forest in the Kaimur Forest Division. Towards the south, it shares its boundary with the Bagdara Wildlife Sanctuary in Madhya Pradesh (Plate 11). This Sanctuary is part of the Kaimur landscape, which starts from the Lalitpur District in Uttar Pradesh and running along the Kaimur Range, extends into Bhabua and Sasaram districts of Bihar, in which there is the Kaimur (Bihar) Wildlife Sanctuary in Bihar. In south-east, this landscape touches Palamau in Jharkhand, through irregular patches of forests. The Kaimur Wildlife Sanctuary is classified under the central highland (zone 6A) province of the Deccan Peninsula bio-geographic zone (Rodgers *et al.* 2002).

**Vegetation:** Kaimur falls under the northern mixed deciduous forest type, as per the revised classification of forest types of India (Champion & Seth 1968). Agriculture covers significant land in the eastern parts, but the remaining forest is comprised of mixed vegetation. *Diospyros melanoxylon*, *Boswellia serrata*, *Lannea coromandalis*, *Acacia catechu* and *Zizyphus* sp. are some of the common plant species here. An old bamboo plantation is also found in Halia range. Some of the areas are severely affected by the invasion of *Lantana camara*. Current management practices being applied here will be making it even worse, as the Sanctuary management has ordered for *Prosopis juliflora* to be planted all over the Sanctuary, to increase forest cover and fencing is to be done to protect it from grazing, which will cause further damage to the habitat.

**Wildlife:** Though the wildlife here is found in very low numbers, wild ungulates like blackbuck, nilgai, chital, chinkara and wild pig are found in this area. Hyena, jackal and fox are the carnivore species here. The presence of leopard is not confirmed.

**Human Life in the area:** This Sanctuary faces a high anthropogenic pressure, since it encompasses about 49 villages with high human density in a small area. Some villages like Markundi have turned into small towns. There has been a lot of destruction of wildlife habitat on

the eastern part of the Sanctuary. Recently approved Tribal Rights bill has encouraged people to encroach into the Sanctuary area and the consequences can be clearly seen. Mining for cement factories of Chopan and Churk is not only a direct threat to this Sanctuary, but it has also attracted a lot of people into this area, who have encroached and colonized the land of the Sanctuary. Some of the larger cities of this area like Mirzapur, Ghorawal, Churk and Robertsganj are situated along the northern boundary of the Sanctuary, which further adversely affect wildlife populations. People on the western part of the Sanctuary are still rural in their life-style. Scarcity of water is an important issue, since the economy of this area is mostly agriculture based. Some of the people do large scale livestock farming with sheep and goat. .

**Prey densities:** Ungulate densities in Kaimur were low at  $5.37/ \text{ km}^2 \pm 1.94$ , while those for all potential cheetah prey species were  $9.61/ \text{ km}^2 \pm 2.63$ . Nilgai was the most frequently encountered ungulate, followed by blackbuck. Chinkara and sambar were both sighted on only one occasion.

**Pellet densities:** The area has high livestock pressure, with 49% pellets encountered during the survey being those of domestic herbivores, of which 35% were of small stock. Amongst wild ungulates, blackbuck pellets were the most frequent, with a density of  $2277/ \text{ ha} \pm 556$ , while those of nilgai had a density of  $2073/ \text{ ha} \pm 440$ . Chinkara ( $596/ \text{ ha} \pm 310$ ) and sambar ( $166/ \text{ ha} \pm 131$ ) pellet densities were also relatively high, though very few individuals of both were seen during transects (Fig. 36).

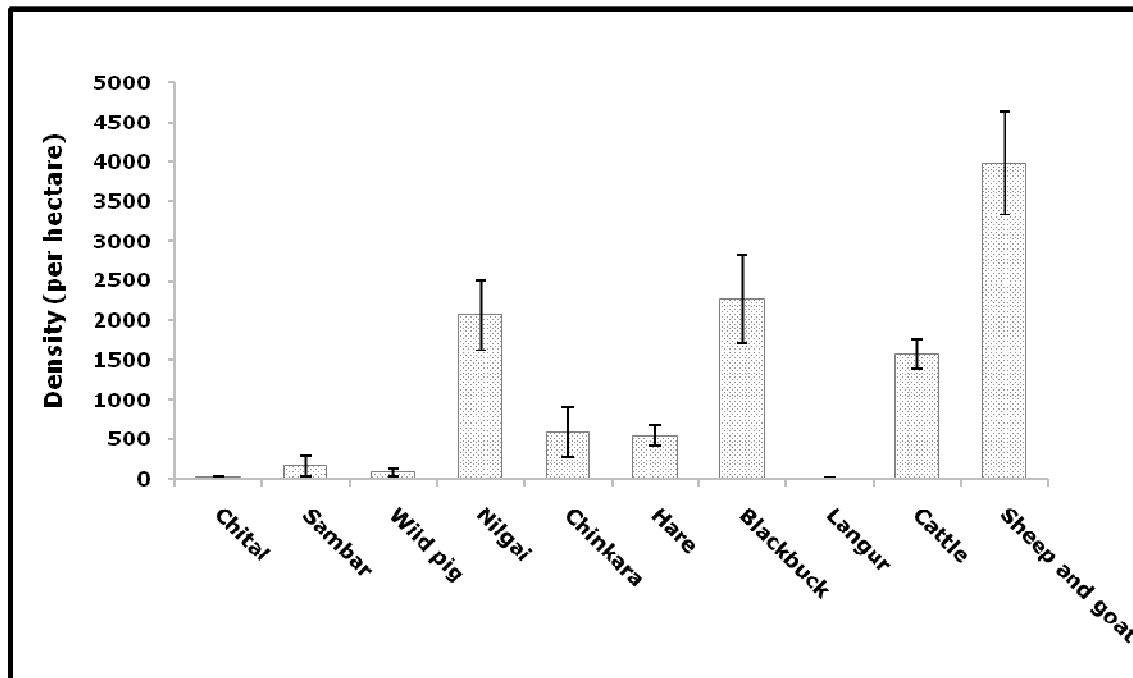


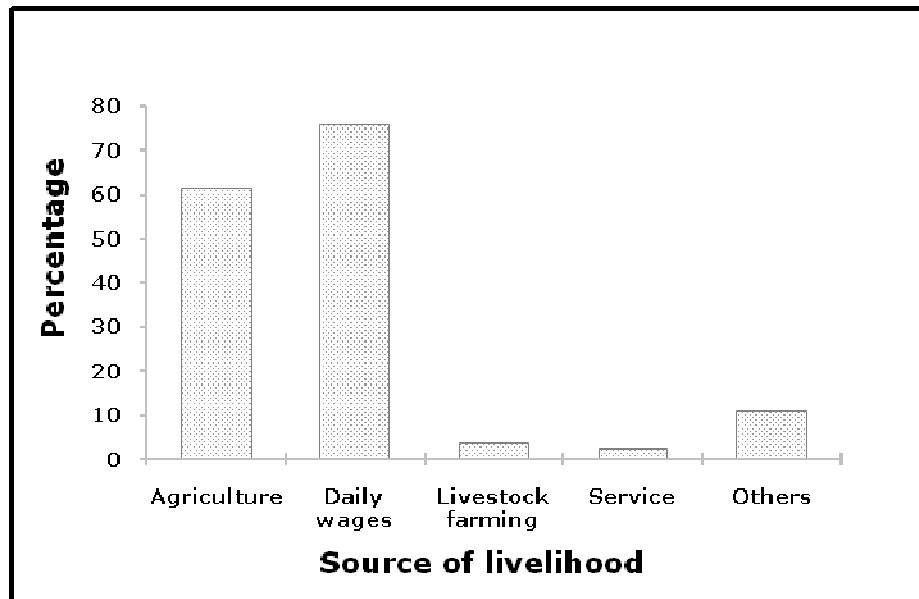
Fig. 36 Herbivore pellet densities (per hectare) in Kaimur wildlife sanctuary

**Human densities:** Human densities in this region were the highest compared to all other study sites. There are 51 villages within the designated protected area, with most of them being large in size with high levels of development. Household densities in the region are 1681/ 100 km<sup>2</sup> with most families owning fertile agriculture land. Rail and road network is well established in the region and most villages in and around the Sanctuary have well established markets and most urban facilities.

**Livestock densities:** Since most families living in this region practice agriculture, animal husbandry is also practiced. Most of this livestock comprises of goats (46/ 100 km<sup>2</sup>), cattle (79/ 100 km<sup>2</sup>) and a relatively high density of buffaloes (13.65/ 100 km<sup>2</sup>). The buffalo density in this region is preceded only by that of Banni, when compared with all our study sites.

**Economic well-being:** People in Kaimur depend mostly on daily wages as a source of income. The average land holding in the area is amongst the lowest of all sites. Most people find jobs as

farm laborers, especially in the harvesting season, where they work on someone else's farm and the returns are not always in terms of money, but include some share of the grain (Fig. 37).



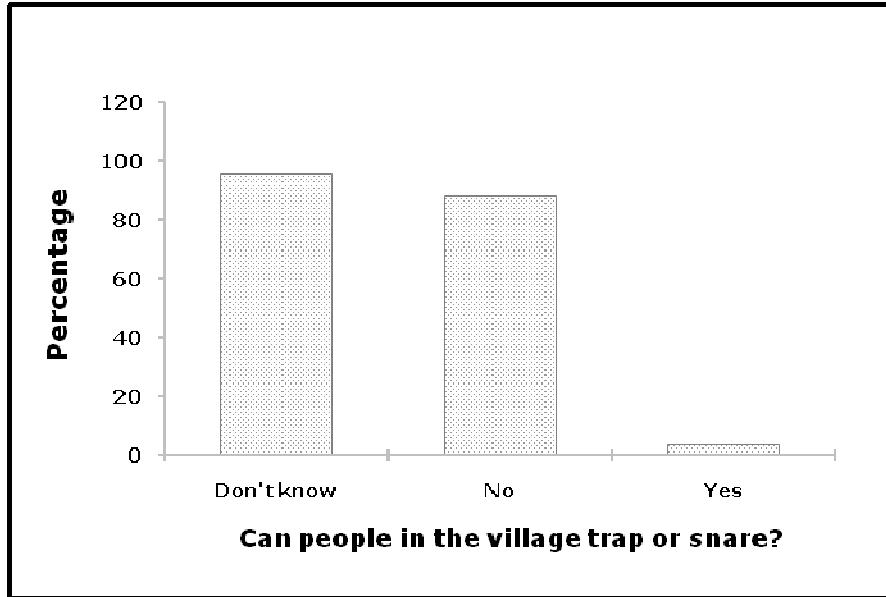
**Fig. 37 Percentage of people involved with each occupation-type in Kaimur**

**Attitudes and perceptions of people towards wildlife in the area:** More than half of the population of Kaimur consists of people who consume meat once in a week on an average. There is a small percentage that eat meat everyday, but most others eat meat only when the opportunity arises, like on a festival or any other special occasion, or whenever they can afford to buy meat from the market. The main source of meat is from domesticated animals. However, people take fish from the Belan River regularly. This area also has people who have bush meat as a part of their diet.

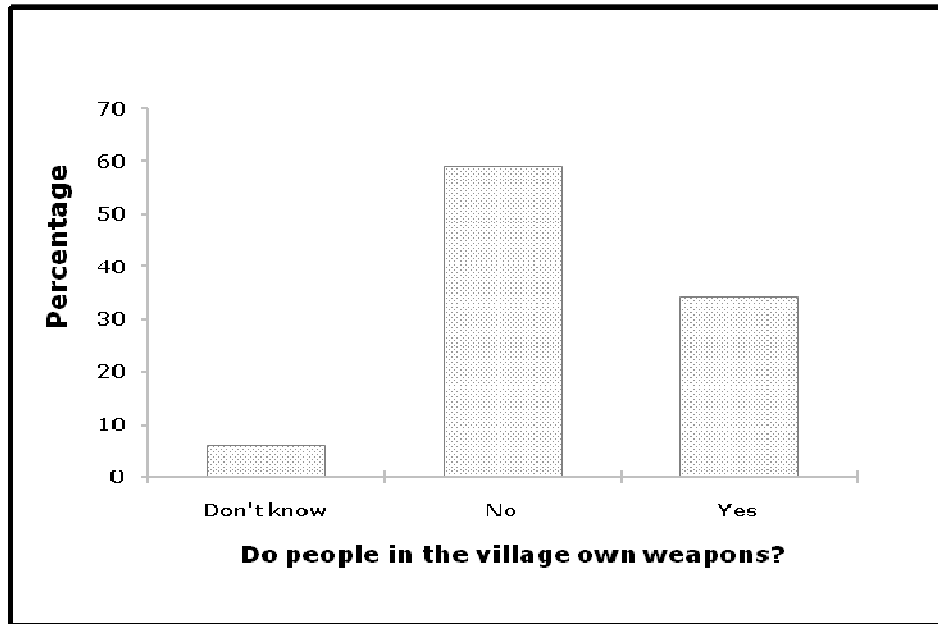
When asked about skills like trapping and snaring animals, most people responded by saying that they did not know or could not say if anyone could trap or snare (Fig. 38). However, a small percentage of the interviewees did say that there were people in the area who possessed the knowledge of laying traps and snares. There is also a significant proportion of people who own weapons (Fig. 39).



Being in the agriculture belt of the country, people in this area face a major problem with crop raiding by wild animals, particularly by nilgai followed by wild pigs. However, there was no major problem reported regarding livestock depredation, which could be because of lack of predators.



**Fig. 38 Percentage of respondents in Kaimur providing information on expertise available to set traps and snares for poaching of wildlife**



**Fig. 39 Percentage of respondents in Kaimur providing information on awareness about people owning weapons in the area**

### **Potential and Strategy for Bagdara-Kaimur**

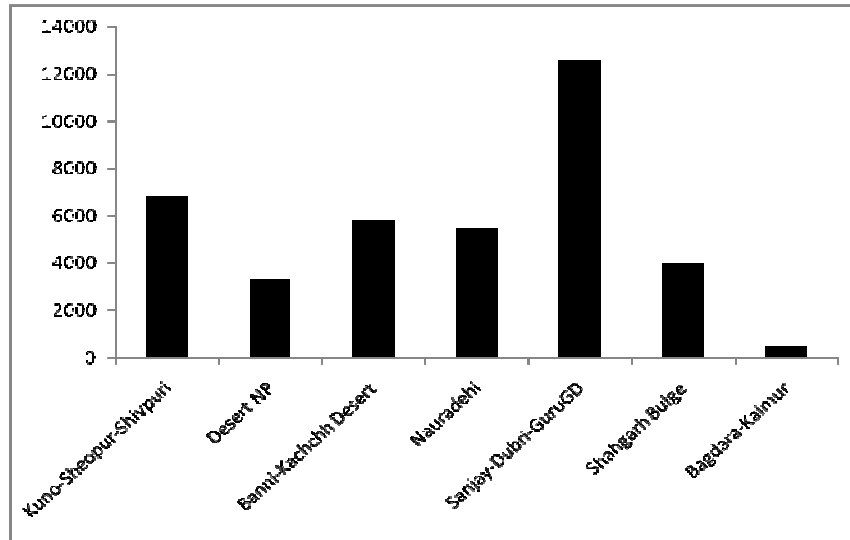
Bagdara-Kaimur landscape is fraught with conflict. This is because the protected area is interspersed with agricultural areas that are privately owned. Due to a good management regime that is able to control poaching, the ungulate densities were reasonably good in the region. However, since the forested area was small, this good management practice has led to increase in the numbers of ungulates and heightened conflict with local communities in the form of crop raiding. Due to its small area, the carrying capacity for cheetah in the area given the current prey density was just nine individuals. This could potentially be enhanced with restorative management, reduction of human pressures and relocation of a few strategically located settlements, to about 15 cheetah. There are very little prospects of increase of suitable habitat around these Pas. The investments required to acquire privately owned land to restore an intact landscape are phenomenal. In the case of Bagdara-Kaimur we do not see a potential for attempting a reintroduction of cheetah as it would only add to the conflict in the area without having a foreseeable successful establishment of the introduced population.

## 5

### *Is reintroducing the Cheetah feasible in India?*

To answer this question we revert back to the introduction section where we objectively assess the field realities for a) Habitat, b) Prey related carrying capacity, c) Human pressures and attitudes (IUCN 1998). Though we surveyed and assessed 10 sites, Bagdara and Kaimur form part of one landscape, while the Dubri Wildlife Sanctuary, Sanjay National Park and Guru Ghasidas National Park are parts of another landscape and forming a contiguous habitat patch. We therefore provide our assessment for seven regions (landscapes).

Considering contiguous habitats available for the cheetah, the Sanjay-Dubri-Guru Ghasidas Landscape was the largest (over 12,500 km<sup>2</sup>) and is strategically located, connecting important protected areas like Bandhavgarh and Palamau (Plate 9, Fig. 40). The other surveyed sites too were parts of reasonably large landscapes (Fig. 40 ) ranging between 3000 to 7000 km<sup>2</sup>, except for the Bagdara-Kaimur site, which was too small for further consideration. Besides, Bagdara-Kaimur had residents who owned large areas of agricultural land, making it extremely expensive to acquire these lands for conservation purposes (Fig. 48).



**Fig. 40 Comparisons between landscape unit sizes of the surveyed sites for cheetah reintroduction**

Nauradehi Wildlife Sanctuary is part of a 5500 km<sup>2</sup> forest patch. While Kuno is part of the Sheopur-Shivpuri forest complex commencing from Ranthambore Tiger Reserve in Rajasthan through Morena and Gwalior districts to Madhav National Park, about 6800 km<sup>2</sup> in extent (Jhala *et al.* 2008). The Banni-Kachchh Desert Wildlife Sanctuary covers a vast area but the potential cheetah habitat is limited to about 5800 km<sup>2</sup>. The arid areas of Jaisalmer that includes the Desert National Park (3160 km<sup>2</sup>) and the Shahgarh Landscape, (4300 km<sup>2</sup>) forms a vast tract of habitat. However, in this region areas outside of the protected areas would be fraught with high conflict due to a very high free ranging small livestock density. Thus, cheetah habitat for the Desert National Park should be considered limited to the Protected Area, which is by no standards small. In the case of the Shahgarh landscape there is currently no protected area, but we propose to fence off over 4000 km<sup>2</sup> from livestock and it is this area that should be considered as a potential cheetah habitat.

Though the Sanjay-Dubri-Guru Ghasidas site was large and has high merit in this context, it had depressed prey densities, probably due to subsistence hunting by tribal communities residing in this region (Fig ungulate density only). In the context of prey densities and subsequent

translation to cheetah carrying capacity, (considering simultaneously the size of the potential site), the Kuno-Palpur Wildlife Sanctuary and the Nauradehi Wildlife Sanctuary fare well. As of the current status, each site could support over 25 cheetah. If considered as a reintroduction site with additional restorative inputs and law enforcement resources as recommended in this report, these sites could well support viable populations (of over 30 and 50 individuals, respectively (Fig. 41). Since contiguous habitat is available at both sites, the cheetah could potentially disperse to occupy the larger landscape (albeit at low densities) and the landscape populations could exceed 50 and 70 individuals, respectively (Fig. 42). These are conservative estimates, considering landscape prey densities to be a mere fraction of those observed in protected areas.

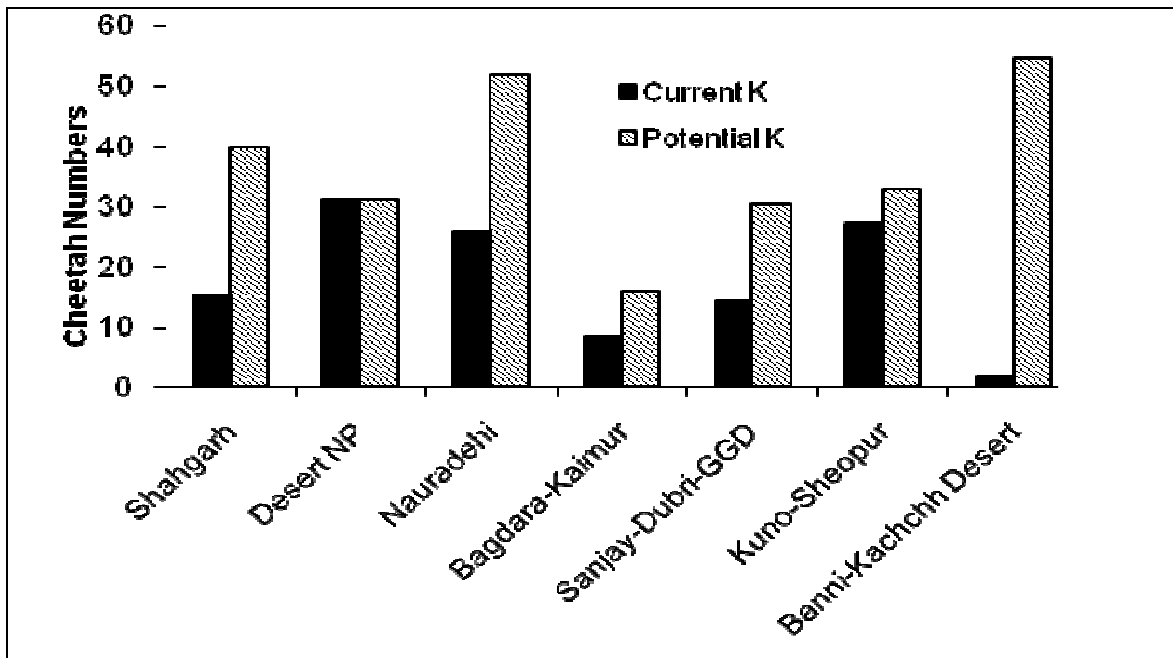
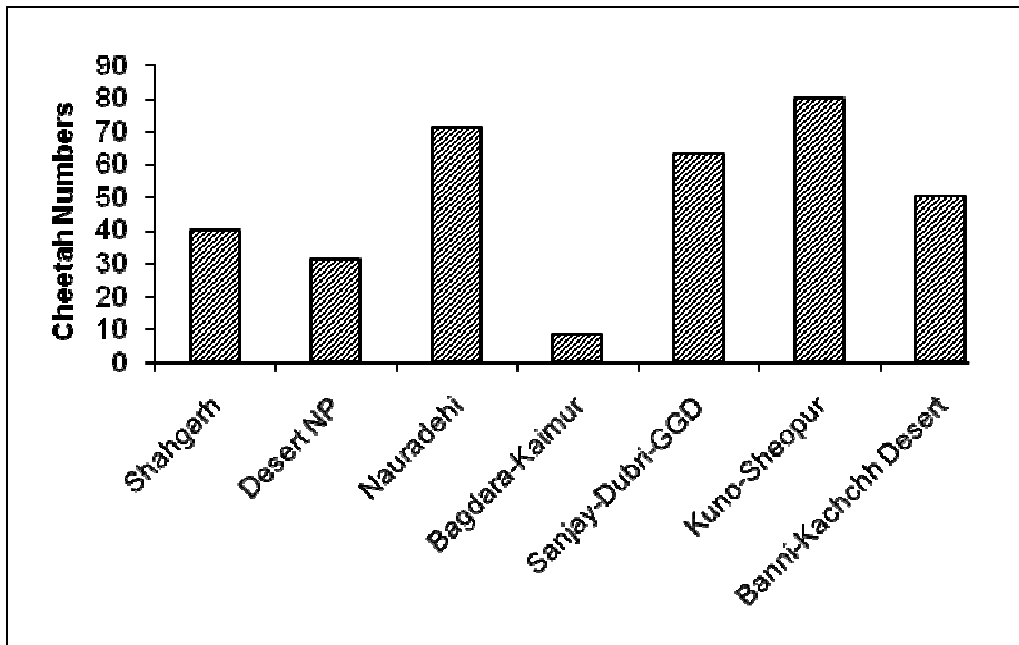


Fig. 41 Current and potential carrying capacity for cheetah at the surveyed sites

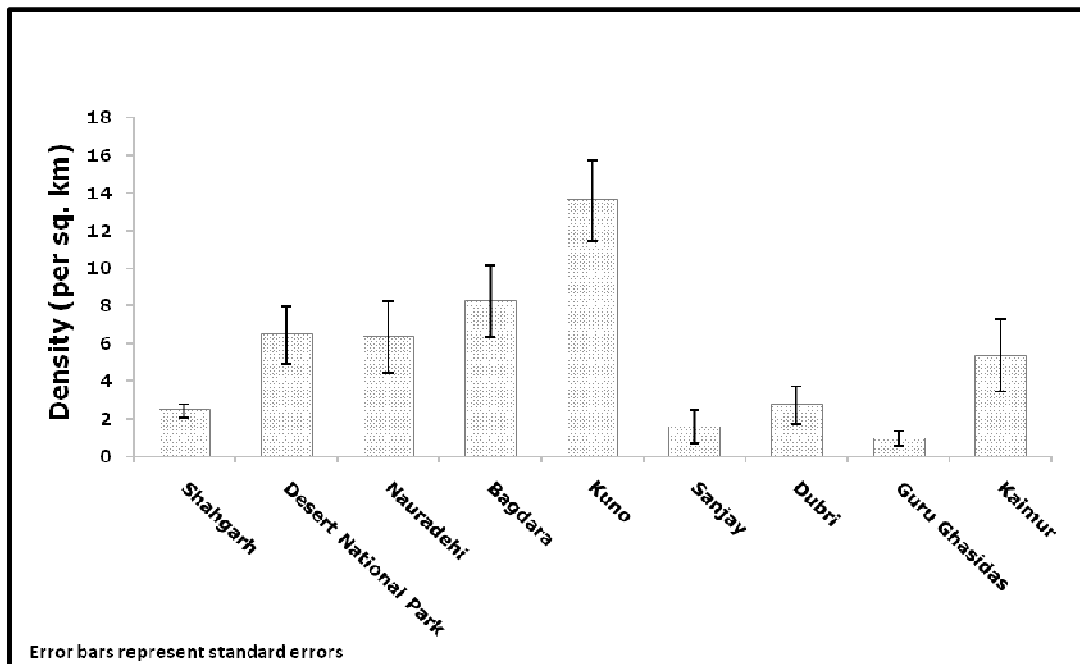


**Fig 42 Potential of the surveyed landscapes to support cheetah populations.**

Amongst the arid sites, the Banni-Kachchh Desert Sanctuary as of today does not have prey to consider a reintroduction effort. The potential of this site is great, but a lot of inputs are required. Since some species like the blackbuck have become locally extinct, their reintroduction may also be needed before considering the site further for the cheetah.

The Desert National Park in the Jaisalmer District of Rajasthan has the required size criteria and reasonably good prey densities. However, it lacks regulatory mechanisms necessary in a National Park. Livestock graze almost in all parts of the National Park (Fig. 43, 44, 45 and 46), and state highways crisscross through the National Park as well. Due to the large porous (both to wildlife and livestock) perimeter of the Park, reintroduced cheetah would not be contained within the limits of the National Park and would come in regular conflict with pastoralists. If the perimeter of the park is fenced to keep the livestock out and to keep the wildlife within the perimeter. It could be highly recommended for a reintroduction program. Fencing around the National Park would benefit the objective of conserving the biodiversity of the desert fauna and

flora for which this park was designated. It would be of particular significance for conserving the last viable population of the endangered great Indian bustard. A factor, however, which has to be kept in view is that in current enclosures such as Sudasiri which have the last of the surviving great Indian bustard population of Jaisalmer, putting the cheetah in with the bustard cannot be contemplated at all, because of the threat to this most gravely endangered bird.



**Fig. 43 Comparisons of prey densities (ungulate species) across all the surveyed sites**

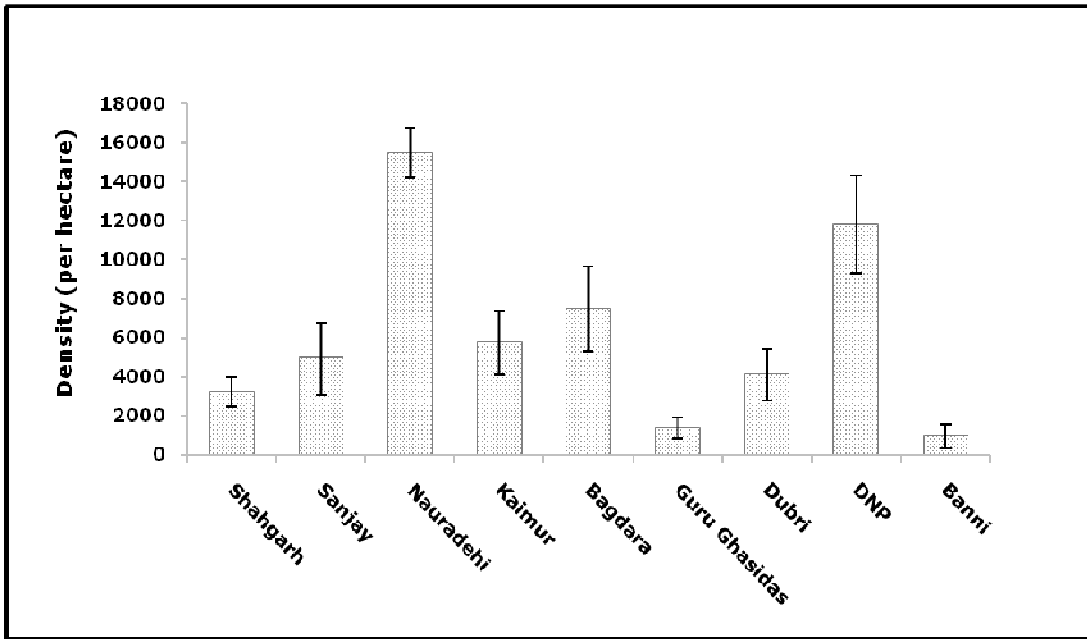


Fig. 44 Pellet densities of wild herbivores (per hectare) in all surveyed sites

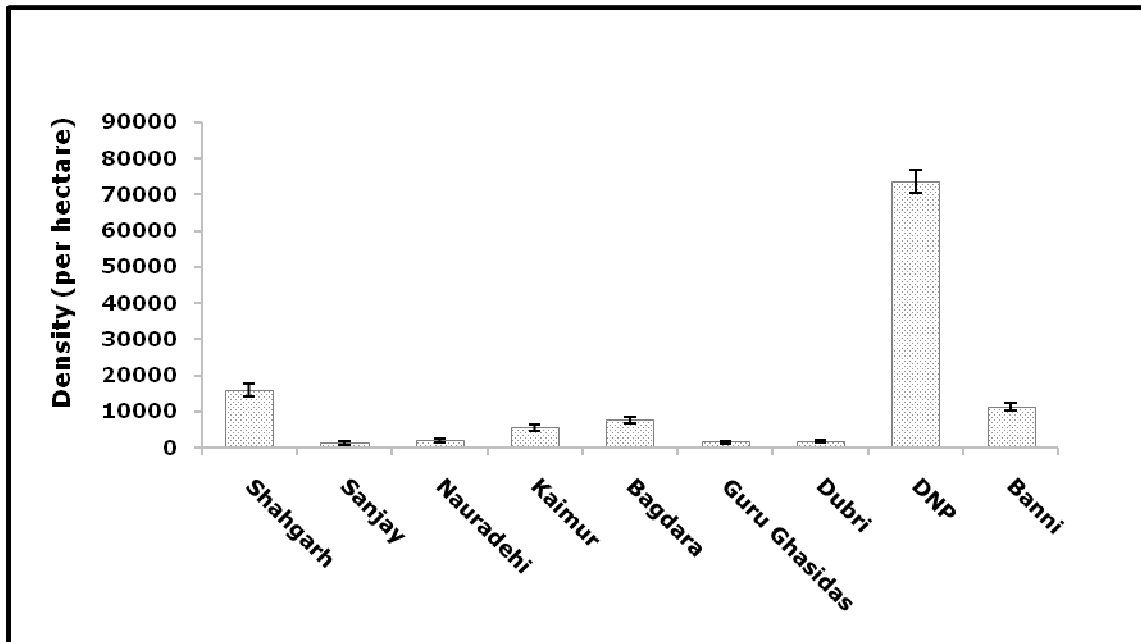
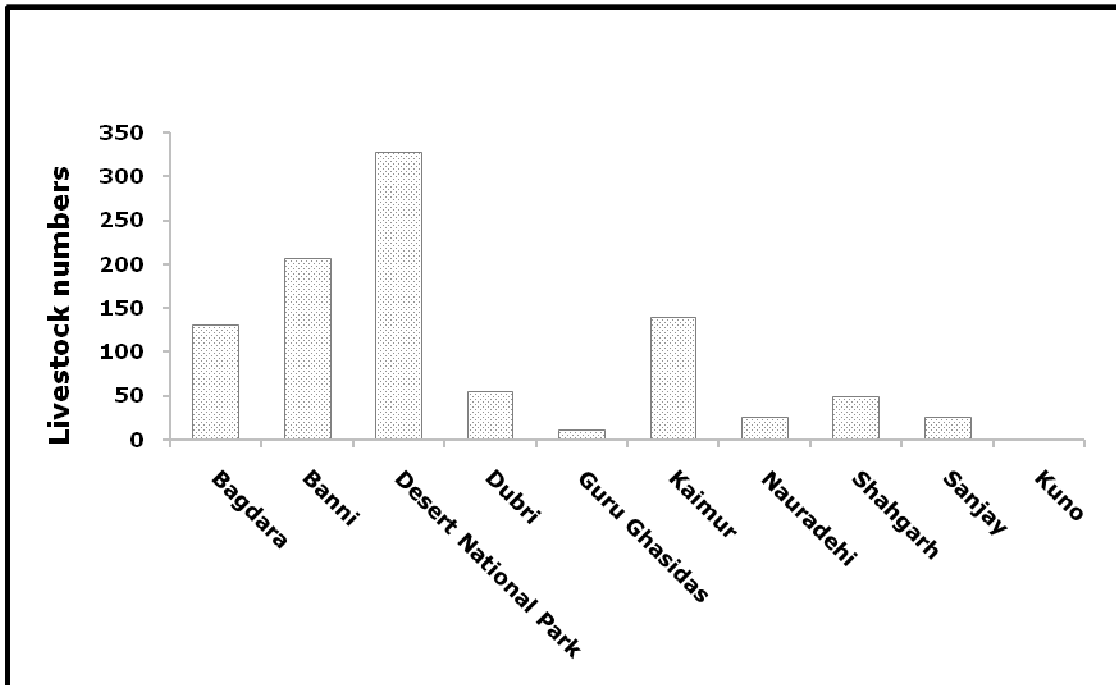


Fig. 45 Pellet densities of domestic herbivores (per hectare) in all surveyed sites

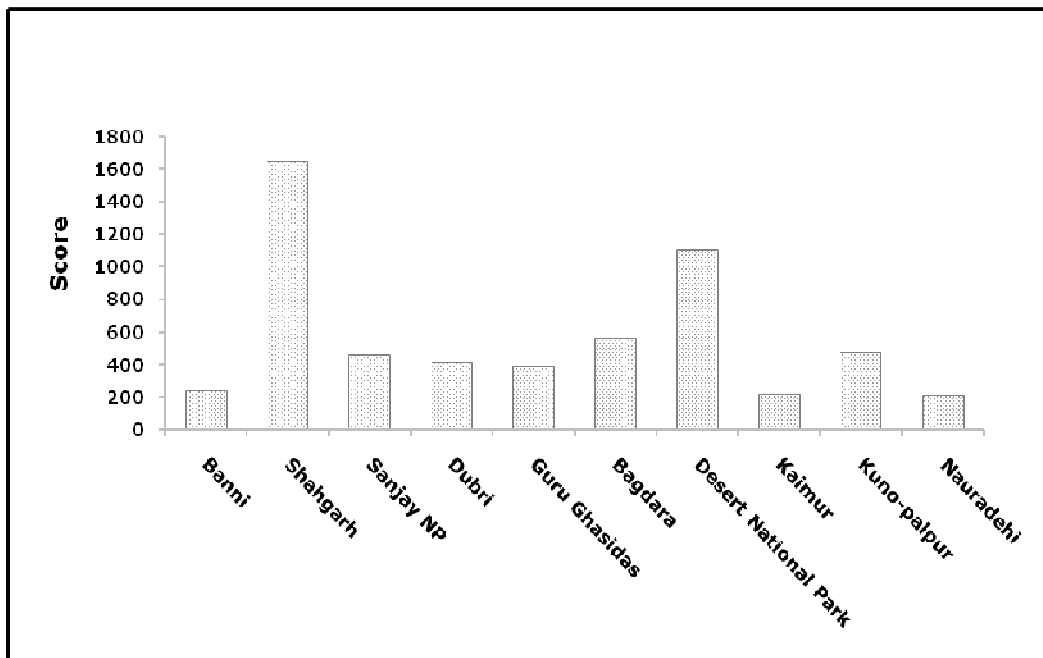




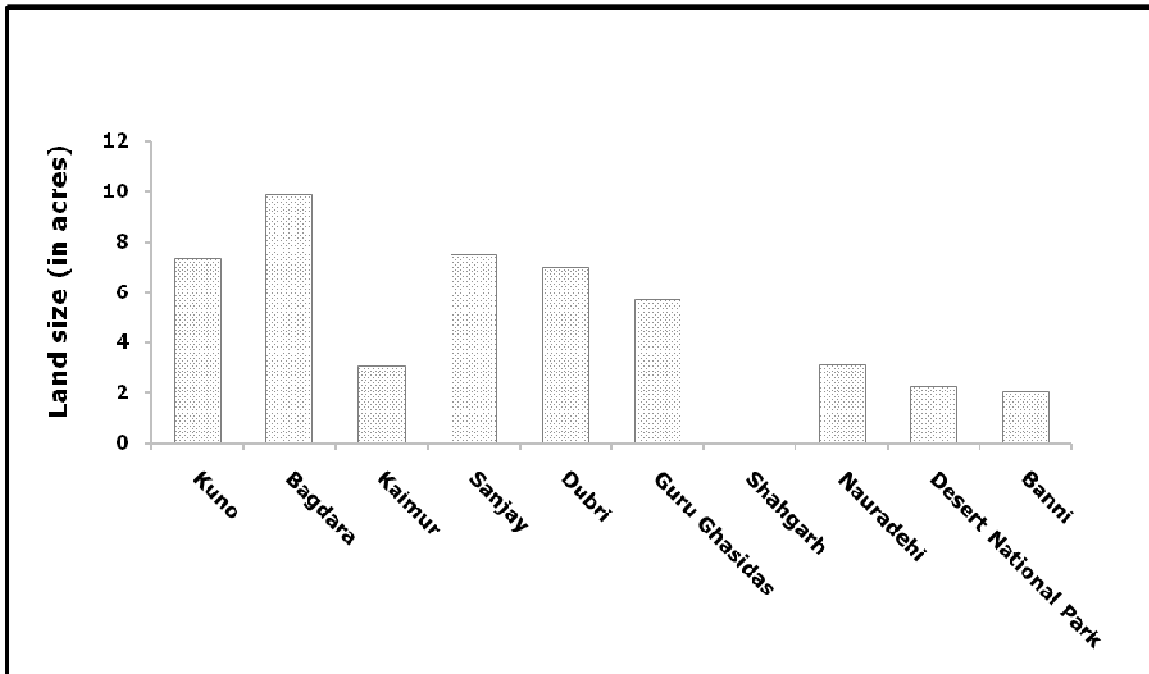
**Fig. 46 Comparative index for density of livestock (per 100 sq. km) across all surveyed sites**

The southern Shahgarh Landscape area is a well conserved representative of the desert biome. Human and livestock impact on this area has been limited for the past 50 years due to the proximity of the international border and the prevailing tensions between India and Pakistan. The proposed reintroduction site covers over 3500-4000 km<sup>2</sup> of a continuous xyrophytic habitat. It is already fenced off along the two sides of the bulge triangle by a double barbed wire fence along the international border. Our recommendation is to fence off the bulge area as shown in Plate 2 by an east-west and north-south oriented chain-linked fencing. Local pastoral communities that have traditionally been grazing their stock seasonally within this bulge area would need to be adequately and generously compensated and relocated outside of the bulge area. These local seasonal residents amount to about 80 Dhanis, each with 5-10 households. The alignment of this fence requires a more detailed on-site study so as to minimize inclusion of human interests and habitations in the area. The current alignment of the fence shown in Plate 2 is only indicative. The area does not need to be declared under any Protected Area category but managed with conservation as one of the primary objective. We do not envision that oil and gas explorations, defense personnel movements or exercises and other activities (as long as they are not totally adverse to the conservation objectives e.g. using the area a firing range for heavy artillery), to be

detrimental to the reintroduction objectives of the project. The current cheetah prey (primarily chinkara) can support about 15 cheetah. With the fencing off of the area and subsequent removal of livestock and habitat management, the carrying capacity is likely to increase to about 40 cheetah, which constitute a viable population as determined by a PHVA (IUCN 1998). Considering the sensitive location, the control of the area will continue to rest with the Border Security Force or other defense agencies as may be required. A collaborative approach with the BSF, wildlife agency of the state and expert agencies such as WII & WTI would be desired for the logistics implementation and management of the reintroduction project. This site has a high potential of success as it would be almost devoid of conflict regarding livestock predation by cheetah. The displaced local population is economically well off (Fig. 47) even though they do not own land and is nomadic in nature and, therefore, would have far less resistance to being relocated especially if adequately compensated. The large fenced off area of this landscape is likely to become a paradise for desert biota, for which the cheetah would serve as a flagship.



**Fig. 47 Economic well being index of local communities residing within and around the potential reintroduction sites**



**Fig. 48 Comparison of average land holding (in acres) of agricultural land owned by people living in the surveyed sites**

The Kuno-Palpur Wildlife Sanctuary has been managed with large investments to prepare the area for the reintroduction of the Asiatic lion. Though the current area the Sanctuary is small, it has good prey densities and can support around 25 cheetah. With additional inputs as suggested in this report and considering the larger buffer of the Kuno-Sheopur forest, the potential carrying capacity of the area is about 30 (Fig. 41). If cheetah are successfully established here, then the landscape could potentially support a population of about 80 individuals (Fig. 42). Cheetah reintroduction in this area does not in any way preclude lions from being introduced here as well at a later date. It is important that cheetah are introduced first and allowed to establish before lions are brought in, since lions would be dominant over cheetah (Caro1994) and a reverse sequence of introductions may not be favorable for cheetahs. The Kuno site offers a unique opportunity where the entire large felid community of India could potentially be reestablished by having tigers, lions, leopards, and cheetah within the same landscape. The people residing in the forested areas outside Kuno are poor and backward and a good compensation package like the one being offered for the core areas of Tiger Reserves would be irresistible.

The Nauradehi site was indeed a pleasant surprise. It was primarily considered due to the size of the landscape of which the Sanctuary is a part. The reasonably good density of cheetah prey was an added bonus. The current prey can sustain about 25 cheetah and if the 700 km<sup>2</sup> area of the Sanctuary is made into an inviolate core area as proposed in this report, the site can sustain a source population of about 50 cheetah (Fig. 41), which would serve to populate the sink areas of the landscape and sustain about 70 individuals. The local communities in this region are poor and devoid of basic modern amenities (Fig. 47). They are most willing to move out of the area for better livelihood options and living conditions. Based on these criteria, we highly recommend Nauradehi as a potential site for cheetah reintroduction.

Based on the population habitat viability model analysis, a cheetah population that has over 30 individuals has a high chance of persistence over the long-term. Managing these different site populations as metapopulations by artificially exchanging individuals between them enhances their chances for long term survival, as well as to maintain their genetic diversity (Gusset 2009). Our assessment based on field data suggests that Nauradehi, Kuno, Shahgarh, and Sanjay-Dubri-Guru Ghasidas meet this criterion, if resources are allocated for restorative management and conservation action taken, as suggested here. Reintroduction efforts take time, often with several failed attempts (Hayward & Somers 2009). We envisage periodic bringing in cheetah to stock the sites for the next 15 years. After this time, resources would be needed to manage the established populations and their habitats. Thus, long-term commitment of intent and resources are required for the program to be successful.

## 6

### **Population Habitat Viability Analysis Results**

With conservative and realistic cheetah population parameters, the PHVA incorporating environmental, genetic and demographic stochasticity, suggests that the three top rated sites for reintroduction have between fair to high probabilities of population persistence. The salient features that permitted population persistence were a i) carrying capacity of over 35 cheetah, ii) an increasing trend in the carrying capacity of the habitats from the current situation (minimum of 15 cheetah) due to implementation of recommendations suggested in this report, till the potential carrying capacity is achieved (over a span of 20 years), iii) introducing an initial population of a minimum of six individuals (2 males and 4 females) and iii) supplementation with a minimum of three to four individuals (2 females and 1 or 2 males) every alternate year for the next 12 years. The Shahgarh population had an 80% chance of persistence for the next 100 years, while for both Kuno and Nauradehi the extinction probability was less than 5% (Appendix 4 for results of PHVA). The comparative low persistence probability was expected for Shahgarh due to its lower carrying capacity and more stochastic environmental conditions. In case of reintroductions at more than one site (the desired option), we propose to manage the different sites together as a “metapopulation”, thereby enhancing the survival chances as well as maintaining the genetic diversity of the founding populations in all the sites chosen.

# 7

## **Aspects of implementation**

### **7.1 Sourcing Cheetah**

As has been approved by Indian and International experts at the Consultative Meeting at Gajner in September 2009, cheetah for reintroduction into the selected sites would be sourced from Africa, depending upon the suitability and continued availability of specimens. The assembly at Gajner had also advocated that there should be a collaboration and synergy between Iran and India with regard to conservation of the cheetah in Asia and that India should learn from the experience in Iran. It is suggested that this recommendation be carried forward and that possibilities of such collaboration be explored with the authorities in Iran, ensuring that any such endeavour would not jeopardize in any way the conservation efforts to save the cheetah in the wild in Iran. This collaboration should result in greater focus and higher risk coverage, adding to the global conservation and reestablishment efforts of the Asiatic cheetah.

As regards the expertise in the matter of care in captivity prior to release and in the reintroduction, rehabilitation and monitoring of the released specimens in India and in the training of our personnel in this regard, we should obtain the best expertise available in Namibia, South Africa and elsewhere.

### **7.2 Some prerequisites for the success of the project**

At all potential reintroduction sites (except Shahgarh, once the fence is in place), cheetah are likely to predate on small livestock. To avoid any hostile reactions from the surrounding communities as well as to promote coexistence, a generous, well planned, fool proof compensation system for livestock damage needs to be implemented at each reintroduction site. The implementation of the compensation scheme should be done by the wildlife agency in collaboration with local NGOs so that depredation events are verified and payments are made

within 48 hours, as its already been done by an NGO outside Corbett Tiger Reserve which has substantially reduced resentment amongst the local communities. Since all introduced cheetah (for the first 15 years) would be equipped with radio-transmitters, predation events should be relatively easy to detect and authenticate. Our preliminary assessment of small livestock presence in the potential landscapes (Fig. 44, 45) suggests that the magnitude of conflict is likely to be relatively high in Kuno Sheopur landscape while in Nauradehi which has few sheep and goat, conflict with reintroduced cheetah should be low here.

A thorough monitoring system needs to be in place so as to provide feed-back in an adaptive management framework (Williams *et al.* 2002). All reintroduced cheetah and cubs > 1.5 years of age should be equipped with radio-transmitters, preferably during the first 8 years with GPS and satellite communication. The introduced cheetah would need to be monitored on a daily basis for the first five years and subsequently, at a longer interval (as deemed necessary at that time). Data collected on all aspects of ecology; ranging patterns, predation and feeding, demography (births, deaths, dispersal), habitat use, and behavior (activity, human avoidance, breeding, maternal care, etc.), analysed and reported annually, so as to adopt the program as needed for a quick establishment of the introduced population. An annual commitment of Rs. 35 lakhs would be required at each site for monitoring activities as proposed above inclusive of satellite telemetry.

Quarantine facility for holding the animals needs to be provided close to the release sites or at a central location near one of the sites, where all cheetah are brought and kept under observation for 3-4 weeks prior to release in the wild. A small holding facility, a small clinic and veterinary facility would be required at each potential release site. This is essential so as to provide treatment for mild ailments, injuries, or to temporarily hold animals that may be unfit for wild release (perpetual livestock raiders, imprinted and habituated individuals, etc.). A capital cost of 80 lakhs and a recurring cost of 15 lakhs per annum would be required for this component at each site.

It is likely that the tourism potential of the sites where the cheetah are reintroduced, would increase substantially. We propose that the revenues generated from tourism and other related activities be shared with the local communities and that they be involved in the development of ecotourism at the sites from the outset so that they develop an economic stake in the venture.

Overall, the venture must be viewed not simply as an introduction of a species however charismatic it may be, but as an endeavour to better manage and restore some of our most valuable yet most neglected ecosystems and the species dependent upon them. It will only succeed if the central and state government collaborate and provide the requisite political support. Funds will, of course, be required as capital investment at the outset and for the maintenance of the project, on a long term basis. But more important than money, would be manpower.

It is recommended that at each of the sites there would have to be a special task force by way of a team of dedicated, trained personnel who would be appointed for duration of four years or more. The involvement of experts from outside of government and even from abroad, at least in the initial stage, would be imperative, as would be the training of our personnel. As eco-development is an important component, a trained person in this field will head those operations. The project sites require much more than what is being currently done for the management of our PA's, so as to provide much better chances of success.

### **7.3 Prioritization of surveyed sites**

Based on the overall assessment inclusive of prey densities, human pressures and potential for conflict we rate the surveyed sites in the following order of priority for cheetah re-introduction:

1. Shahgarh: Taking all aspects into account, this is the most appropriate site, provided the area is enclosed by the proposed fencing and the livestock is excluded.
2. Kuno-Palpur Wildlife Sanctuary: The site is ready to receive a large carnivore and we rate this second, only because of its smaller size. The buffer area requires inputs of relocation



enforcement and eco-development. The resources required here are the least as already part of the proposed core area is made inviolate by relocation of 24 villages.

3. Nauradehi Wildlife Sanctuary: Despite its very high potential, this site is rated third, as substantial investment and time is required to make 700 km<sup>2</sup> inviolate by relocating 21 villages, albeit most of them being ready to relocate.

4. Sanjay-Dubri-Guru Ghasidas National Park: Is rated fourth, as prey densities are extremely low currently, but inputs from Project Tiger if well planned could improve the potential in a few years. Also, inclusion of Guru Ghasidas National Park as part of Project Tiger would assist in the recovery of the area. The costs for creating an inviolate are within Guru Ghasidas National Park would be relatively small as vast tracts of uninhabited forests are already available.

At this point, we do not recommend considering other sites for re-introduction. Thus, in conclusion, there is high potential for re-introducing cheetah in India, but it would require commitment of substantial resources on a long term basis and political support. Such a project would prevent further degradation of the listed sites and revitalize them for their primary objective of Biodiversity Conservation with the cheetah being their flagship.

## 8

### *The Way Ahead*

The Hon'ble Minister for Environment and Forests had mandated us to carry out this survey. Our objective was to carry out an assessment of the sites selected at the consultation meeting at Gajner, to determine whether it was feasible to re-introduce the cheetah in any of these sites and if so, their inter-se priority in this regard, and what would, in brief, be required to further improve the prospects of success in the sites chosen.

The task has been carried out with the support of various government representatives and individuals. Since the Hon'ble Minister has also asked the undersigned to prepare a road map for the return of the cheetah, it would not be perhaps presumptuous to briefly outline the next stages, as it were, on this road map.

1. Though the concept has met with the approval of the National Board for Wildlife, the Government of India, based upon this report, would decide whether or not to bring back the cheetah and to support the endeavor financially and otherwise, on a long-term basis. It would then also approve or disapprove the sites selected for re-introduction in this report.
2. The concerned state governments would also have to agree to the proposal in principle.
3. Thereafter, a further study of 3 sites selected to determine their requirements in detail and the cost thereof, both capital and recurring, would have to be undertaken, and approved.
4. Carefully selected implementation teams comprising of managers and experts would have to be set up at each of the project sites. The training of personnel both, within India and abroad, would be required. Expertise from abroad would also be needed, at least in the initial stage.

5. A central coordination committee or task force needs to be set up, comprising of the representatives of the central and concerned state governments, Wildlife institute of India (WII), Wildlife Trust of India (WTI) and other experts and agencies involved, such as the BSF. It would have to have a nodal person or agency who would be devoting full time on behalf of this task force to monitor and follow up on the project.
6. Simultaneously, negotiations could begin to source Cheetah specimens most appropriate for re-introduction in the sites selected, and protocols worked out, so that suitable animals are available when our release sites are ready to receive them. Future supply of specimens over a period of time would also have to be ensured. Preparations to receive them and to hold them prior to release would have to begin in time, dependent upon when the experts deem the respective sites would be ready for release.
7. When the experts deem that a given site is ready for release and the requisite infrastructure to receive, hold and care for the animals is in place, the animals will be obtained and released, based upon IUCN guidelines and the advice of experts.

Re-introduction of apex carnivores should be seen as ecosystems conservation rather than merely as species conservation. Re-introduction of the cheetah into India would be reclaiming a part of India's wonderful and varied natural heritage.

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## Appendix 1

### Summary of line transect data

#### LINE-TRANSECT DATA

	Dubri WLS	Sanjay TR	Guru Ghasi Das NP	Bagdara WLS	Kaimur WLS	Desert NP	Shahgarh grasslands	Banni grasslands	Kuno- Palpur WLS	Nauradehi
<b>No. of transects walked</b>	21	24	48	28	26	16	19	21	10	49
<b>Total length of transects walked (km)</b>	59.6	65.6	108.1	86.8	61.2	144.3	581.90	197.4	90.65	131.2
<b>No. of ungulate sightings</b>	10	7	13	56	33	139	131	7	94	46
<b>No. of other sightings (lagomorphs)</b>	0	2	1	8	4	0	3	1	3	4
<b>No. of primate sightings</b>	33	37	43	4	8	0	0	0	22	34
<b>No. of livestock sightings</b>	4*	3*	14*	5*	2*	N/A	N/A	N/A	N/A	2*
<b>No. of carnivore sightings</b>	2	4	10	11	7	9	6	3	5	4
<b>No. of peafowl/jungle fowl sightings</b>	1	1	7	5	4	6	0	0	19	2
<b>Total no. of sightings</b>	50	54	88	89	58	154	140	11	143	92

\*Inconsistency in data collection: Cattle sightings not included by all observers

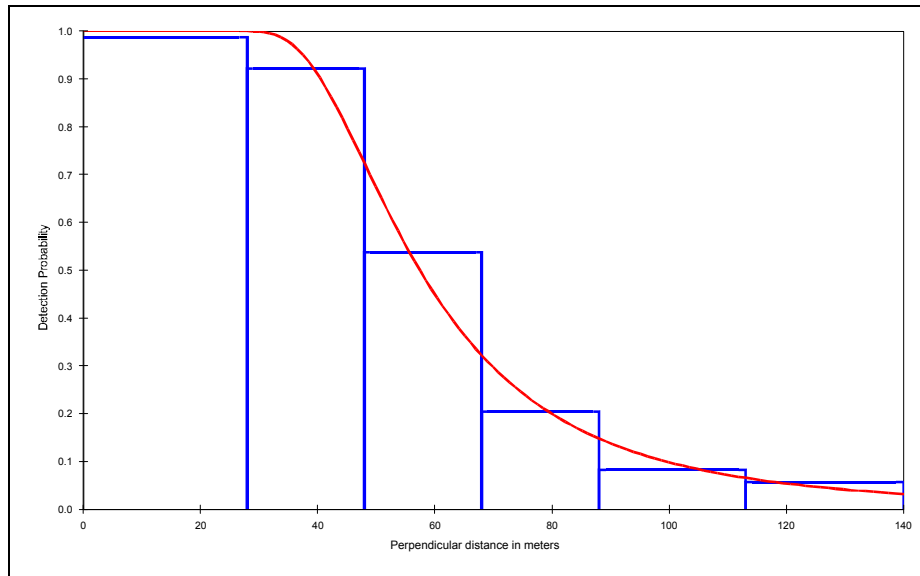
## Appendix 2 Detection function curves

### 2.1 Shahgarh grasslands inclusive of Morar-Lunaar area

#### 2.1.1 Category: Ungulates

**Species:** Chinkara

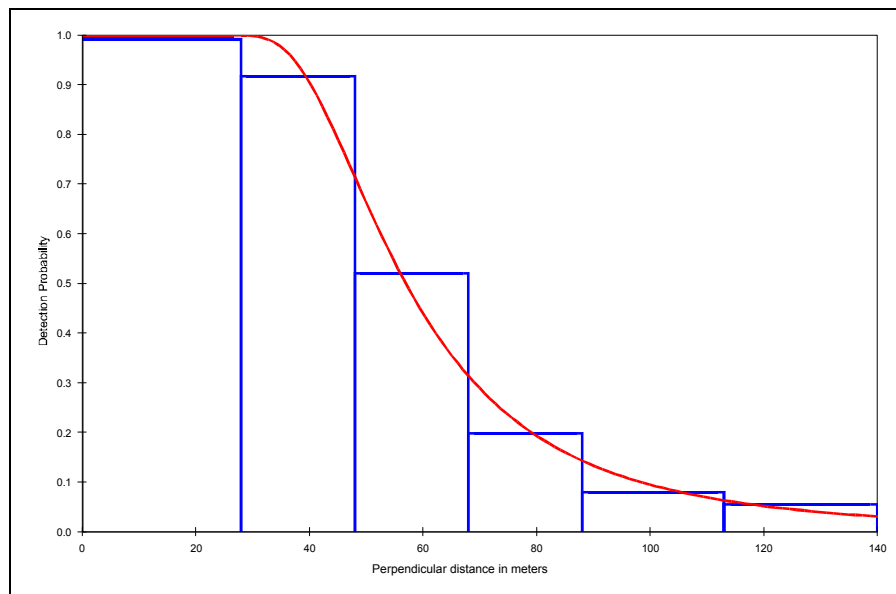
**Model:** Hazard rate key model with cosine adjustment term  
(Chi-square value = 0.9280;  $p = 0.4604$  (CV (p %) = 7.79%))



#### 2.1.2 Category: Total prey

**Species:** Chinkara, hare

**Model:** Hazard rate key model with cosine adjustment term  
(Chi-square value = 0.9352;  $p = 0.4566$  (CV (p %) = 7.68%))

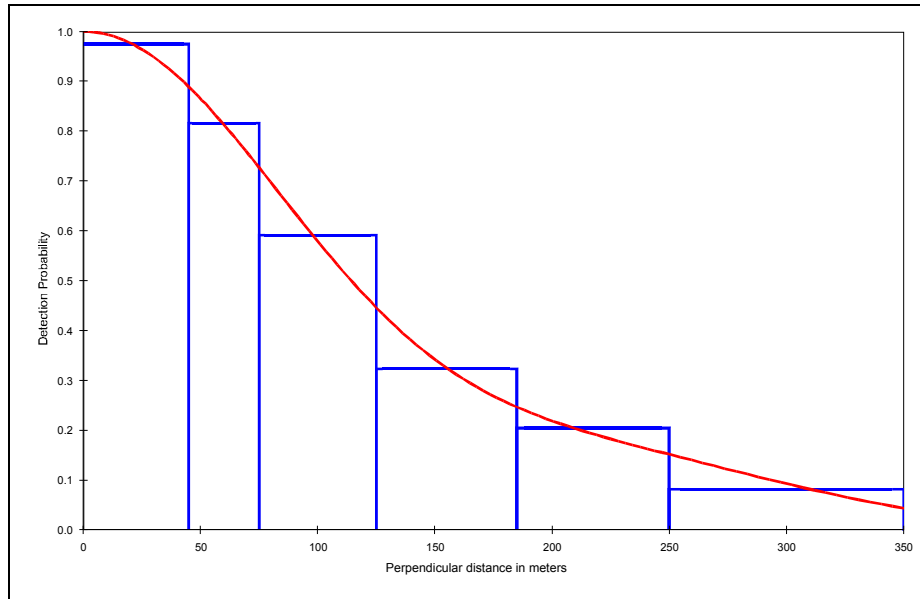


## 2.2 Desert National Park

### 2.2.1 Category: Ungulates

**Species:** Chinkara

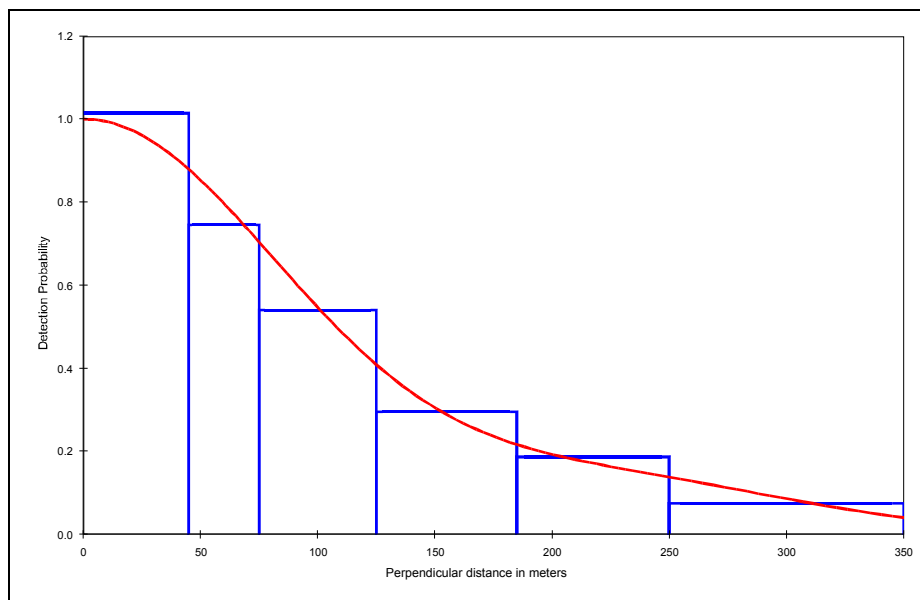
**Model:** Half normal key model with cosine adjustment term  
(Chi-square value = 0.9737;  $p = 0.3963$  (CV (p %) = 9.3%))



### 2.2.2 Category: Total prey

**Species:** Chinkara, peafowl

**Model:** Half normal key model with cosine adjustment term  
(Chi-square value = 0.9137;  $p = 0.3777$  (CV (p %) = 8.51%))

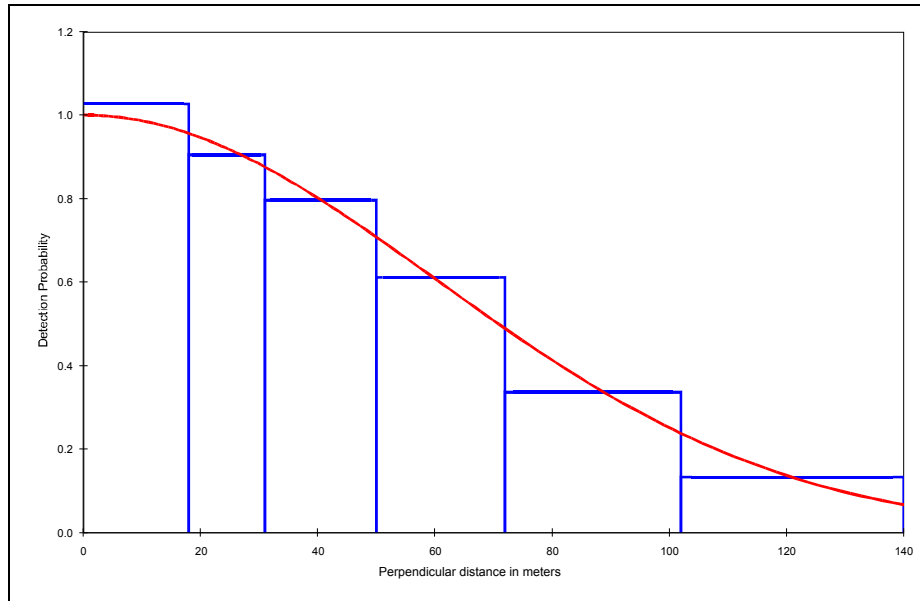


## 2.3 Nauradehi Wildlife Sanctuary

### 2.3.1 Category: Ungulates

**Species:** Chinkara, chital, sambar, nilgai, wild pig

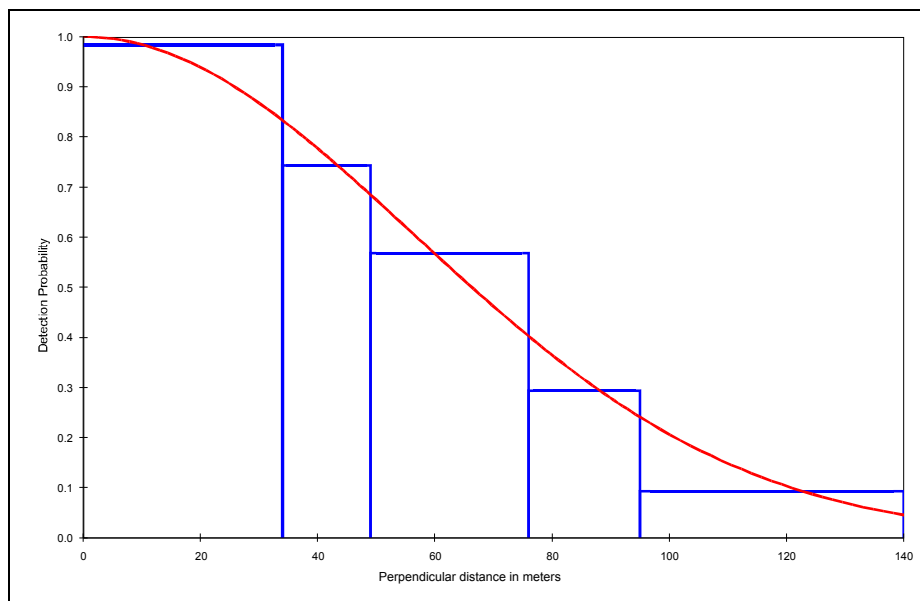
**Model:** Half normal key model with cosine adjustment term  
(Chi-square value = 0.9997;  $p = 0.5280$  (CV (p %) = 11.48%))



### 2.3.2 Category: Prey base excluding primates

**Species:** Chinkara, chital, sambar, nilgai, wild pig, peafowl and hare

**Model:** Half normal key model with cosine adjustment term  
(Chi-square value = 0.9514;  $p = 0.4978$  (CV (p %) = 10.18%))

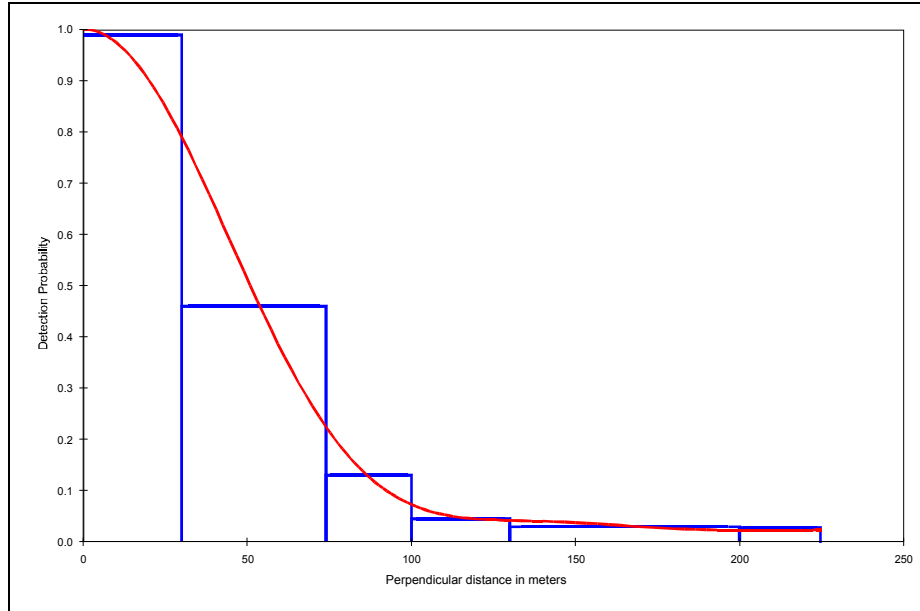


**2.3.3 Category:** Total prey including langur

**Species:** Chinkara, chital, sambar, nilgai, wild pig, peafowl, hare, langur

**Model:** Uniform key model with cosine adjustment term

(Chi-square value = 0.5171;  $p = 0.2550$  (CV (p %) = 8.85%))



### Appendix 3 Summary of ungulate model parameters

#### 3.1 Category: Ungulates

Site	Shahgarh	Nauradehi	DNP	Bagdara	Kaimur	GGD	Sanjay	Dubri
<b>Total observations</b>	131	46	139	56	33	13	7	10
<b>Observations post truncation</b>	126	44	136	53	33	13	7	10
<b>Maximum Detection Distance</b>	300.00	178.75	500.00	392.65	314.58	168.14	168.14	168.14
<b>Truncated at</b>	140	140	350	230	None	None	None	None
<b>Model</b>	Hazard rate	Half normal	Half normal	Half normal	Half normal	Half normal	Half normal	Half normal
<b>Model adjustment term</b>	Cosine	Cosine	Cosine	Cosine	Cosine	Cosine	Cosine	Cosine
<b>AIC value</b>	1149.46	419.09	1514.27	544.00	358.41	302.04	302.04	302.04
<b>D</b>	2.44	6.34	6.45	8.26	5.37	0.94	1.58	2.74
<b>D(CV)%</b>	14.58	29.97	24.10	23.17	36.09	38.77	55.33	36.55
<b>D (SE)</b>	0.36	1.90	1.55	1.91	1.94	0.37	0.88	1.00
<b>D 95% UCL</b>	3.26	11.34	10.51	13.03	10.91	1.99	4.53	5.60
<b>D 95% LCL</b>	1.83	3.55	3.95	5.24	2.65	0.45	0.55	1.34
<b>chi-p</b>	0.9280	0.9997	0.9737	0.9990	0.9601	0.9801	0.9801	0.9801
<b>p</b>	0.4604	0.5280	0.3963	0.4487	0.4351	0.6014	0.6014	0.6014
<b>CV (p)%</b>	7.79	11.48	9.30	9.47	10.41	14.43	14.43	14.43
<b>Effective Strip Width</b>	64.45	73.92	138.69	103.20	136.86	101.12	101.12	101.12
<b>ESW (CV%)</b>	7.79	11.48	9.30	9.47	10.41	14.43	14.43	14.43

### 3.2 Category : Total prey excluding primates

Site	Shahgarh	Nauradehi	DNP	Bagdara	Kaimur	GGD	Sanjay	Dubri
<b>Total observations</b>	134	52	145	69	41	21	10	11
<b>Observations post truncation</b>	129	50	142	65	39	21	10	11
<b>Strip width</b>	300.00	178.75	500.00	392.65	314.58	168.14	168.14	168.14
<b>Truncated at</b>	140	140	350	220	None	None	None	None
<b>Model</b>	Hazard rate	Half normal	Half normal	Half normal	Half normal	Half normal	Half normal	Half normal
<b>Model adjustment term</b>	Cosine	Cosine	Cosine	Cosine	Cosine	Cosine	Cosine	Cosine
<b>AIC value</b>	1174.67	471.82	1573.22	649.72	435.39	414.40	414.40	414.40
<b>D</b>	2.50	7.16	7.18	10.31	6.54	1.77	2.10	3.28
<b>D(CV)%</b>	14.68	27.56	23.76	20.68	30.52	32.69	48.32	35.99
<b>D (SE)</b>	0.37	1.97	1.71	2.13	2.00	0.58	1.02	1.18
<b>D 95% UCL</b>	3.35	12.25	11.65	15.48	11.91	3.35	5.32	6.65
<b>D 95% LCL</b>	1.87	4.19	4.43	6.86	3.59	0.94	0.83	1.61
<b>chi-p</b>	0.9352	0.9514	0.9137	0.9962	0.37246	0.8968	0.8968	0.8968
<b>p</b>	0.4566	0.4978	0.3777	0.4064	0.3206	0.5177	0.5177	0.5177
<b>CV (p)%</b>	7.68	10.18	8.51	9.17	12.50	10.90	10.90	10.90
<b>ESW</b>	63.92	69.69	132.20	89.41	100.86	87.05	87.05	87.05
<b>ESW (CV%)</b>	7.68	10.18	8.51	9.17	12.50	10.90	10.90	10.90



### 3.3 Category: Total prey including langur

Site	Shahgarh	Nauradehi	DNP	Bagdara	GGD	Sanjay	Dubri	Kaimur
<b>Total observations</b>	134	85	145	73	61	43	38	48
<b>Observations post truncation</b>	129	85	142	68	61	43	38	48
<b>Strip width</b>	300	224.7	500	392.65	168.14	168.14	168.14	314.58
<b>Truncated at</b>	140	None	350	230	None	None	None	None
<b>Model</b>	Hazard rate	Uniform	Half-normal	Half-normal	Half-normal	Half-normal	Half-normal	Half normal
<b>Model adjustment term</b>	Cosine	Cosine	Cosine	Cosine	Cosine	Cosine	Cosine	Cosine
<b>AIC value</b>	1174.67	807.75	1573.22	690.33	1339.39	1339.39	1339.39	502.82
<b>D</b>	2.50	15.83	7.18	9.90	14.80	17.91	24.84	9.61
<b>D(CV)%</b>	14.68	22.30	23.76	19.14	22.12	24.68	32.16	27.41
<b>D (SE)</b>	0.37	3.53	1.71	1.90	3.27	4.42	7.99	2.63
<b>D 95% UCL</b>	3.35	24.49	11.65	14.44	22.80	29.17	46.80	16.48
<b>D 95% LCL</b>	1.87	10.23	4.43	6.79	9.61	10.99	13.19	5.60
<b>chi-p</b>	0.9352	0.5171	0.9137	0.9826	0.9995	0.9995	0.9995	0.3076
<b>p</b>	0.4566	0.2550	0.3777	0.4223	0.3595	0.3595	0.3595	0.3011
<b>CV (p)%</b>	7.68	8.85	8.51	7.95	8.83	8.83	8.83	10.76
<b>ESW</b>	63.92	57.31	132.20	97.14	60.45	60.45	60.45	94.73
<b>ESW (CV%)</b>	7.68	8.85	8.51	7.95	8.83	8.83	8.83	10.76

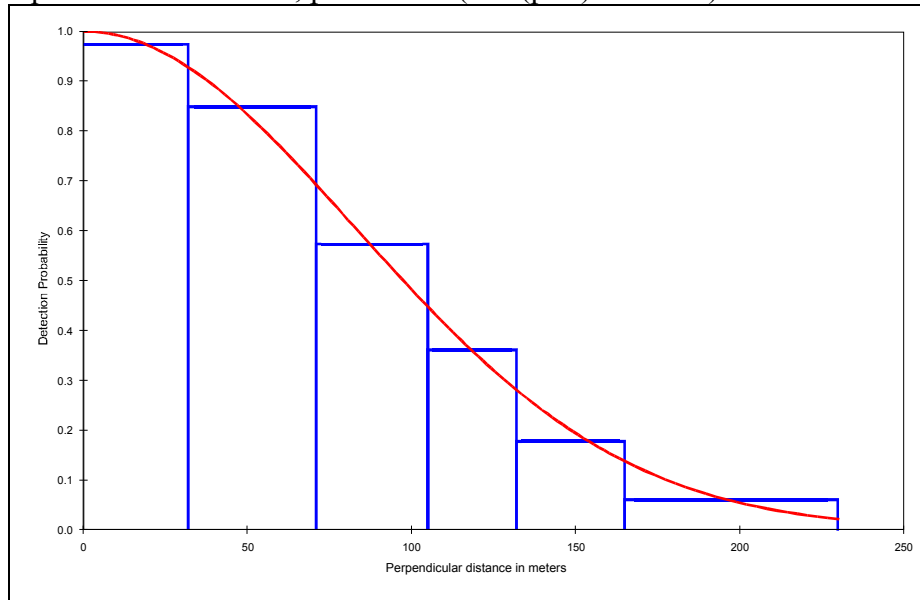
## 2.4 Bagdara Wildlife Sanctuary

### 2.4.1 Category: Ungulates

**Species:** Chinkara, blackbuck, nilgai, wild pig

**Model:** Half normal key model with cosine adjustment term

(Chi-square value = 0.9990;  $p = 0.4487$  (CV (p %) = 9.47%))

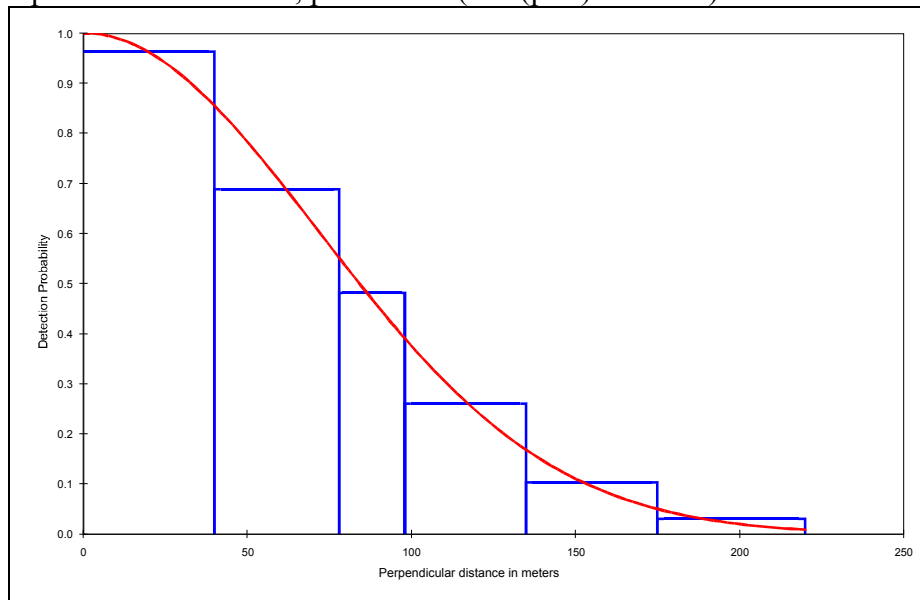


### 2.4.2 Category: Total prey excluding primates

**Species:** Chinkara, blackbuck, nilgai, wild pig, hare, peafowl, jungle fowl

**Model:** Half normal key model with cosine adjustment term

(Chi-square value = 0.9962;  $p = 0.4064$  (CV (p %) = 9.17%))

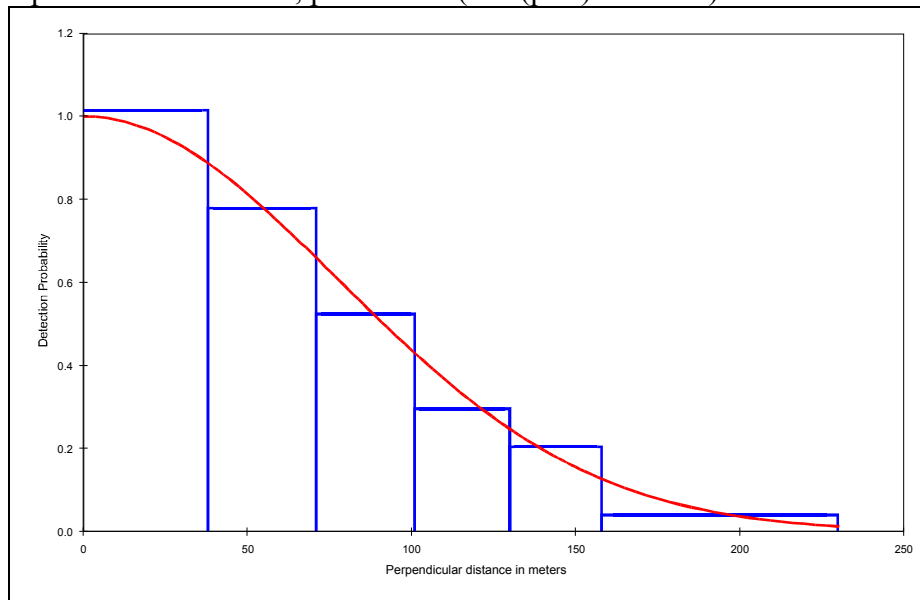


**2.4.3 Category:** Total prey including primates

**Species:** Chinkara, blackbuck, nilgai, wild pig, peafowl, jungle fowl

**Model:** Half normal key model with cosine adjustment term

(Chi-square value = 0.9826;  $p = 0.4223$  (CV (p %) = 7.95%))

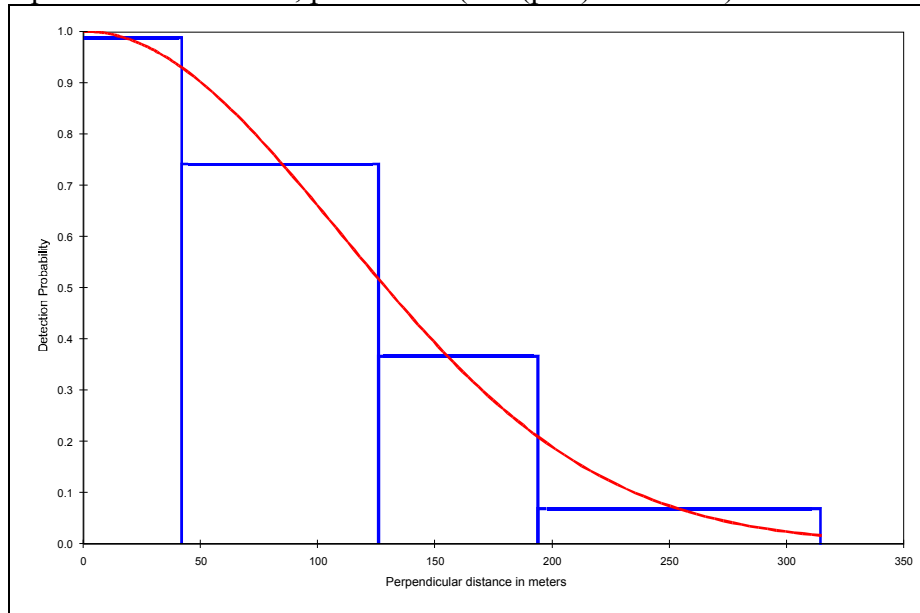


## 2.5 Kaimur Wildlife Sanctuary

### 2.5.1 Category: Ungulates

**Species:** Chinkara, blackbuck, nilgai, sambar

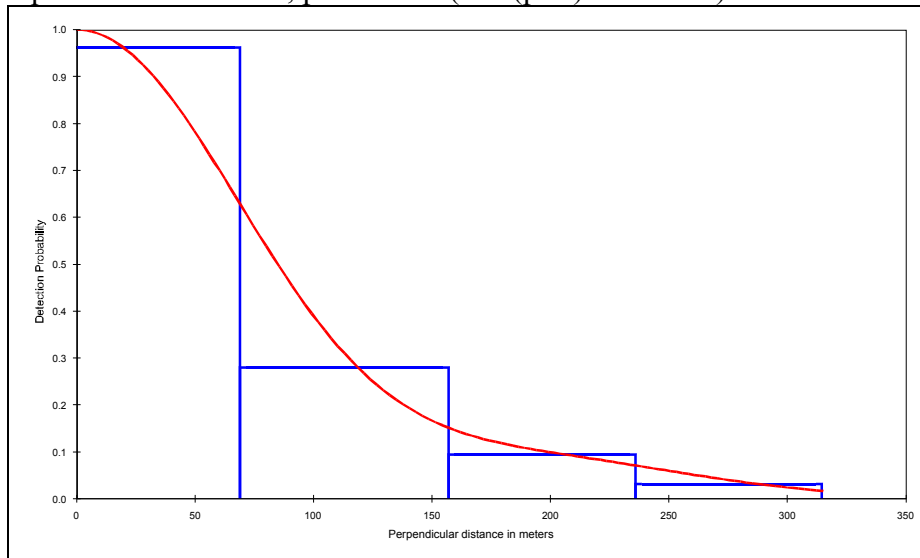
**Model:** Half normal key model with cosine adjustment term  
(Chi-square value = 0.9601;  $p = 0.4351$  (CV (p %) = 10.41%))



### 2.5.2 Category: Total prey excluding primates

**Species:** Chinkara, blackbuck, nilgai, sambar, peafowl, hare

**Model:** Half normal key model with cosine adjustment term  
(Chi-square value = 0.6.54;  $p = 0.3206$  (CV (p %) = 12.50%))

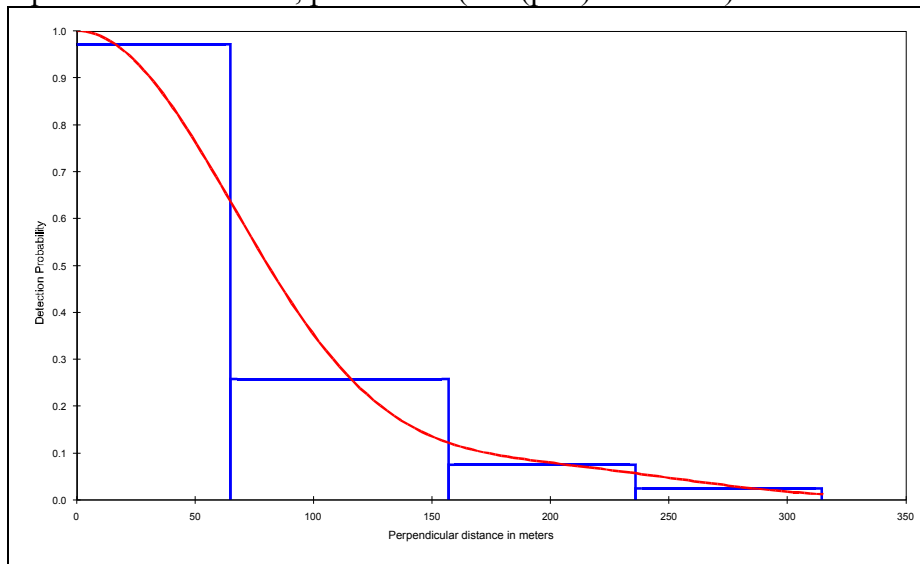


**2.5.3 Category:** Total prey including langur

**Species:** Chinkara, blackbuck, nilgai, sambar, peafowl, hare, langur

**Model:** Half normal key model with cosine adjustment term

(Chi-square value = 0.3076;  $p = 0.3011$  (CV (p %) = 10.76%))



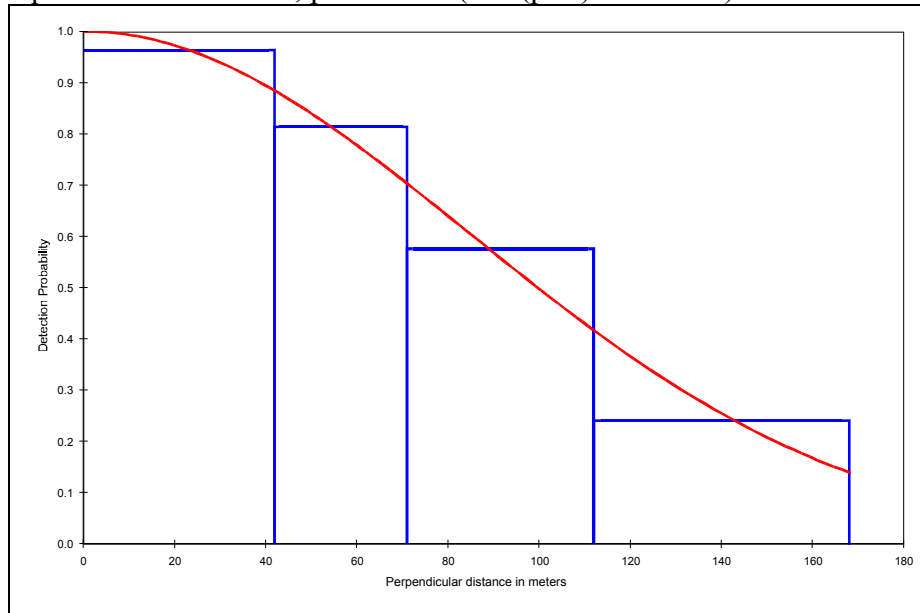
## 2.6 Sanjay-Dubri-Guru Ghasidas Landscape

### 2.6.1 Category: Ungulates

**Species:** Chinkara, muntjac, chital, nilgai, wild pig

**Model:** Half normal key model with cosine adjustment term

(Chi-square value = 0.9801;  $p = 0.6014$  (CV (p %) = 10.41%))

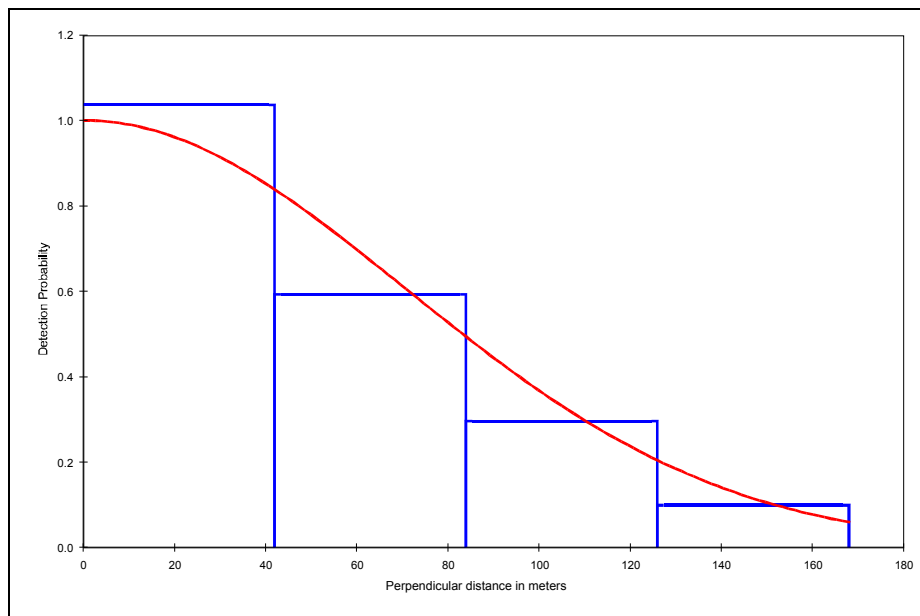


### 2.6.2 Category: Total prey excluding primates

**Species:** Chinkara, muntjac, chital, nilgai, hare, wild pig, peafowl

**Model:** Half normal key model with cosine adjustment term

(Chi-square value = 0.8968;  $p = 0.5177$  (CV (p %) = 10.90%))

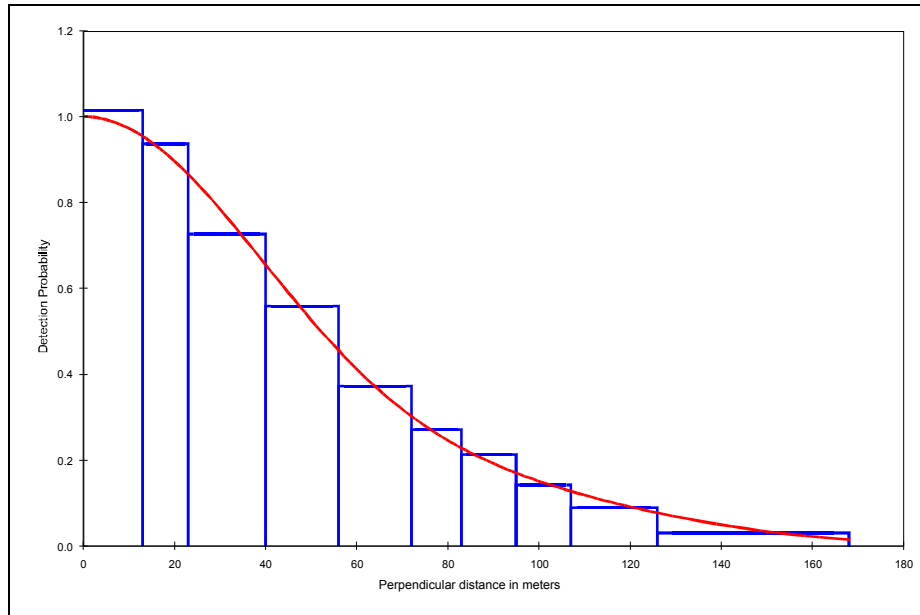


**2.6.3 Category:** Total prey including langur

**Species:** Chinkara, muntjac, chital, nilgai, hare, wild pig, peafowl, langur

**Model:** Half normal key model with cosine adjustment term

(Chi-square value = 0.9995;  $p = 0.3595$  (CV (p %) = 8.83%))



## Appendix 4 Population Habitat Viability Analysis

VORTEX 9.93 -- simulation of population dynamics

### 4.1 Shahgarh Bulge Single Population

1 population(s) simulated for 100 years, 1000 iterations  
Each simulation year is 365 days duration.

Extinction is defined as no animals of one or both sexes.

Inbreeding depression modeled with 3.14000 lethal equivalents per individual,  
comprised of 1.57000 recessive lethal alleles,  
and 1.57000 lethal equivalents not subject to removal by selection.

EV in reproduction and mortality will be concordant.

First age of reproduction for females: 3 for males: 3  
Maximum breeding age (senescence): 12  
Sex ratio at birth (percent males): 50

Population 1: Shahgarh

Polygynous mating;  
% of adult males in the breeding pool = 33.4

% adult females breeding =  $(100 - ((100 - 70) * ((N/K)^8))) * (N / (0 + N))$   
EV in % adult females breeding: SD = 5

Distribution of number of separately sired broods produced by a female in a year ...  
50.00 percent of females produce 0 broods (litters, clutches) in an average year  
50.00 percent of females produce 1 broods (litters, clutches) in an average year

Of those females producing progeny, ...  
30.00 percent of females produce 1 progeny in an average year  
40.00 percent of females produce 2 progeny in an average year  
20.00 percent of females produce 3 progeny in an average year  
10.00 percent of females produce 4 progeny in an average year

% mortality of females between ages 0 and 1 = 40  
EV in % mortality: SD = 8  
% mortality of females between ages 1 and 2 = 15  
EV in % mortality: SD = 1.5  
% mortality of females between ages 2 and 3 = 12  
EV in % mortality: SD = 1.5



% mortality of adult females ( $3 \leq \text{age} \leq 12$ ) = 12  
 EV in % mortality: SD = 1.2  
 % mortality of males between ages 0 and 1 = 40  
 EV in % mortality: SD = 8  
 % mortality of males between ages 1 and 2 = 15  
 EV in % mortality: SD = 1.5  
 % mortality of males between ages 2 and 3 = 15  
 EV in % mortality: SD = 1.5  
 % mortality of adult males ( $3 \leq \text{age} \leq 12$ ) = 15  
 EV in % mortality: SD = 1.5

EVs may be adjusted to closest values possible for binomial distribution.

Catastrophe type 1: 0  
 Frequency (as a percent): 10  
 Multiplicative effect on reproduction = .6  
 Multiplicative effect on survival = .7

Initial size of Shahgarh: 6

Age	1	2	3	4	5	6	7	8	9	10	11	12	Total
	0	0	0	2	0	0	0	0	0	0	0	0	2 Males
	0	0	4	0	0	0	0	0	0	0	0	0	4 Females

Carrying capacity = 15  
 with a 4.000 percent increase for 30 years.  
 EV in Carrying capacity = 2

Animals added to Shahgarh, year 2 through year 10 at 2 year intervals:  
 females 2 years old: 2  
 males 3 years old: 1

### SHAHGARH Simulation Results

Year 100

N[Extinct] = 204, P[E] = 0.204  
 N[Surviving] = 796, P[S] = 0.796  
 Mean size (all populations) = 19.83 ( 0.39 SE; 12.35 SD)  
 Means across extant populations only:  
 Population size = 24.88 ( 0.29 SE; 8.15 SD)  
 Expected heterozygosity = 0.436 ( 0.007 SE; 0.202 SD)  
 Observed heterozygosity = 0.477 ( 0.008 SE; 0.235 SD)  
 Number of extant alleles = 2.71 ( 0.03 SE; 0.93 SD)  
 Lethal alleles / diploid = 0.24 ( 0.01 SE; 0.28 SD)

In 1000 simulations of Shahgarh for 100 years:

204 went extinct and 796 survived.

This gives a probability of extinction of 0.2040 (0.0127 SE),  
or a probability of success of 0.7960 (0.0127 SE).

211 simulations went extinct at least once.

Of those going extinct,  
mean time to first extinction was 57.83 years (1.93 SE, 28.10 SD).

11 recolonizations occurred.

Mean time to recolonization was 1.00 years (0.00 SE; 0.00 SD).

4 re-extinctions occurred.

Mean time to re-extinction was 48.25 years (11.76 SE; 23.51 SD).

Means across all populations (extant and extinct) ...

Mean final population was 19.83 (0.39 SE; 12.35 SD)

Age 1	2	Adults	Total	
1.91	1.63	5.92	9.46	Males
2.03	1.61	6.74	10.37	Females

Means across extant populations only ...

Mean final population for successful cases was 24.88 (0.29 SE, 8.15 SD)

Age 1	2	Adults	Total	
2.40	2.04	7.44	11.88	Males
2.55	2.03	8.46	13.03	Females

During years of harvest and/or supplementation

mean growth rate (r) was 0.3188 (0.0033 SE, 0.2334 SD, mean n = 5.0 years)

During years without harvest or supplementation,

mean growth rate (r) was 0.0386 (0.0007 SE; 0.2162 SD)

Across all years, prior to carrying capacity truncation,

mean growth rate (r) was 0.0538 (0.0007 SE; 0.2263 SD)

Final expected heterozygosity was 0.4362 ( 0.0071 SE; 0.2016 SD)

Final observed heterozygosity was 0.4773 ( 0.0083 SE; 0.2353 SD)

Final number of alleles was 2.71 ( 0.03 SE; 0.93 SD)

Number of lethal alleles per diploid 0.24 ( 0.01 SE; 0.28 SD)

## 4.2 Metapopulation Simulation (Noradehi-Kuno Population)

2 population(s) simulated for 100 years, 1000 iterations  
Each simulation year is 365 days duration.

Extinction is defined as no animals of one or both sexes.

Inbreeding depression modeled with 3.14000 lethal equivalents per individual,  
comprised of 1.57000 recessive lethal alleles,  
and 1.57000 lethal equivalents not subject to removal by selection.

Minimum age at dispersal is 2.  
Maximum age at dispersal is 10.  
Both females and males disperse.  
Percent survival during dispersal = 90

Dispersal rate matrix (rows are source populations; columns are recipient populations):

	Kuno	Noradehi
Kuno	1.00000	
Noradehi	1.00000	

EV in reproduction and mortality will be concordant.  
Correlation of EV among populations = 0.500000

First age of reproduction for females: 3 for males: 4  
Maximum breeding age (senescence): 12  
Sex ratio at birth (percent males): 50

Population 1: Kuno

Polygynous mating;  
% of adult males in the breeding pool = 33.4

% adult females breeding =  $(100 - ((100 - 40) * ((N/K)^1))) * (N / (0 + N))$   
EV in % adult females breeding: SD = 10

Distribution of number of separately sired broods produced by a female in a year ...  
50.00 percent of females produce 0 broods (litters, clutches) in an average year  
50.00 percent of females produce 1 broods (litters, clutches) in an average year

Of those females producing progeny, ...  
30.00 percent of females produce 1 progeny in an average year  
40.00 percent of females produce 2 progeny in an average year  
20.00 percent of females produce 3 progeny in an average year

10.00 percent of females produce 4 progeny in an average year

% mortality of females between ages 0 and 1 = 40

EV in % mortality: SD = 8

% mortality of females between ages 1 and 2 = 15

EV in % mortality: SD = 1.5

% mortality of females between ages 2 and 3 = 12

EV in % mortality: SD = 1.5

% mortality of adult females ( $3 \leq \text{age} \leq 14$ ) = 10

EV in % mortality: SD = 1.5

% mortality of males between ages 0 and 1 = 40

EV in % mortality: SD = 8

% mortality of males between ages 1 and 2 = 15

EV in % mortality: SD = 1.5

% mortality of males between ages 2 and 3 = 15

EV in % mortality: SD = 1.5

% mortality of males between ages 3 and 4 = 15

EV in % mortality: SD = 1.5

% mortality of adult males ( $4 \leq \text{age} \leq 14$ ) = 15

EV in % mortality: SD = 1.5

EVs may be adjusted to closest values possible for binomial distribution.

Catastrophe type 1: 0

Type 1 catastrophes are local.

Frequency (as a percent): 10

Multiplicative effect on reproduction = .6

Multiplicative effect on survival = .8

Initial size of Kuno: 9

Total: 3 Adult Males; 6 Adult Females

Carrying capacity = 20

with a 4.000 percent increase for 25 years.

EV in Carrying capacity = 3

Animals added to Kuno, year 2 through year 10 at 2 year intervals:

females 3 years old: 2

males 4 years old: 1

Population 2: Noradehi

Polygynous mating;

% of adult males in the breeding pool = 33.4

% adult females breeding =  $(100 - ((100 - 40) * ((N/K)^1))) * (N / (0 + N))$   
EV in % adult females breeding: SD = 10

Distribution of number of separately sired broods produced by a female in a year ...  
50.00 percent of females produce 0 broods (litters, clutches) in an average year  
50.00 percent of females produce 1 broods (litters, clutches) in an average year

Of those females producing progeny, ...  
30.00 percent of females produce 1 progeny in an average year  
40.00 percent of females produce 2 progeny in an average year  
20.00 percent of females produce 3 progeny in an average year  
10.00 percent of females produce 4 progeny in an average year

% mortality of females between ages 0 and 1 = 40  
EV in % mortality: SD = 8  
% mortality of females between ages 1 and 2 = 15  
EV in % mortality: SD = 1.5  
% mortality of females between ages 2 and 3 = 12  
EV in % mortality: SD = 1.5  
% mortality of adult females ( $3 \leq \text{age} \leq 14$ ) = 10  
EV in % mortality: SD = 1.5  
% mortality of males between ages 0 and 1 = 40  
EV in % mortality: SD = 8  
% mortality of males between ages 1 and 2 = 15  
EV in % mortality: SD = 1.5  
% mortality of males between ages 2 and 3 = 15  
EV in % mortality: SD = 1.5  
% mortality of males between ages 3 and 4 = 15  
EV in % mortality: SD = 1.5  
% mortality of adult males ( $4 \leq \text{age} \leq 14$ ) = 15  
EV in % mortality: SD = 1.5

EVs may be adjusted to closest values possible for binomial distribution.

Catastrophe type 1: 0  
Type 1 catastrophes are local.  
Frequency (as a percent): 10  
Multiplicative effect on reproduction = .6  
Multiplicative effect on survival = .8

Initial size of Noradehi: 9  
Total: 3 Adult Males; 6 adult Females

Carrying capacity = 20  
with a 6.000 percent increase for 25 years.  
EV in Carrying capacity = 2

Animals added to Noradehi, year 2 through year 10 at 2 year intervals:  
females 3 years old: 2  
males 4 years old: 1

## Results of the Metapopulation Simulations

### KUNO-Sheopur Population

Year 100

N[Extinct] = 11, P[E] = 0.011

N[Surviving] = 989, P[S] = 0.989

Mean size (all populations) = 25.27 ( 0.23 SE; 7.17 SD)

Means across extant populations only:

Population size = 25.53 ( 0.22 SE; 6.78 SD)

Expected heterozygosity = 0.687 ( 0.004 SE; 0.114 SD)

Observed heterozygosity = 0.731 ( 0.005 SE; 0.148 SD)

Number of extant alleles = 5.62 ( 0.05 SE; 1.50 SD)

Lethal alleles / diploid = 0.57 ( 0.01 SE; 0.41 SD)

In 1000 simulations of Kuno for 100 years:

11 went extinct and 989 survived.

This gives a probability of extinction of 0.0110 (0.0033 SE),  
or a probability of success of 0.9890 (0.0033 SE).

45 simulations went extinct at least once.

Of those going extinct,

mean time to first extinction was 66.20 years (3.86 SE, 25.92 SD).

60 recolonizations occurred.

Mean time to recolonization was 4.97 years (0.62 SE; 4.84 SD).

26 re-extinctions occurred.

Mean time to re-extinction was 6.04 years (1.92 SE; 9.79 SD).

Means across all populations (extant and extinct) ...

Mean final population was 25.27 (0.23 SE; 7.17 SD)

Age	1	2	3	Adults	Total
	2.31	1.84	1.49	5.92	11.56 Males
	2.33	1.80		9.58	13.71 Females

Means across extant populations only ...

Mean final population for successful cases was 25.53 (0.22 SE, 6.78 SD)

Age	1	2	3	Adults	Total	
	2.34	1.86	1.50	5.99	11.69	Males
	2.36	1.82		9.69	13.86	Females

During years of harvest and/or supplementation

mean growth rate (r) was 0.2252 (0.0027 SE, 0.1901 SD, mean n = 5.0 years)

During years without harvest or supplementation,

mean growth rate (r) was 0.0292 (0.0006 SE; 0.1813 SD)

Across all years, prior to carrying capacity truncation,

mean growth rate (r) was 0.0391 (0.0006 SE; 0.1868 SD)

Final expected heterozygosity was 0.6874 ( 0.0036 SE; 0.1144 SD)

Final observed heterozygosity was 0.7308 ( 0.0047 SE; 0.1476 SD)

Final number of alleles was 5.62 ( 0.05 SE; 1.50 SD)

Number of lethal alleles per diploid 0.57 ( 0.01 SE; 0.41 SD)

### **NORADEHI Population**

Year 100

N[Extinct] = 3, P[E] = 0.003

N[Surviving] = 997, P[S] = 0.997

Mean size (all populations) = 37.81 ( 0.29 SE; 9.27 SD)

Means across extant populations only:

Population size = 37.92 ( 0.29 SE; 9.05 SD)

Expected heterozygosity = 0.698 ( 0.003 SE; 0.108 SD)

Observed heterozygosity = 0.732 ( 0.004 SE; 0.128 SD)

Number of extant alleles = 5.95 ( 0.05 SE; 1.50 SD)

Lethal alleles / diploid = 0.57 ( 0.01 SE; 0.39 SD)

In 1000 simulations of Noradehi for 100 years:

3 went extinct and 997 survived.

This gives a probability of extinction of 0.0030 (0.0017 SE),

or a probability of success of 0.9970 (0.0017 SE).

8 simulations went extinct at least once.

Of those going extinct,

mean time to first extinction was 39.88 years (11.93 SE, 33.73 SD).

7 recolonizations occurred.

Mean time to recolonization was 1.14 years (0.14 SE; 0.38 SD).

2 re-extinctions occurred.

Mean time to re-extinction was 3.00 years (2.00 SE; 2.83 SD).

Means across all populations (extant and extinct) ...

Mean final population was 37.81 (0.29 SE; 9.27 SD)

Age 1	2	3	Adults	Total	
3.31	2.66	2.25	9.34	17.56	Males
3.37	2.74		14.14	20.24	Females

Means across extant populations only ...

Mean final population for successful cases was 37.92 (0.29 SE, 9.05 SD)

Age 1	2	3	Adults	Total	
3.32	2.67	2.26	9.36	17.62	Males
3.38	2.75		14.18	20.30	Females

During years of harvest and/or supplementation

mean growth rate (r) was 0.2181 (0.0027 SE, 0.1909 SD, mean n = 5.0 years)

During years without harvest or supplementation,

mean growth rate (r) was 0.0249 (0.0005 SE; 0.1685 SD)

Across all years, prior to carrying capacity truncation,

mean growth rate (r) was 0.0346 (0.0006 SE; 0.1748 SD)

Final expected heterozygosity was 0.6982 ( 0.0034 SE; 0.1078 SD)

Final observed heterozygosity was 0.7321 ( 0.0040 SE; 0.1278 SD)

Final number of alleles was 5.95 ( 0.05 SE; 1.50 SD)

Number of lethal alleles per diploid 0.57 ( 0.01 SE; 0.39 SD)

## **METAPOPULATION**

Year 100

N[Extinct] = 1, P[E] = 0.001

N[Surviving] = 999, P[S] = 0.999

Mean size (all populations) = 63.07 ( 0.39 SE; 12.25 SD)

Means across extant populations only:

Population size = 63.14 ( 0.38 SE; 12.09 SD)

Expected heterozygosity = 0.750 ( 0.003 SE; 0.088 SD)

Observed heterozygosity = 0.731 ( 0.003 SE; 0.108 SD)

Number of extant alleles = 7.09 ( 0.05 SE; 1.58 SD)

Lethal alleles / diploid = 0.57 ( 0.01 SE; 0.34 SD)



In 1000 simulations of Metapopulation for 100 years:  
1 went extinct and 999 survived.

This gives a probability of extinction of 0.0010 (0.0010 SE),  
or a probability of success of 0.9990 (0.0010 SE).

1 simulations went extinct at least once.  
Of those going extinct,  
mean time to first extinction was 86.00 years (0.00 SE, 0.00 SD).

Means across all populations (extant and extinct) ...  
Mean final population was 63.07 (0.39 SE; 12.25 SD)

Age 1	2	3	Adults	Total	
5.63	4.50	3.74	15.26	29.12	Males
5.70	4.54		23.72	33.95	Females

Means across extant populations only ...  
Mean final population for successful cases was 63.14 (0.38 SE, 12.09 SD)

Age 1	2	3	Adults	Total	
5.63	4.50	3.74	15.27	29.15	Males
5.70	4.54		23.74	33.98	Females

During years of harvest and/or supplementation  
mean growth rate (r) was 0.2220 (0.0020 SE, 0.1390 SD, mean n = 5.0 years)

During years without harvest or supplementation,  
mean growth rate (r) was 0.0293 (0.0004 SE; 0.1248 SD)

Across all years, prior to carrying capacity truncation,  
mean growth rate (r) was 0.0389 (0.0004 SE; 0.1324 SD)

Final expected heterozygosity was	0.7504 ( 0.0028 SE; 0.0881 SD)
Final observed heterozygosity was	0.7305 ( 0.0034 SE; 0.1081 SD)
Final number of alleles was	7.09 ( 0.05 SE; 1.58 SD)
Number of lethal alleles per diploid	0.57 ( 0.01 SE; 0.34 SD)

## Appendix 5

### SOCIO-ECONOMIC AND ATTITUDE SURVEY OF HOUSEHOLDS

Name of the interviewer:

Date:

Name of the settlement:

Village:

Tehsil:

District:

State:

#### Section 1: Interviewer's assessment (Do a visual assessment of the interviewee)

**Note:** Do not ask interviewee questions from this section

1.1 Based a visual assessment of the interviewee, answer the following:

(a) Age (approximate):  (b) Sex: Male/Female

(b) Condition and quality of clothes (rate on a scale of 0-5, where 0 is very poor and 5 is excellent):

Quality and quantity of ornaments, wrist watch, etc. (rate on a scale of 0-5, where 0 is none and 5 is numerous of high quality):

(c) What mode of transportation is being used by the interviewee?

(a) None (b) Cycle (c) Fuel propelled two-wheeler (d) Others (specify).....

#### Section 2: Household characteristics

2.1 What type of house do you have?

(a) *pucca* (b) *semi-pucca* (c) *kutcha*

2.2 What type of roof does your house have?

(a) Thatch (b) Tinned/cement sheets (c) Mud baked tiles (old/new type) (d) Concrete

2.3 Do you have electricity connection?

(a) Yes (b) No

2.4 What is your source of drinking water?

(a) Tap (b) Open well (c) Bore hole

(d) Stream/river (e) Lake/pond (f) Others

2.5 How far do you have to travel to get drinking water?

(a) Home supply (b) 0-5 minute walk (c) >5-15 minute walk (d) >15 minute walk

2.6 What source of fuel do you use for cooking purpose?

(a) LPG gas (b) Kerosene (c) Bio-gas (d) Fuel wood

2.7 How long have you lived in this place?

(a) First generation (b) Second generation (c) More than two generations

2.8 How far is the closest urban centre?

- (a) 0-30 kilometres      (b) >30-60 kilometres      (c) >60 kilometres

2.8 How often you go there?

- (a) Every day      (b) Once a week      (c) Once a fortnight      (d) Once a month

2.10 What is/are your source/s of livelihood? (List in terms of priority if more than one)

- (a) Service (government/private)      (b) Agriculture      (c) Livestock farming/sericulture  
 (d) Daily wages      (e) Others

**Section 3: Livestock**

3.1 Do you own livestock?

- (a) Yes      (b) No

3.2 How much livestock do you own? (Mention numbers for each)

- (a) Sheep            (b) Goats            (c) Cattle        
 (d) Buffaloes            (e) Camel            (f) Others (specify).....

3.3 Do you lose livestock to disease/carnivores, if yes, how many?

	Disease	Carnivores				Feral dogs
		Leopard	Wolf	Hyena	Others (specify)	
Sheep						
Goats						
Cattle						
Others (specify)						

3.4 How far do you have to travel to sell livestock products: milk/wool/meat?

- (a) 0-60 kilometres      (b) 60-150 kilometres      (c) >150 kilometres

3.5 How many months of the year does livestock from your village remain in this area?

- (a) 1-3 months      (b) >3-6 months      (c) >6 months      (d) Year round

3.6 Does livestock from outside your village graze in your pastures?

- (a) Yes      (b) No      (c) Don't know

If "Yes" to the above, for how many months of the year.....

How many animals..... (Mention the species).....

**Section 4: Agriculture**

4.1 Do you own agricultural land?

- (a) Yes      (b) No

If "Yes" to the above, is it irrigated? Yes/No.....

4.2 What form of irrigation facilities do you use?

- (a) Bore hole                      (b) Open well                      (c) Stream/river                      (d) Pond/lake  
 (e) Others (specify).....

4.3 What is the size of your land holding? .....

4.4 How many crops do you get from your land in one year?

- (a) 0-1                      (b) 1-2                      (c) >2

4.5 Is crop raiding a problem in your area?

- (a) Yes                      (b) No

4.6 If "Yes" to the above, what species of ungulates damage crops most? (Mention species in terms of priority if more than one).....

**Section 5: Perceptions about wildlife**

5.1 Do people in this village consume meat?

- (a) Yes                      (b) No

If "Yes", how often? .....

5.1.1 What is the source?

(a) Domesticated animals \_\_\_\_\_

(b) Bush meat name species \_\_\_\_\_

5.2 What wildlife species are found in this area?

<b>Carnivores</b>	Tiger	Leopard	Sloth-bear	Hyena	Wolf	Jackal	Fox	
<b>Ungulates</b>	Sambar	Chital	Chowsingha	Barking deer	Blackbuck	Chinkara	Nilgai	Wild Pig
<b>Birds</b>	Peafowl	Great Indian Bustard						
<b>Other Mammals</b>	Hare	Langur	Rhesus macaque					

5.3 Can people in your village trap/snare animals?

- (a) Yes                      (b) No                      (c) Don't know

5.4 Do people in your village own weapons?

- (a) Yes                      (b) No                      (c) Don't know

**Appendix 6 Socio-economic data**

**6.1 Summary of socio economic data**

	<b>Dubri WLS</b>	<b>Sanjay TR</b>	<b>Guru Ghasi Das NP</b>	<b>Bagdara WLS</b>	<b>Kaimur WLS</b>	<b>Desert NP</b>	<b>Shahgarh grasslands</b>	<b>Banni grasslands</b>	<b>Kuno- Palpur WLS</b>	<b>Nauradehi</b>
<b>No. of villages covered during interviews</b>	24	17	31	53	43	29(dhanis+villages)	20 (dhanis)	16	30	69
<b>No. of households interviewed</b>	121	64	77	223	202	67	20	42	98	181
<b>No. of villages unable to cover/abandoned</b>	6	1	9	11	8	25	71*	15	N/A	5

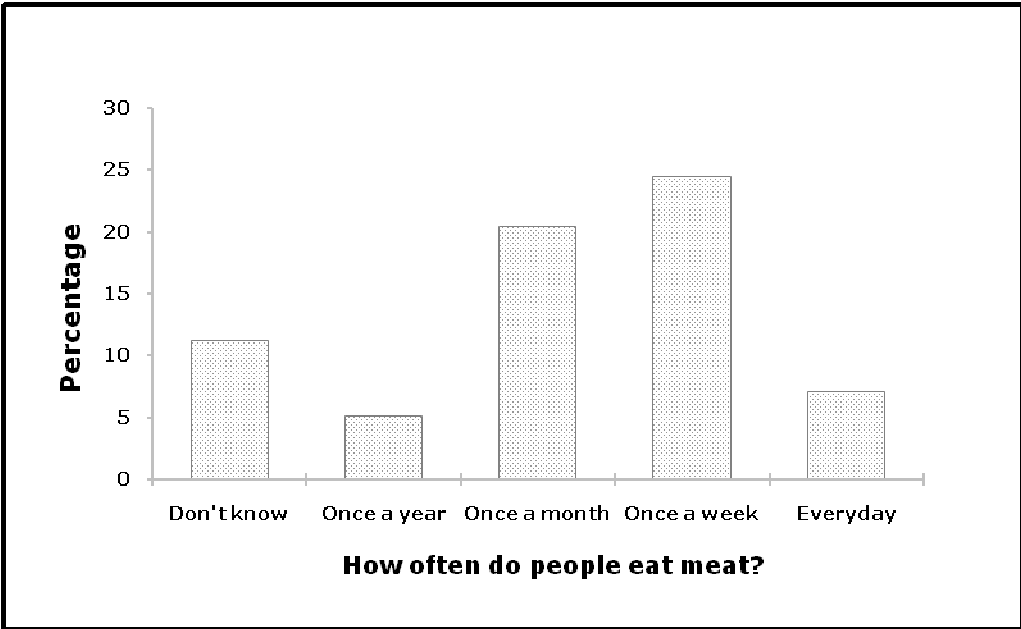
\*Most of them are seasonal settlements

6.2 Summary of livelihoods assessment- average scores for each site

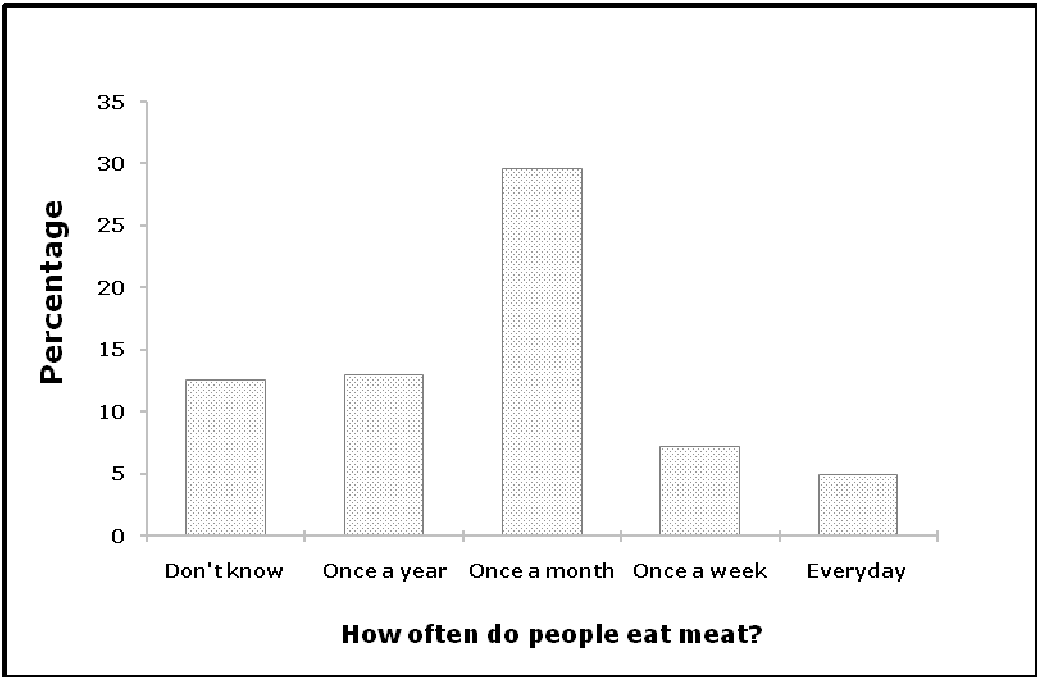
Site	Average score- Clothing (Scale: 0-5)	Average score- Accessories (footwear, ornaments, etc (Scale: 0-5)	Average score- Mode of transportation	Average score- Type of house	Average score- Type of roof	Average landholding (acres)	Is the land irrigated?	Average livestock number
Kuno WLS	1.99 (0.05)	1.86 (0.09)	0.37 (0.11)	1.49 (0.08)	1.54 (0.09)	7.35 (0.99)	1.22 (0.05)	15.88 (1.85)
Bagdara WLS	2.18 (0.05)	1.43 (0.06)	0.14 (0.04)	1.10 (0.03)	2.89 (0.04)	16.95 (1.67)	1.18 (0.03)	8.83 (0.72)
Kaimur WLS	2.13 (0.06)	1.05 (0.06)	0.36 (0.06)	1.10 (0.03)	3.01 (0.03)	3.08 (0.60)	1.11 (0.02)	8.30 (0.81)
Sanjay NP	2.19 (0.13)	1.09 (0.10)	0.16 (0.07)	1.03 (0.02)	3.00 (0.0)	7.46 (1.55)	1.17 (0.06)	12.77 (1.59)
Dubri WLS	2.04 (0.10)	1.39 (0.09)	0.77 (0.10)	1.35 (0.06)	3.01 (0.03)	6.34 (1.61)	1.21 (0.07)	8.90 (2.19)
Guru Ghasidas WLS	2.01 (0.10)	1.18 (0.10)	0.49 (0.11)	1.23 (0.05)	2.95 (0.04)	5.43 (0.63)	1.18 (0.05)	15.66 (1.39)
Shahgarh	2.05 (0.05)	1.35 (0.13)	0.40 (0.28)	1.10 (0.10)	1.00 (0.0)	0.00	N/a	326.10 (44.37)
Nauradehi	2.26 (0.07)	1.27 (0.09)	1.07 (0.08)	1.27 (0.04)	2.92 (0.04)	3.15 (0.29)	1.51 (0.04)	5.86 (0.42)
Desert NP	2.84 (0.05)	2.43 (0.08)	0.13 (0.08)	1.55 (0.09)	1.54 (0.13)	2.24 (0.36)	0.72 (0.06)	193.67 (24.61)
Banni	2.21 (0.13)	1.55 (0.12)	0.74 (0.27)	2.02 (0.13)	2.64 (0.14)	2.02 (1.35)	1.05 (0.03)	20.97 (4.44)

**Appendix 7 Attitudes and perceptions of people towards wildlife in the area**

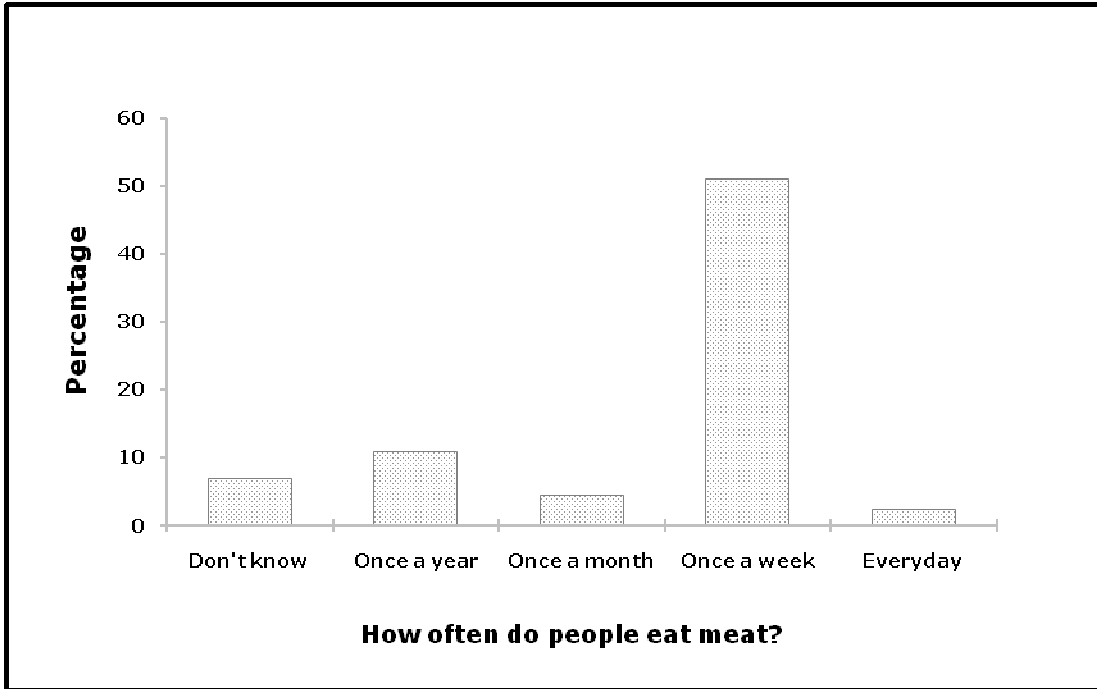
**7.1 How often do people eat meat?**



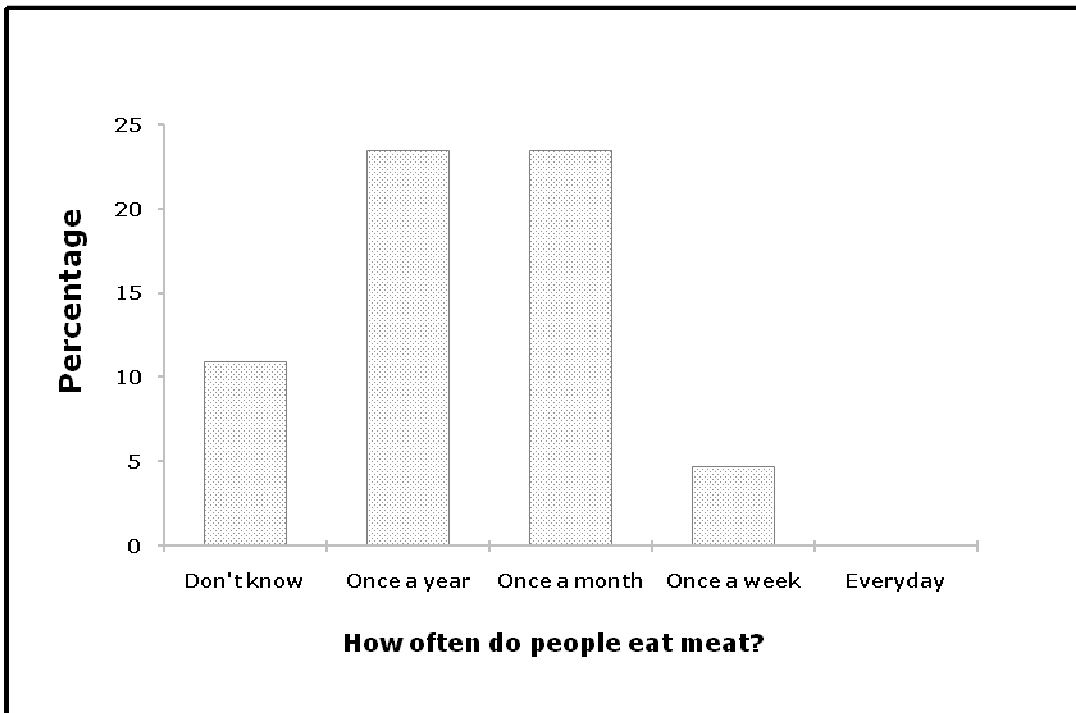
Percentage of respondents in Kuno Palpur - Frequency of eating meat (n=98)



Percentage of respondents in Bagdara - Frequency of eating meat (n=223)

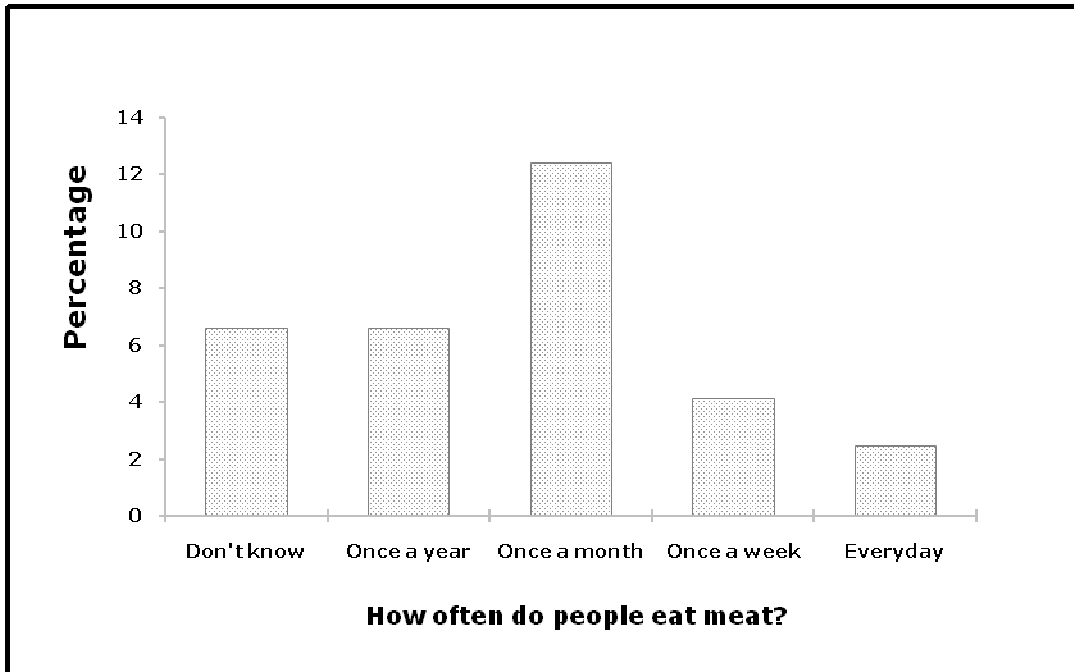


Percentage of respondents in Kaimur - Frequency of eating meat (n=202)

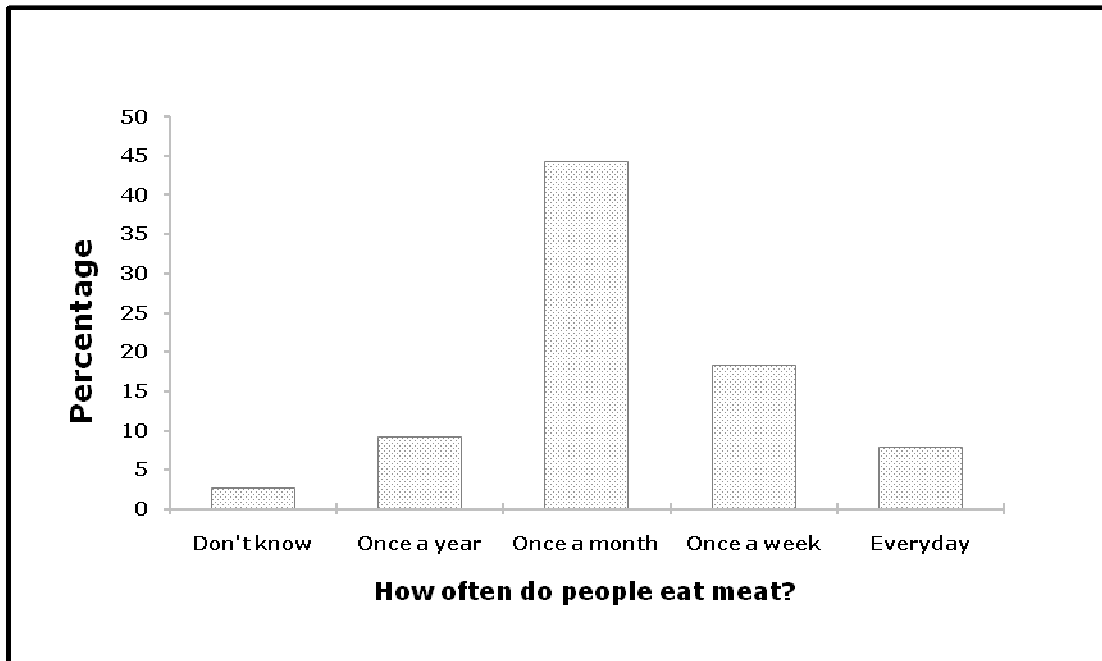


Percentage of respondents in Sanjay- Frequency of eating meat (n=64)

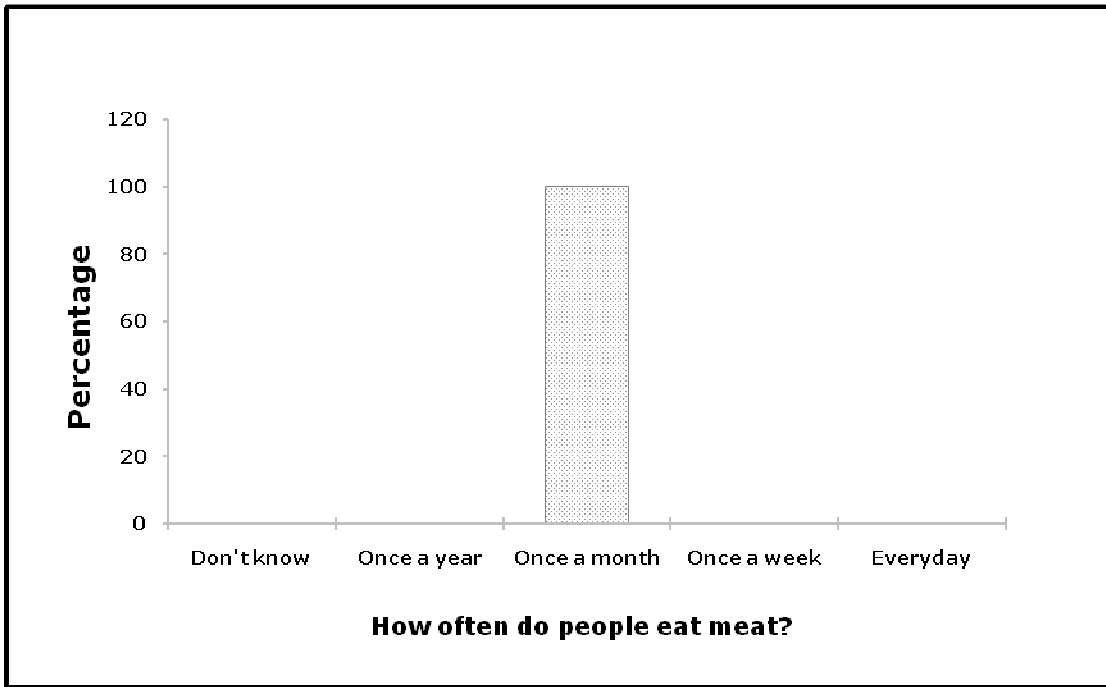




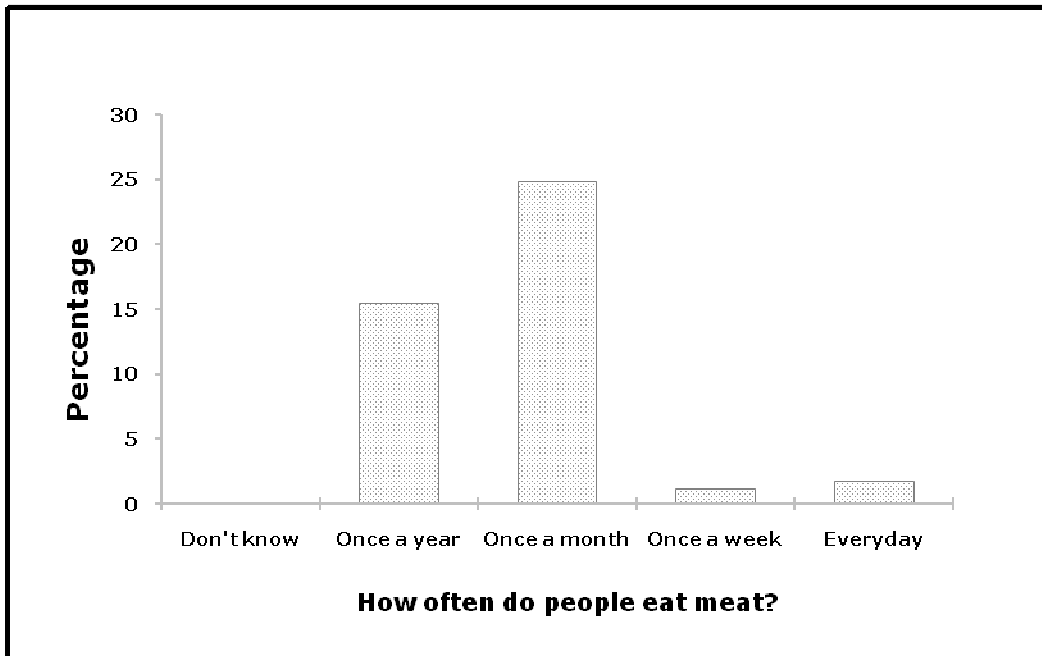
Percentage of respondents in Dubri - Frequency of eating meat (n=121)



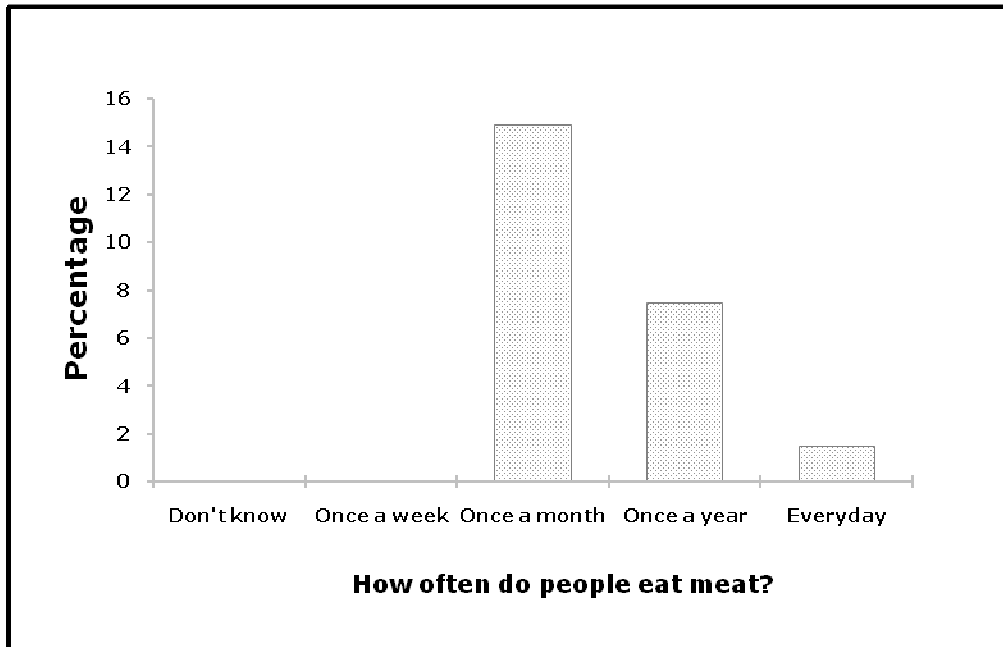
Percentage of respondents in Guru Ghasidas - Frequency of eating meat (n=77)



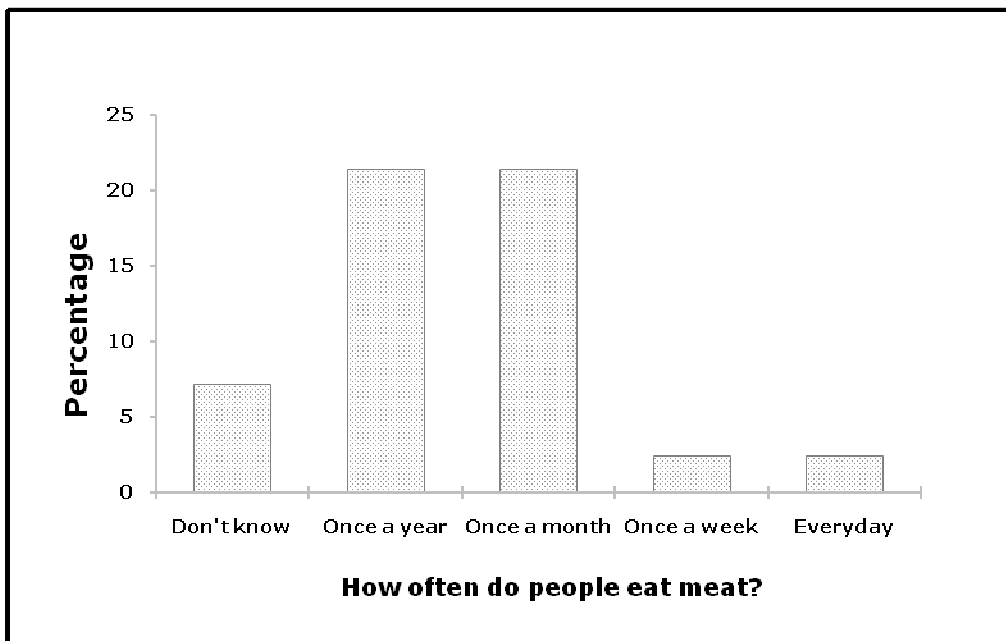
Percentage of respondents in Shahgarh - Frequency of eating meat (n=20)



Percentage of respondents in Nauradehi - Frequency of eating meat (n=181)

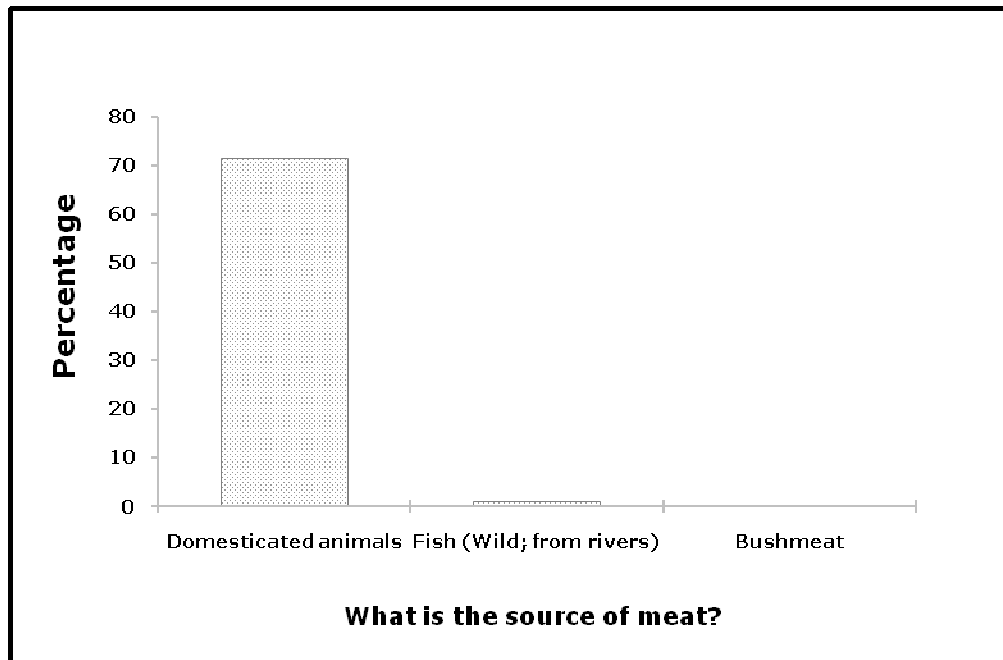


Percentage of respondents in Desert National Park - Frequency of eating meat (n=67)

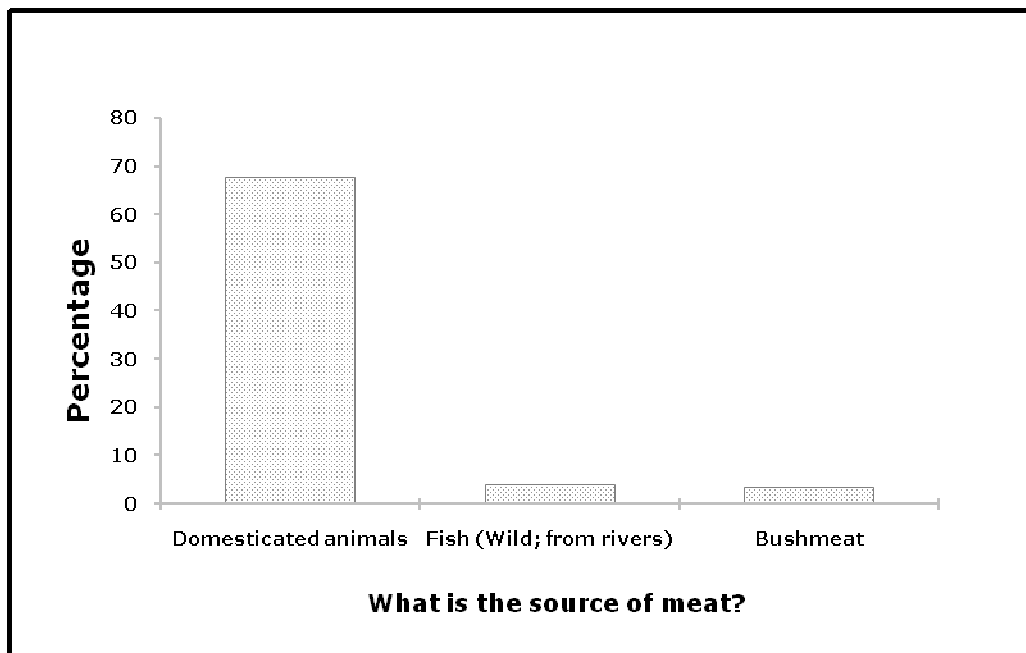


Percentage of respondents in Banni - Frequency of eating meat (n=42)

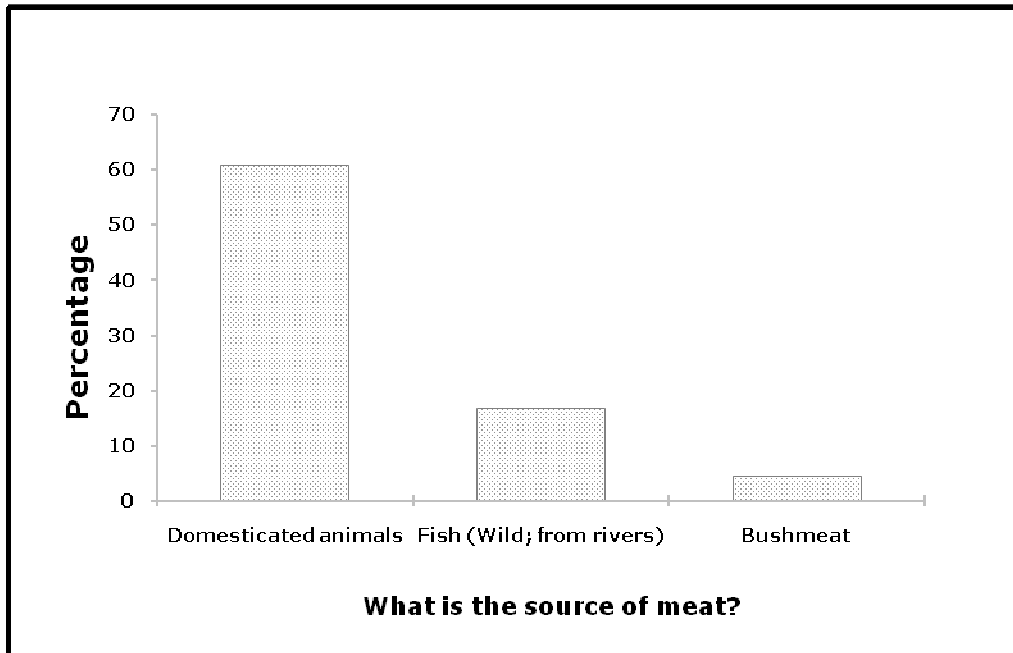
## 7. 2 What is the source of meat?



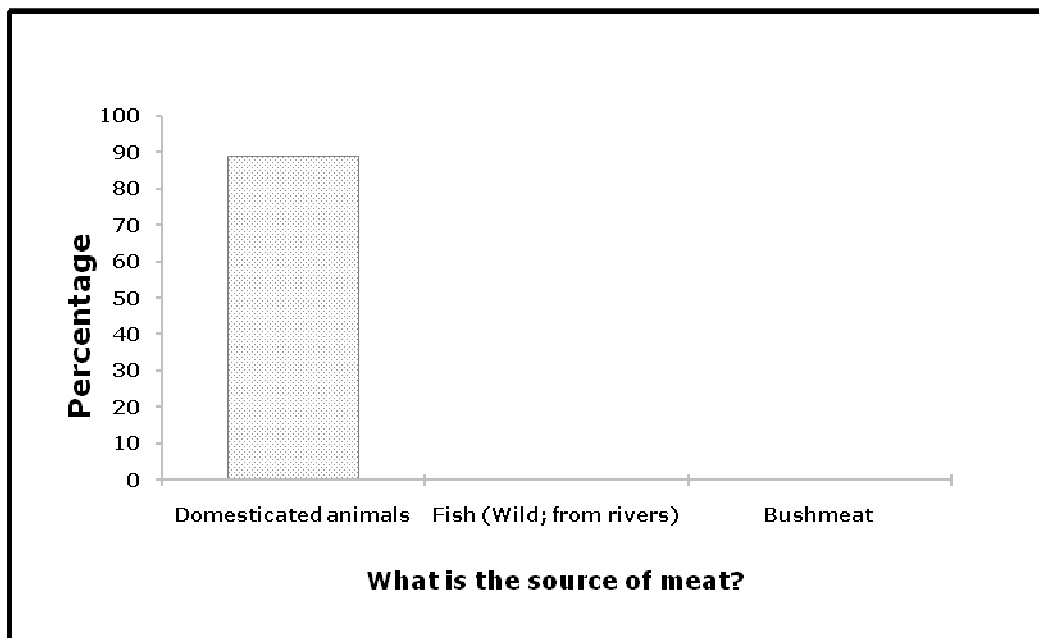
The source of meat in people's diet in Kuno (n=98)



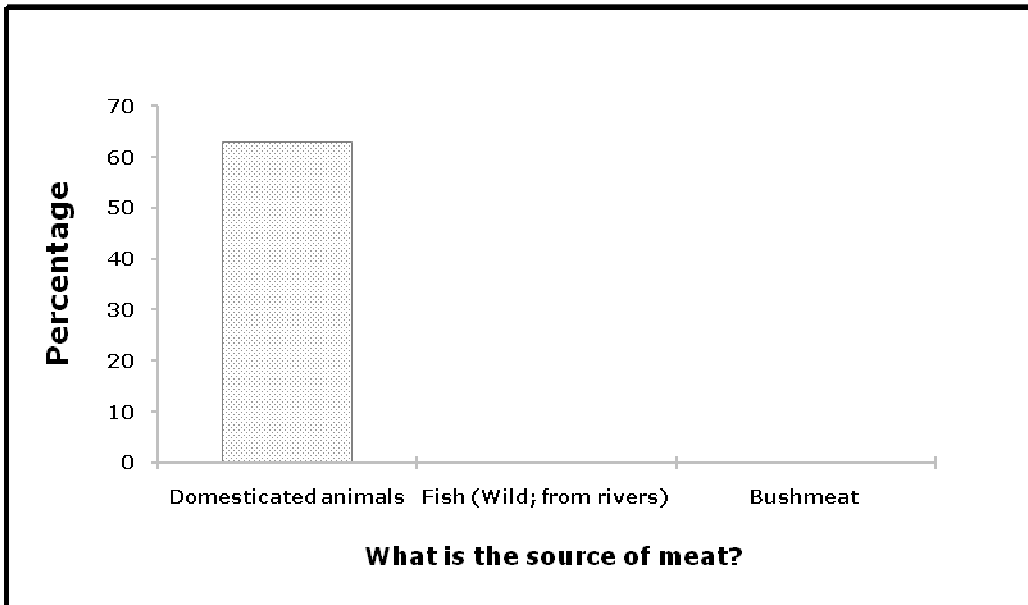
The source of meat in people's diet in Bagdara (n=223)



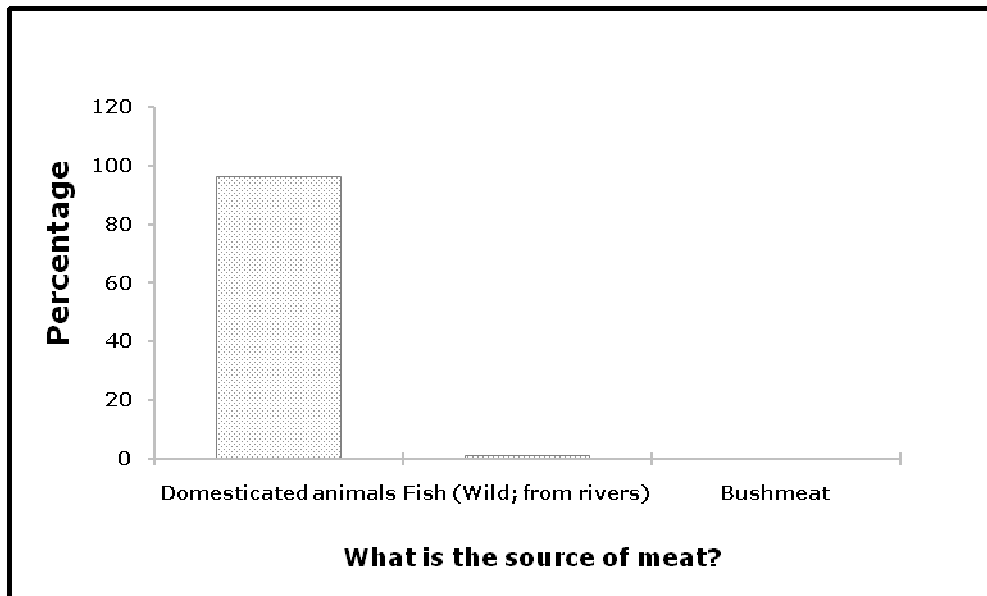
The source of meat in people's diet in Kaimur (n=202)



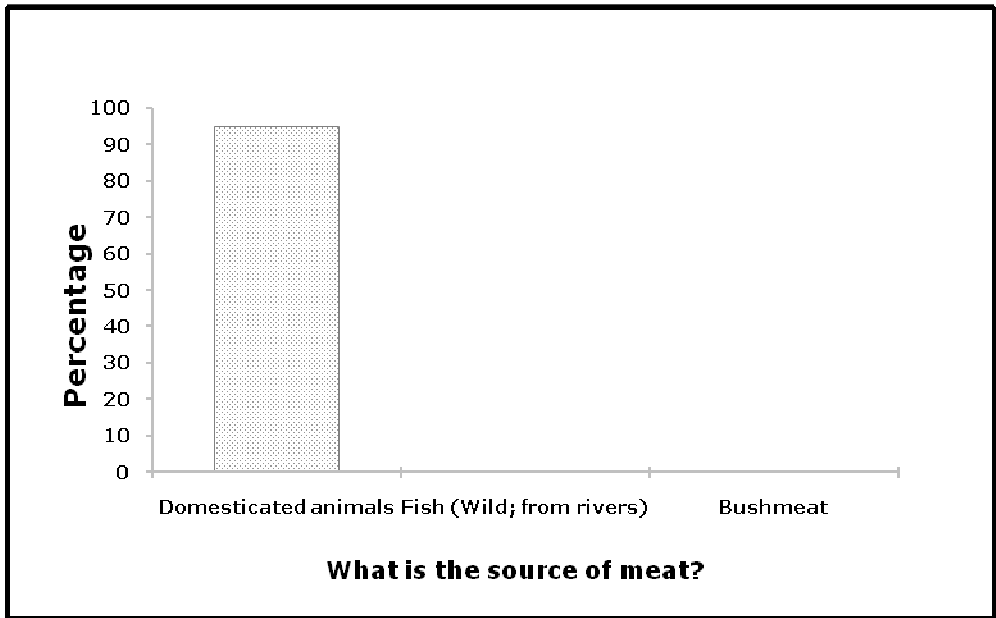
The source of meat in people's diet in Sanjay (n=64)



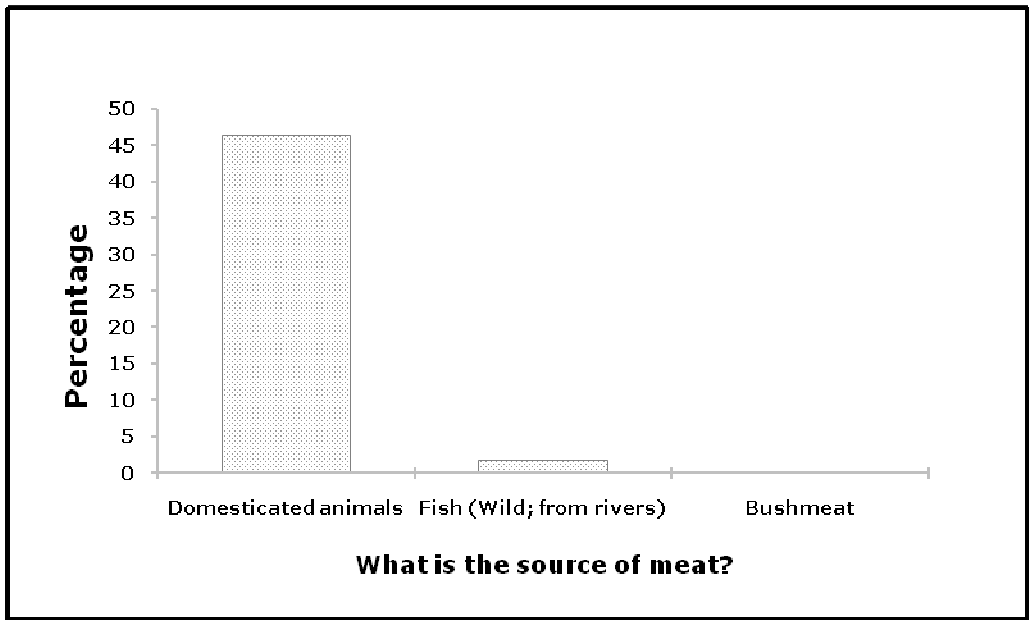
The source of meat in people's diet in Dubri (n=121)



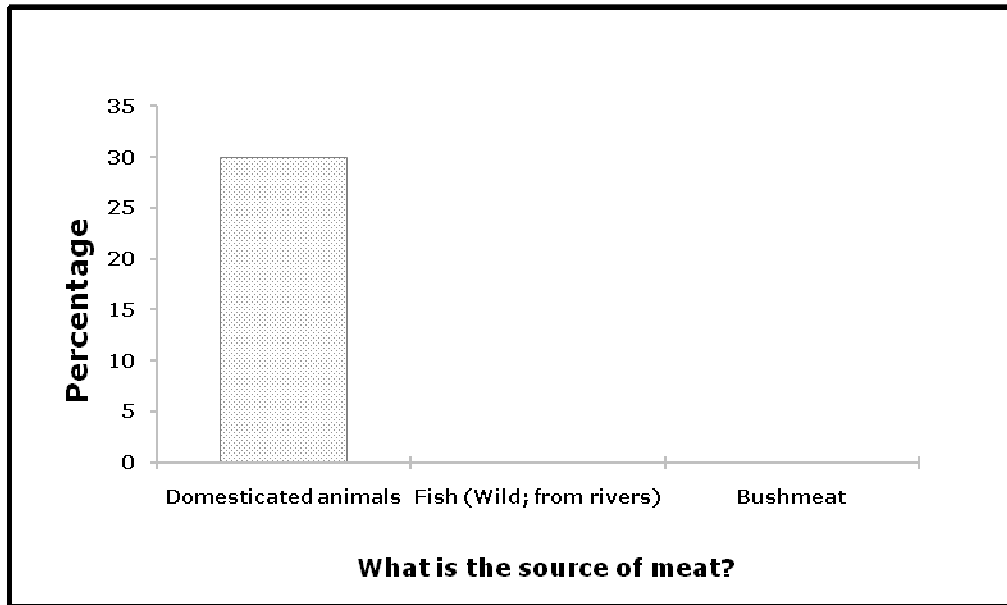
The source of meat in people's diet in Guru Ghasidas (n=77)



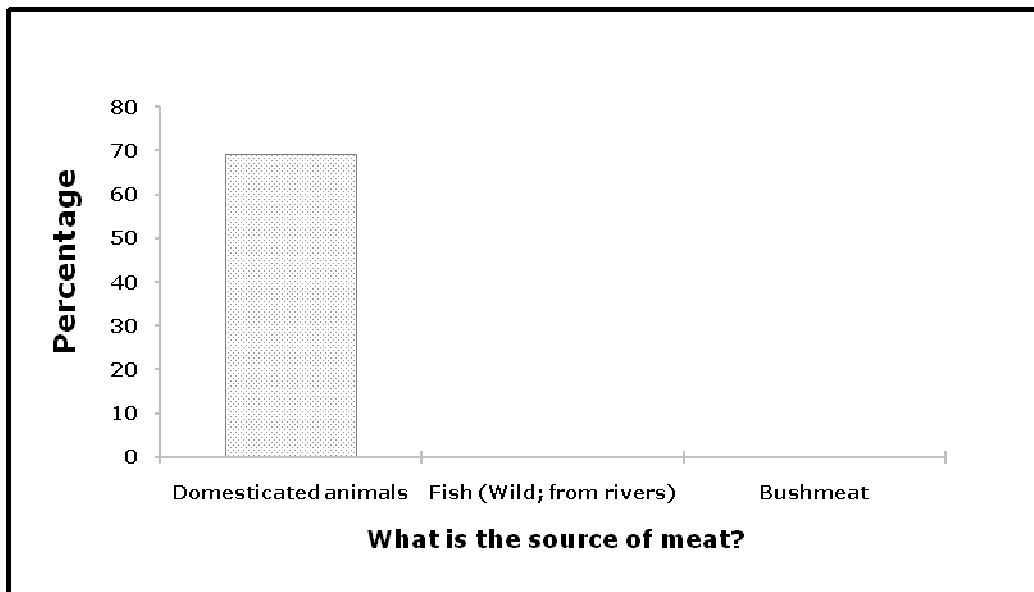
The source of meat in people's diet in Shahgarh (n=20)



The source of meat in people's diet in Nauradehi (n=181)



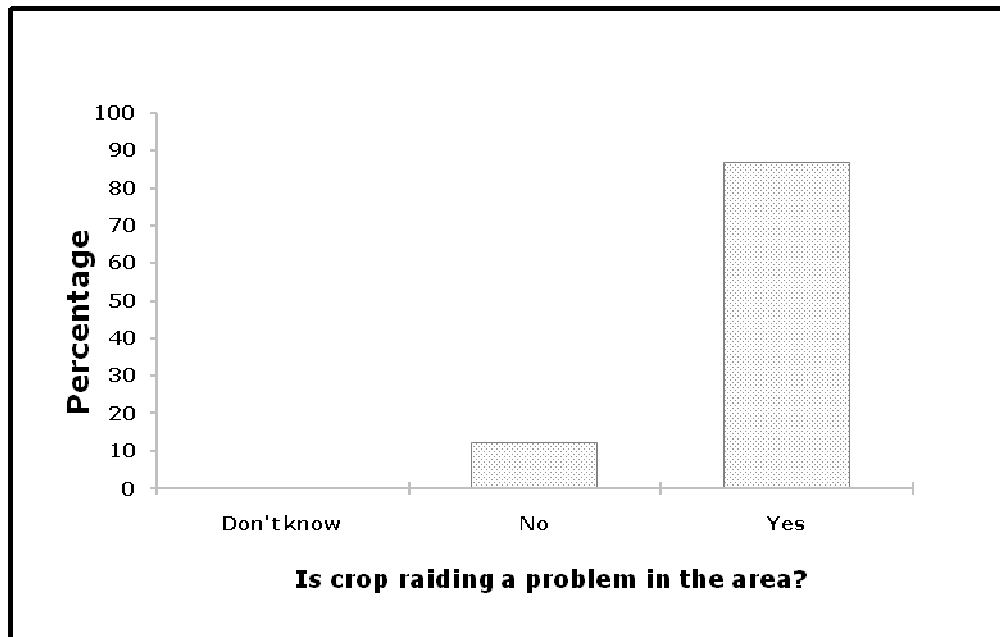
The source of meat in people's diet in Desert National Park (n=67)



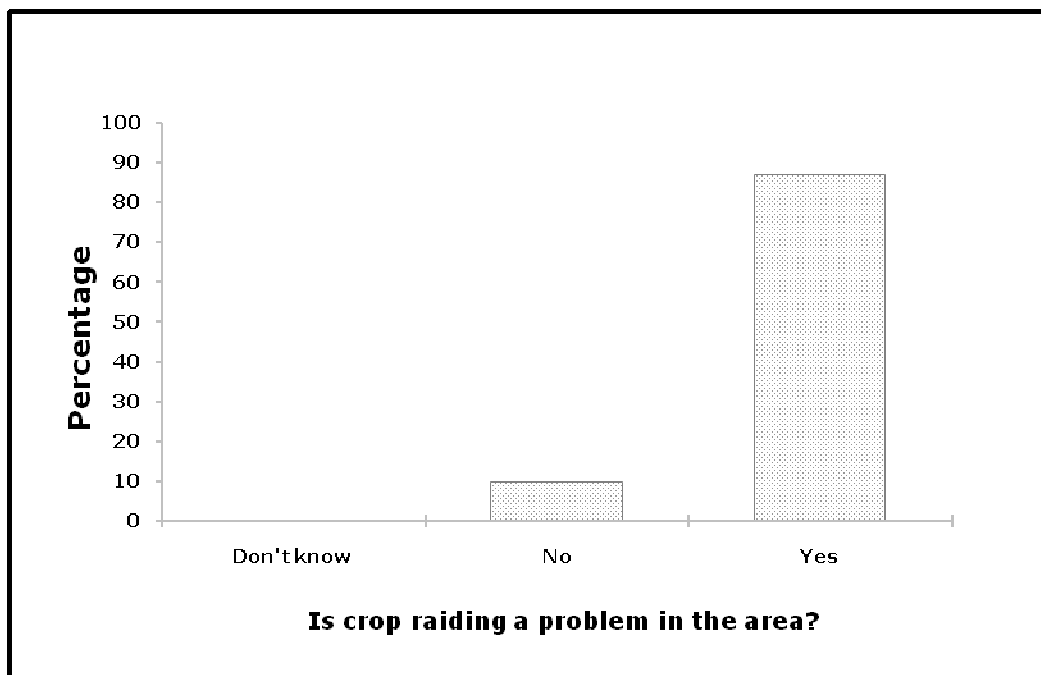
The source of meat in people's diet in Banni (n=42)



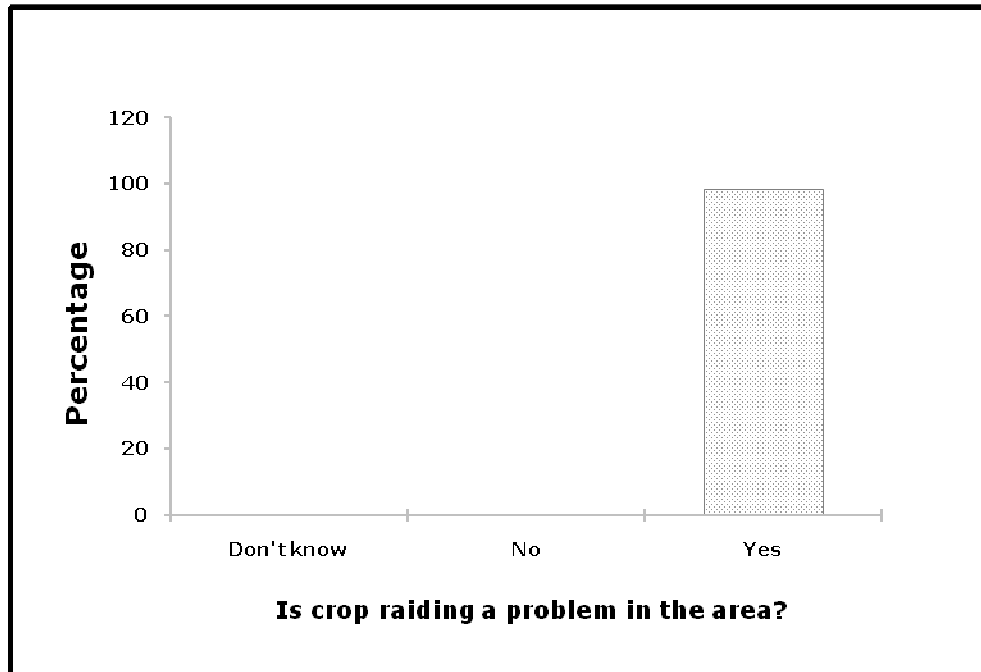
### 7.3 Is crop raiding a problem in the area?



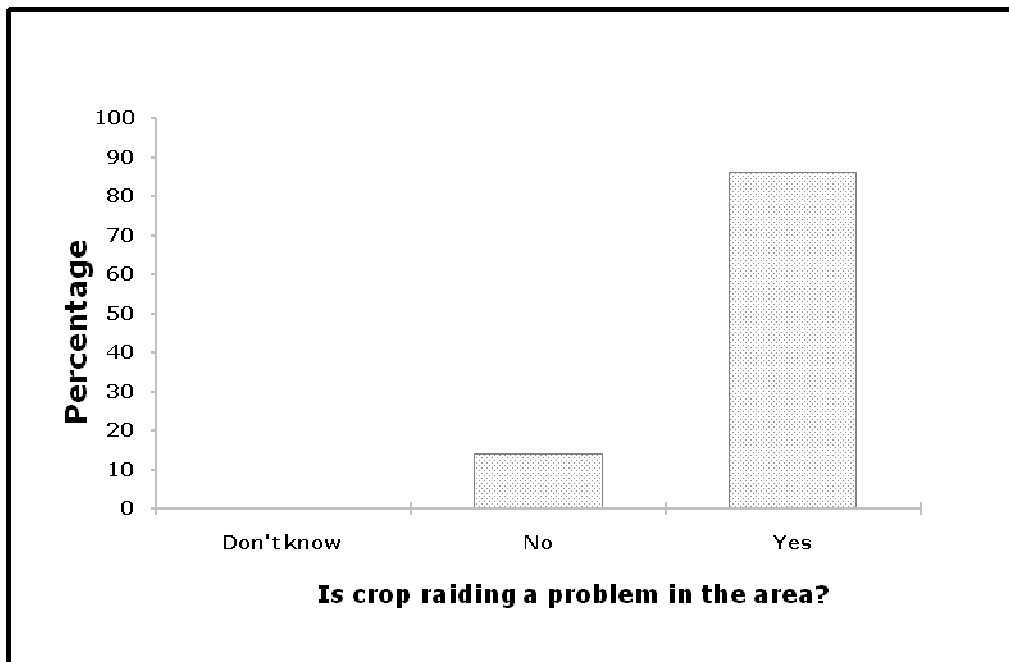
Percentage of respondents who think crop raiding is problem in Kuno (n=98)



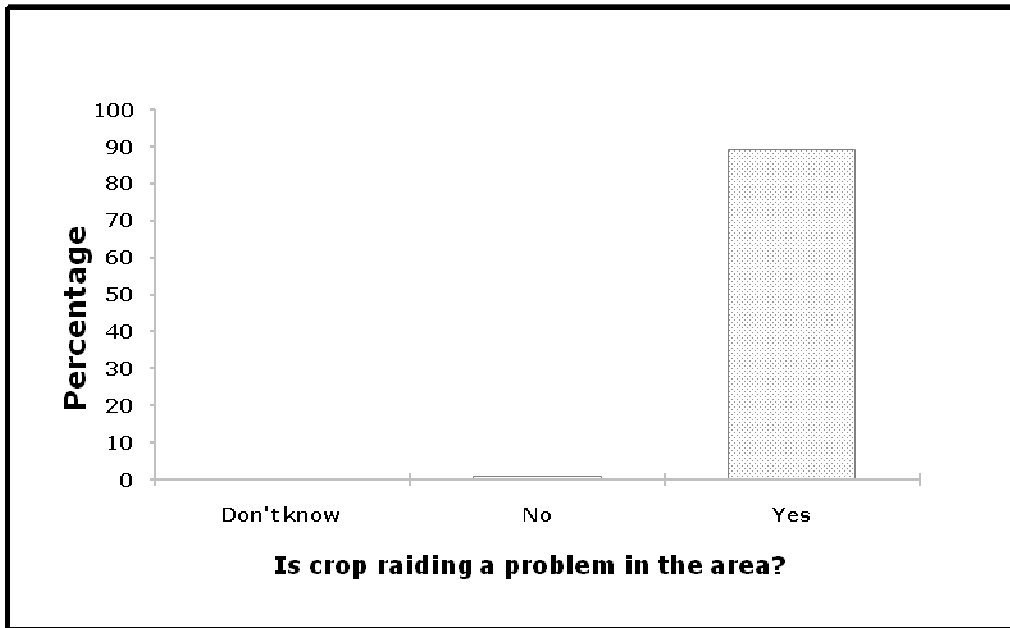
Percentage of respondents who think crop raiding is problem in Bagdara (n=223)



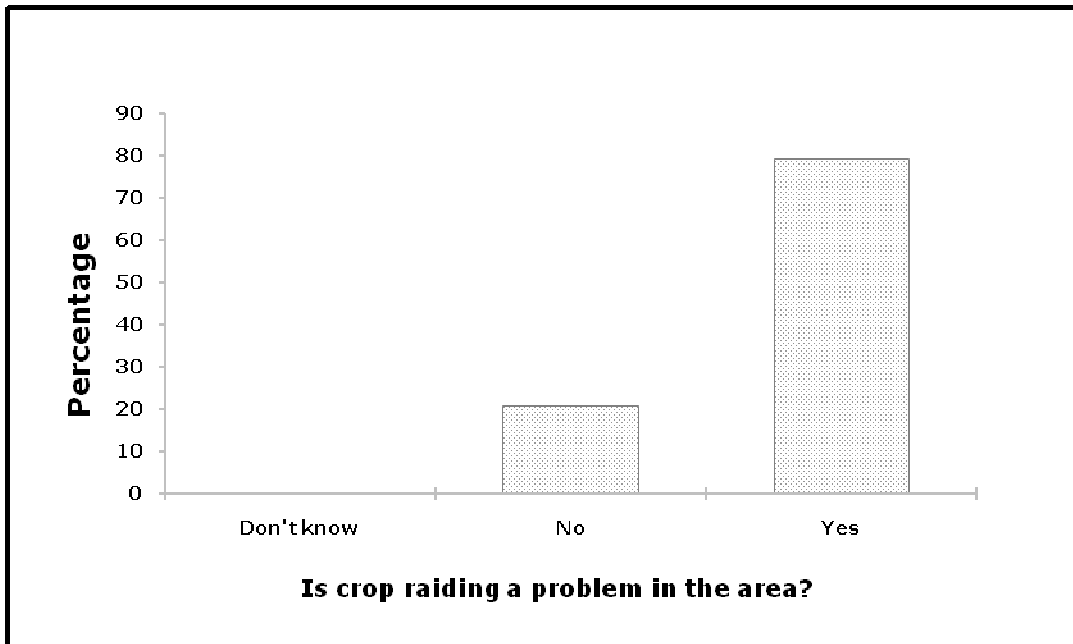
Percentage of respondents who think crop raiding is problem in Kaimur (n=202)



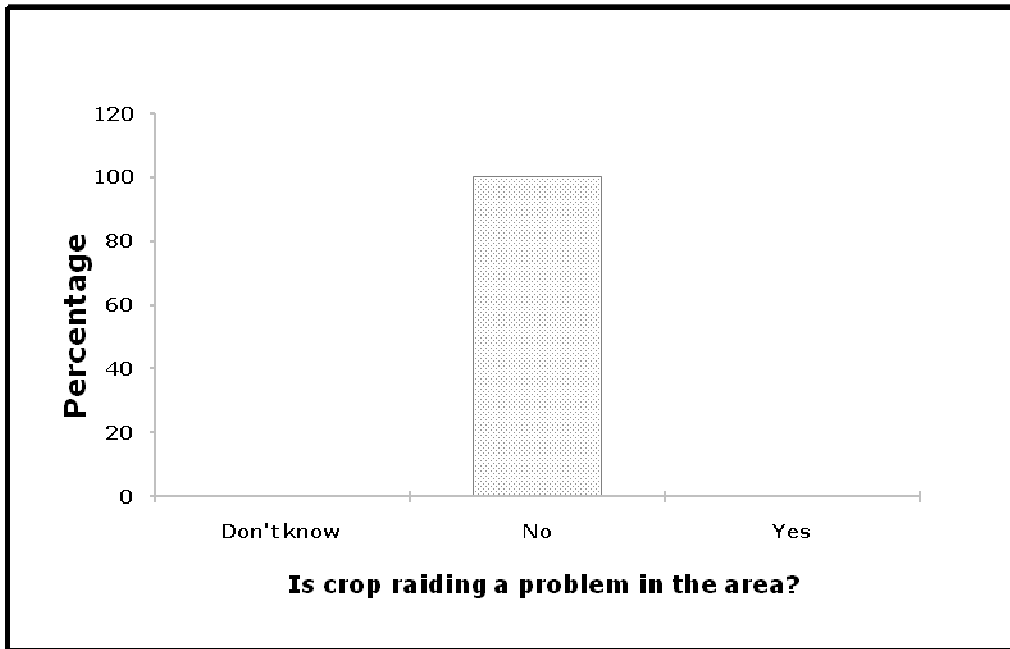
Percentage of respondents who think crop raiding is problem in Sanjay (n=64)



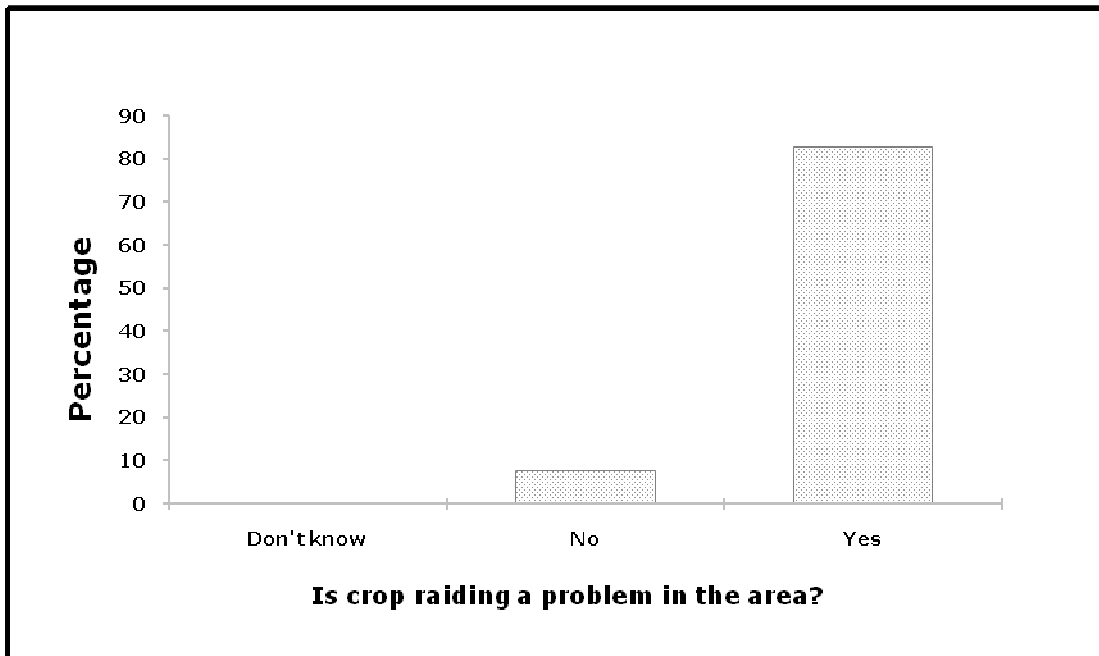
Percentage of respondents who think crop raiding is a problem in Dubri (n=121)



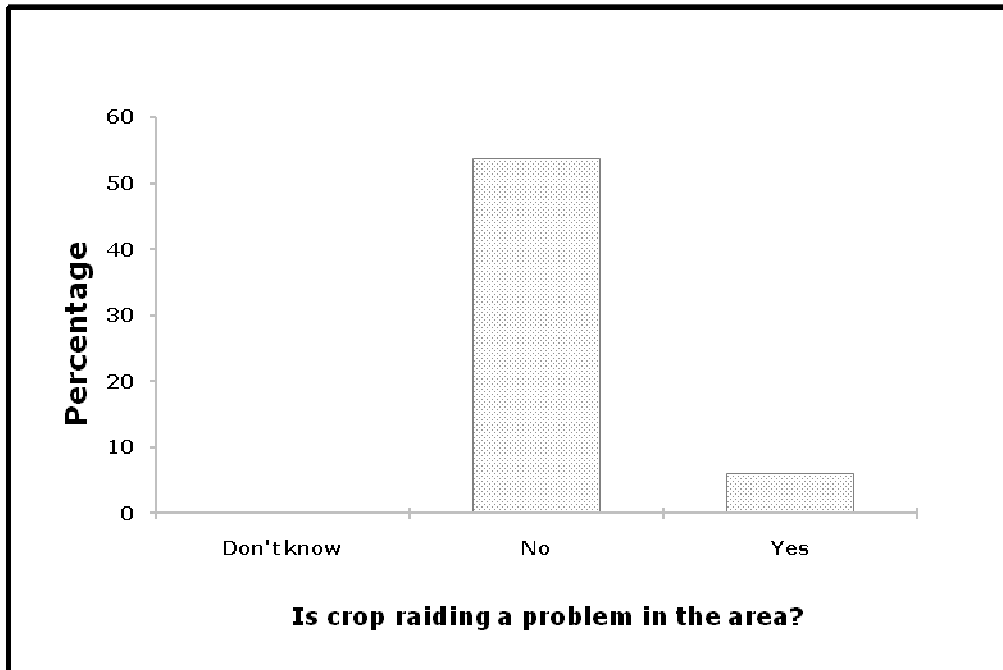
Percentage of respondents who think crop raiding is a problem in Guru Ghasidas (n=77)



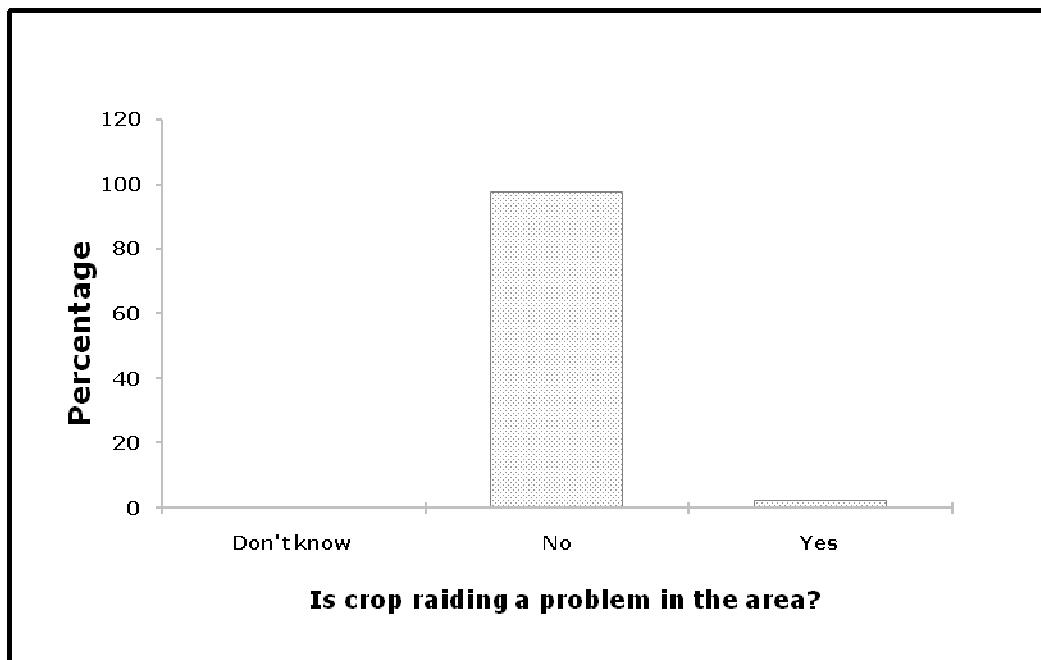
Percentage of respondents who think crop raiding is problem in Shahgarh (n=20)



Percentage of respondents who think crop raiding is problem in Nauradehi (n=181)

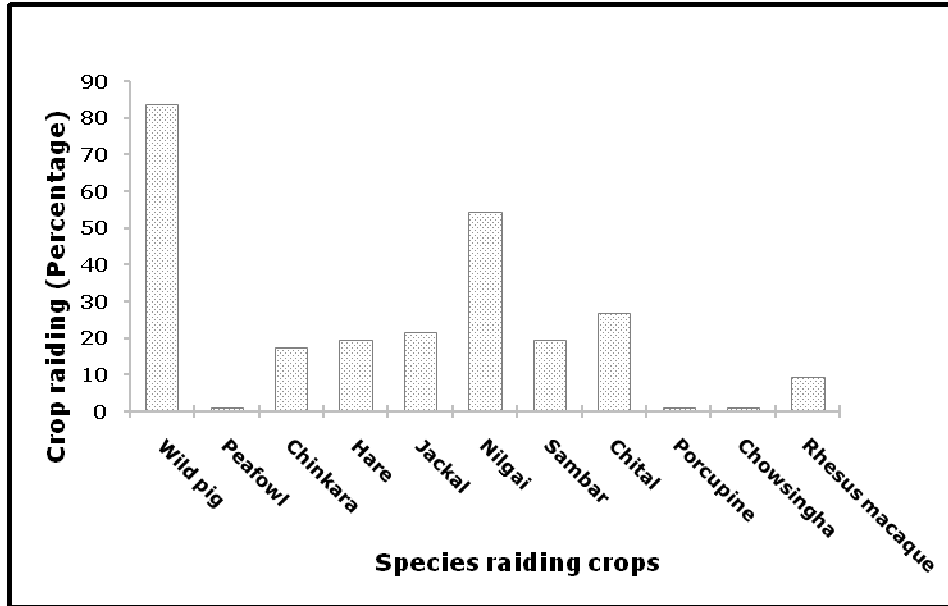


Percentage of respondents who think crop raiding is problem in Desert National Park (n=67)

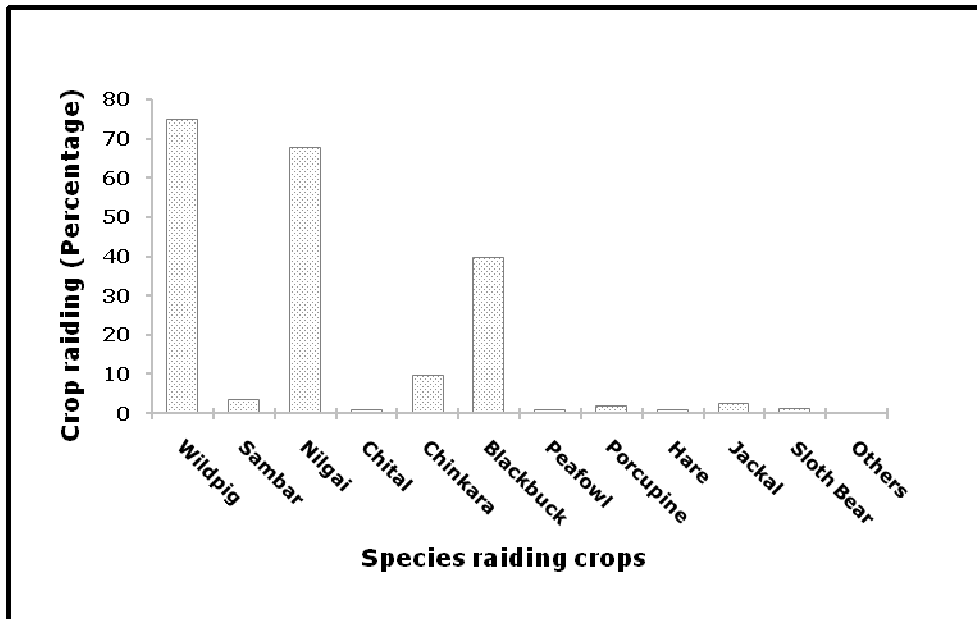


Percentage of respondents who think crop raiding is problem in Banni (n=42)

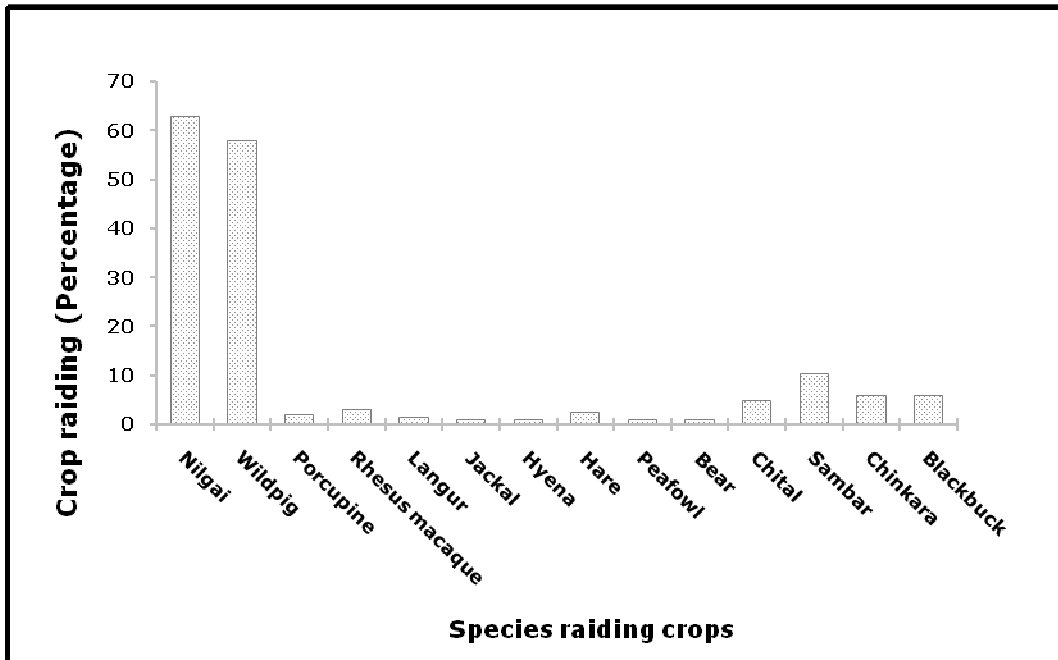
#### 7.4: What species raid crops in the area?



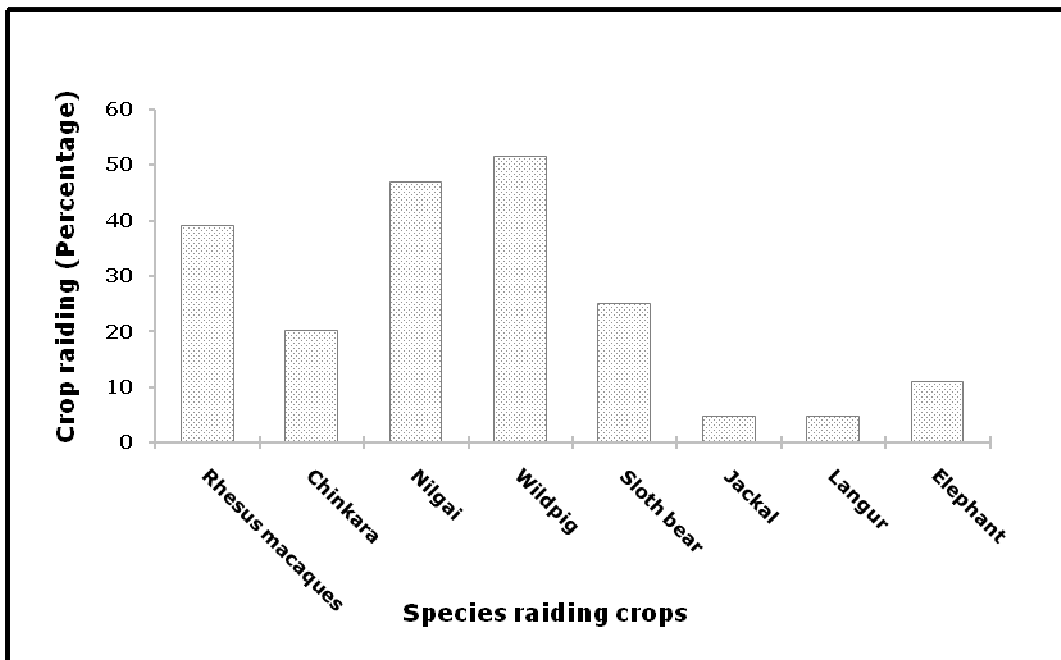
Species causing damage by crop raiding in Kuno (n=98)



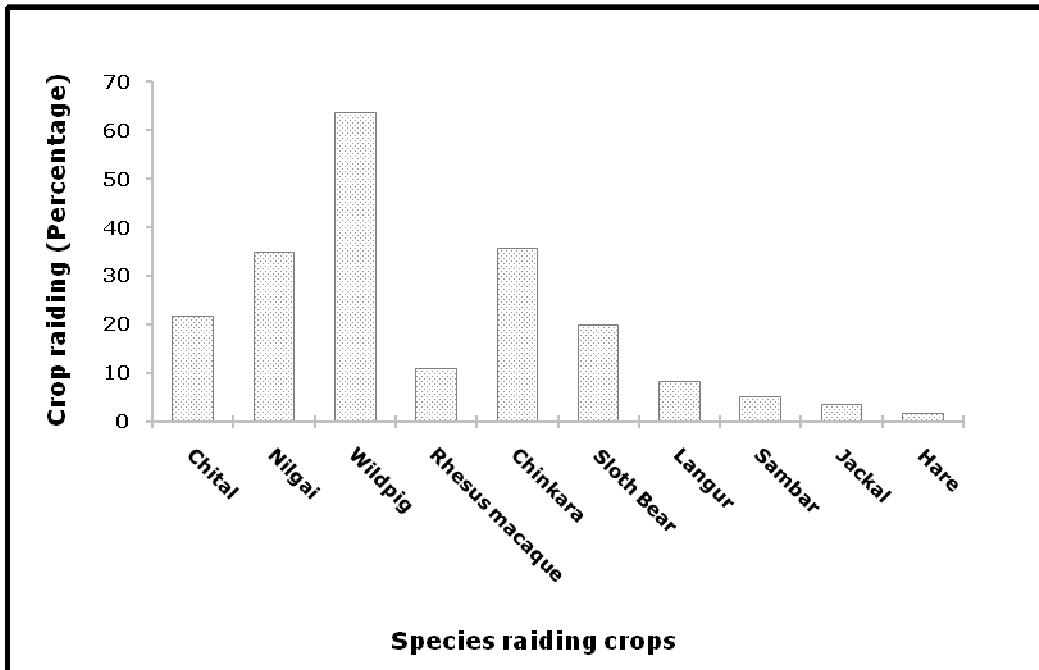
Species causing damage by crop raiding in Bagdara (n=223)



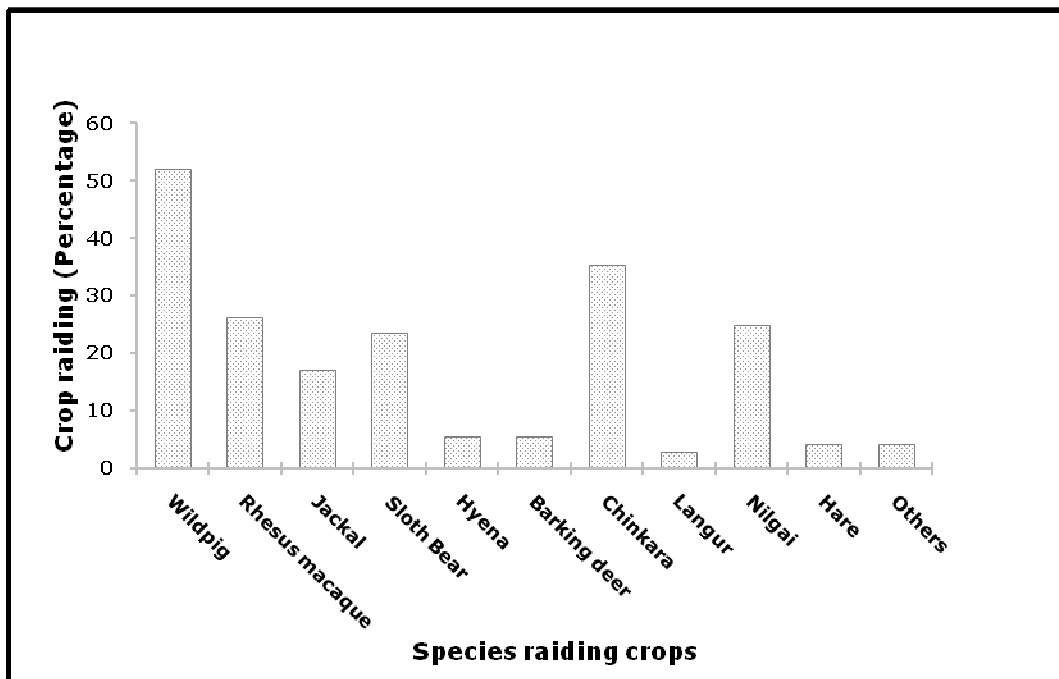
Species causing damage by crop raiding in Kaimur (n=202)



Species causing damage by crop raiding in Sanjay (n=64)

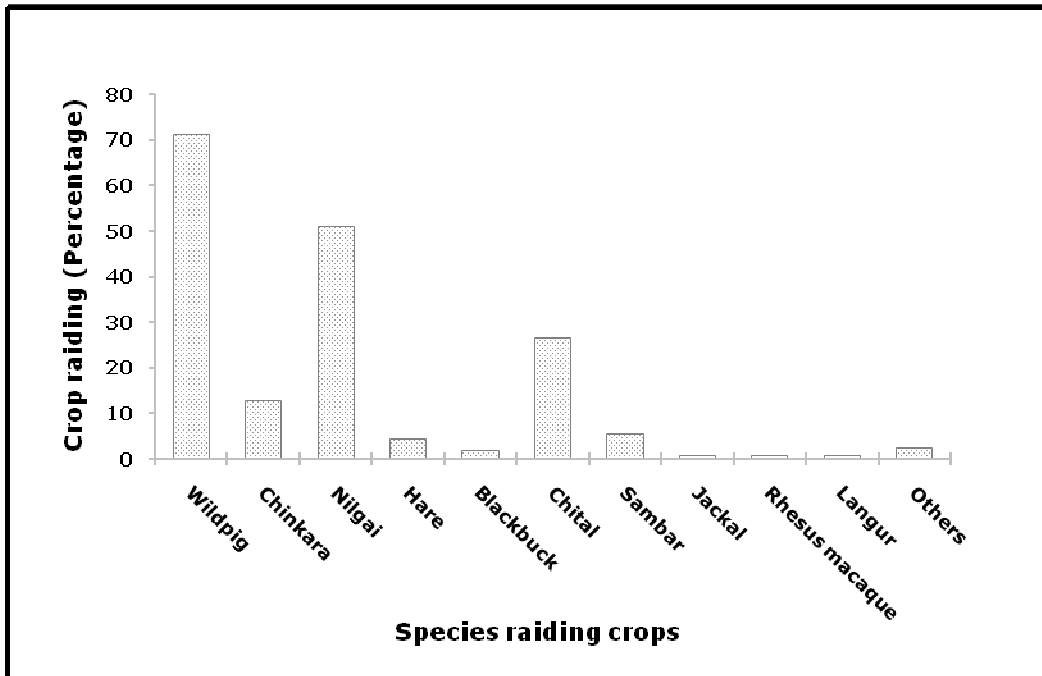


Species causing damage by crop raiding in Dubri (n=121)

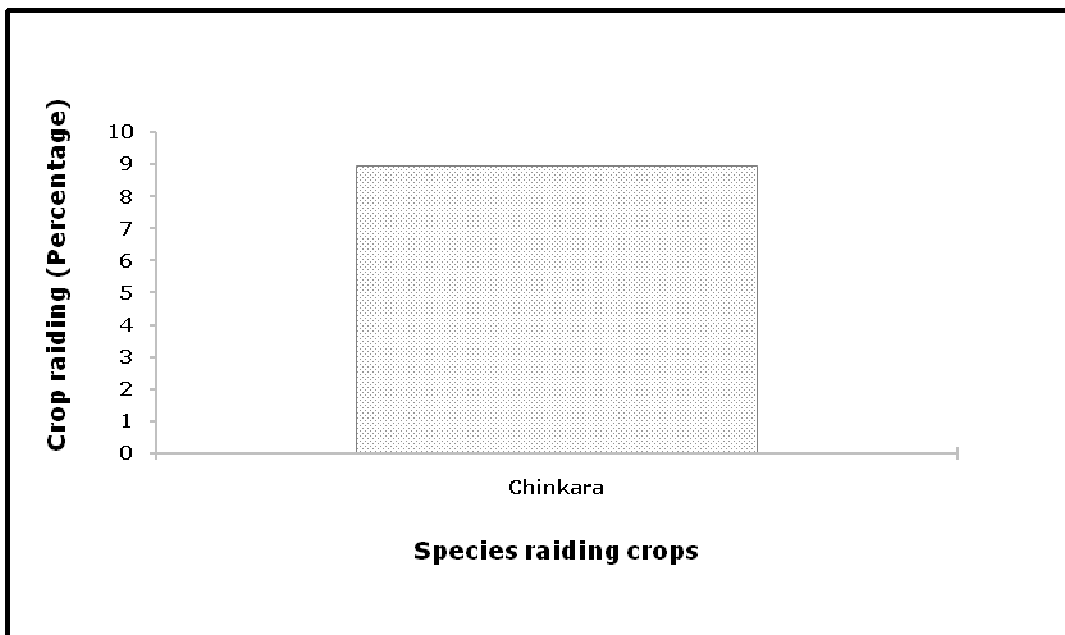


Species causing damage by crop raiding in Guru Ghasidas (n=77)

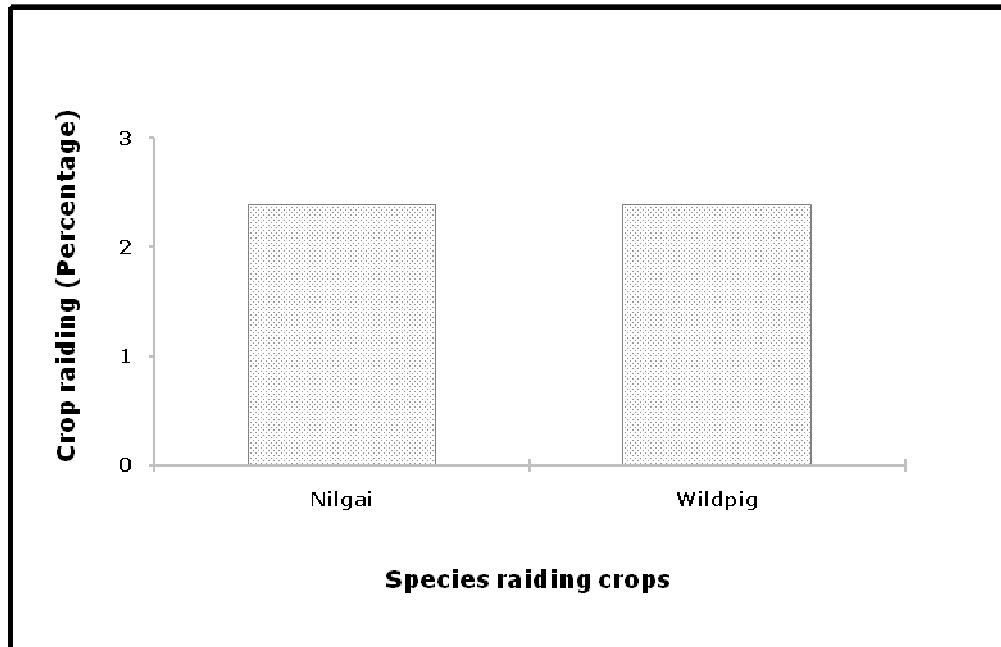




Species causing damage by crop raiding in Nauradehi (n=181)

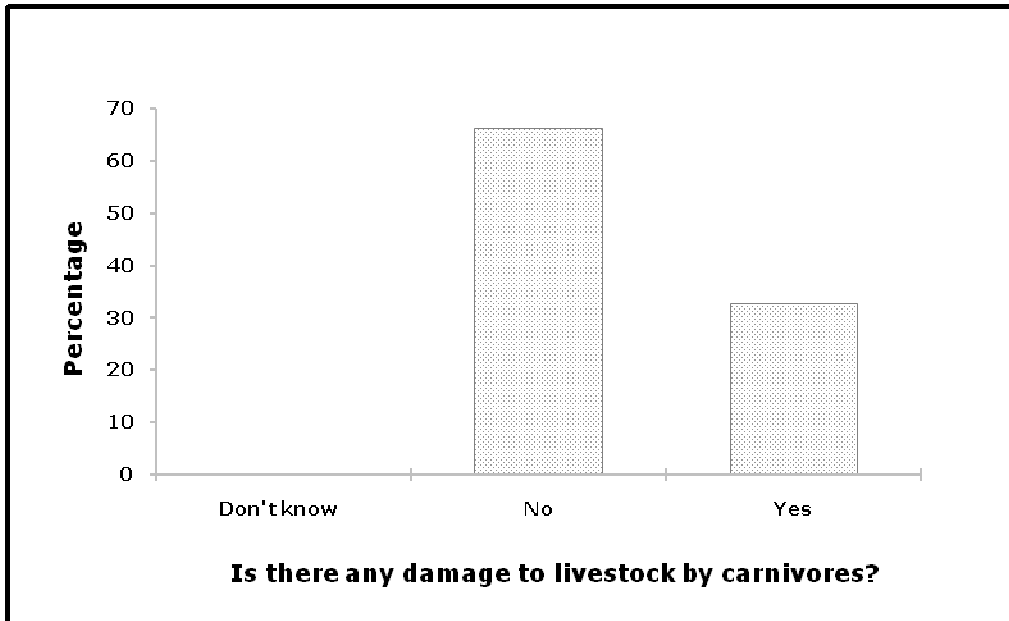


Species causing damage by crop raiding in Desert National Park (n=67)

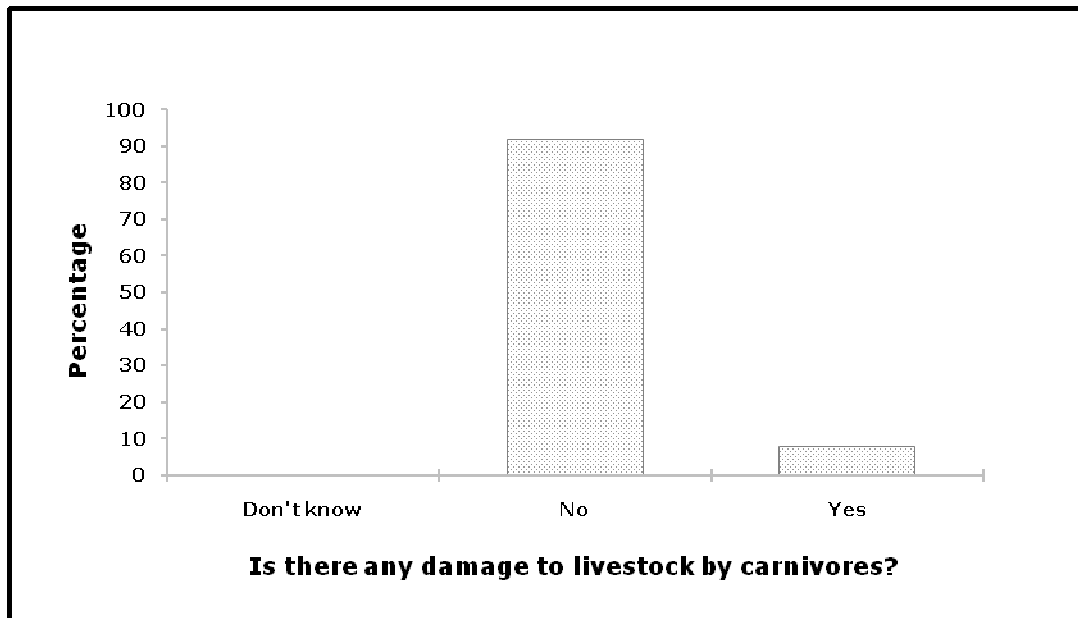


Species causing damage by crop raiding in Banni (n=42)

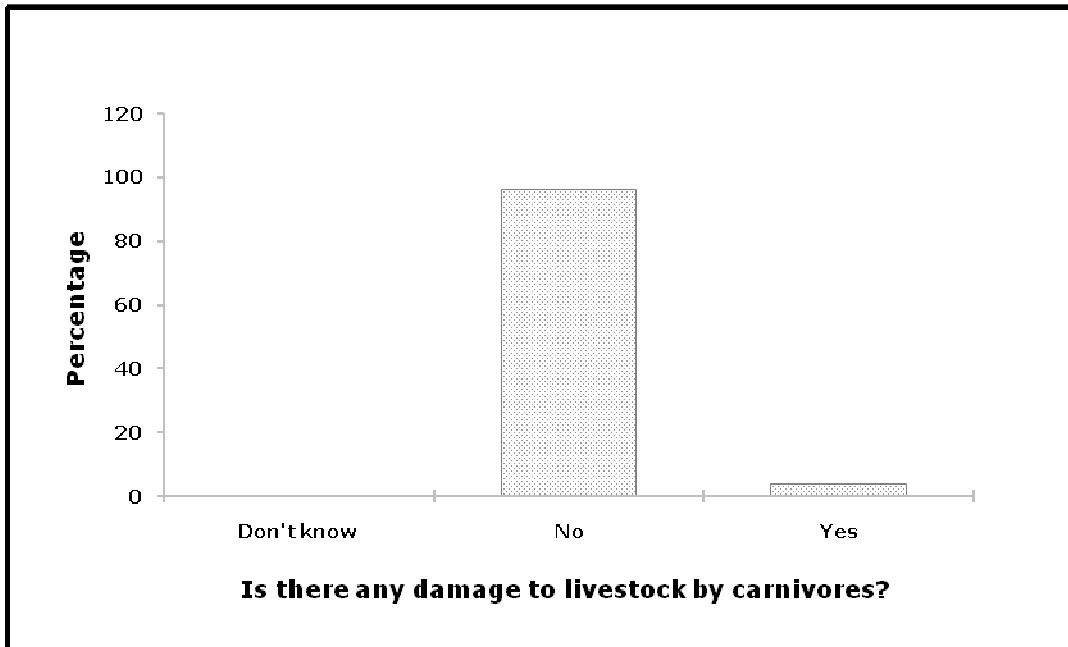
### 7.5: Is livestock depredation a problem in the area?



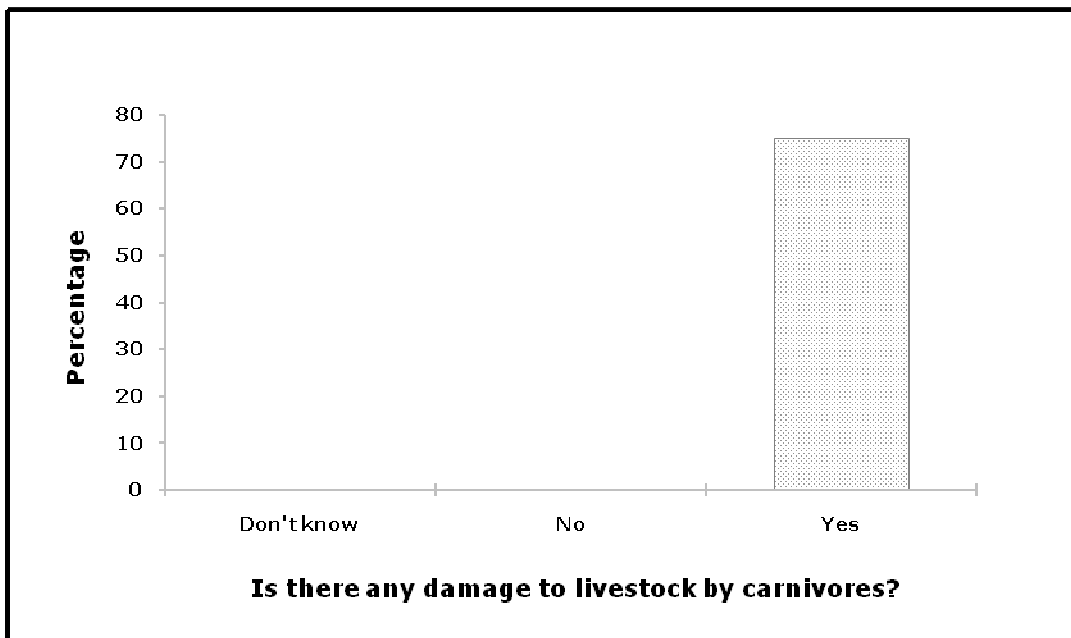
Percentage of respondents who think livestock depredation is a problem in Kuno (n=98)



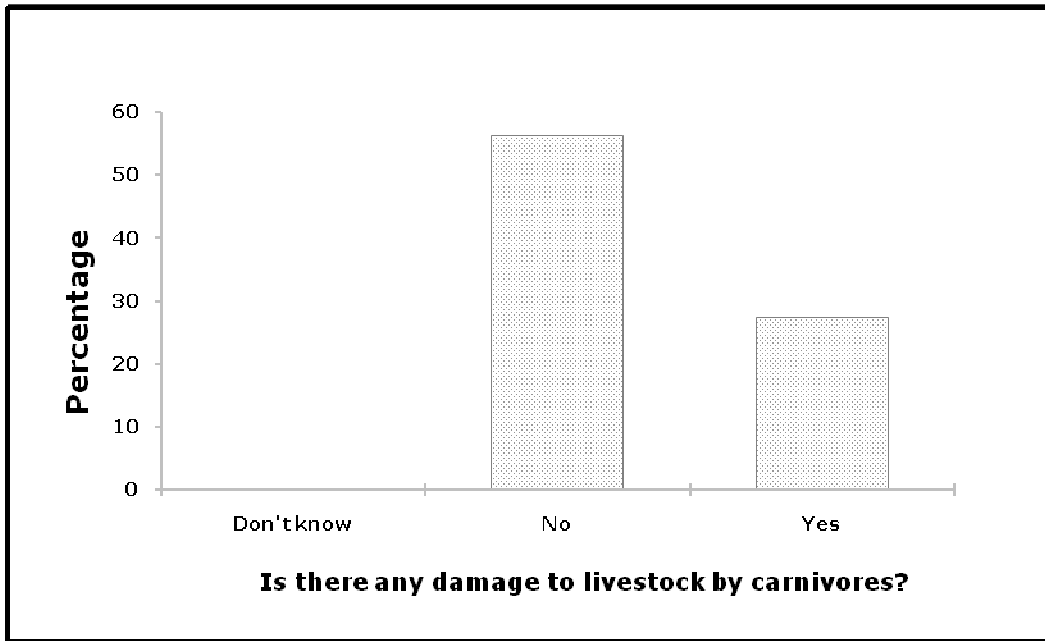
Percentage of respondents who think livestock depredation is a problem in Bagdara (n=223)



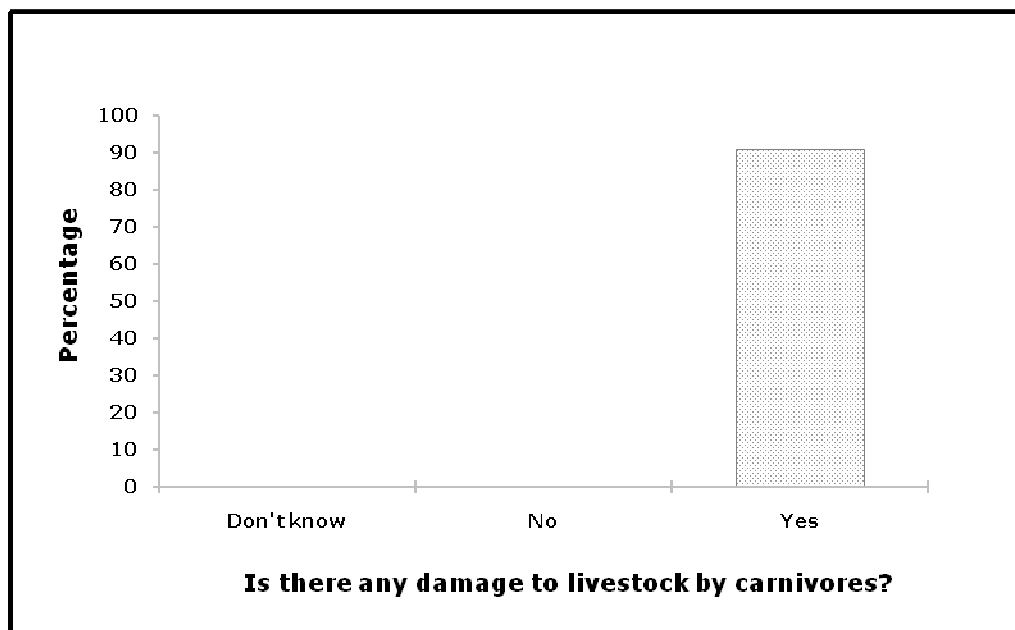
Percentage of respondents who think livestock depredation is a problem in Kaimur (n=202)



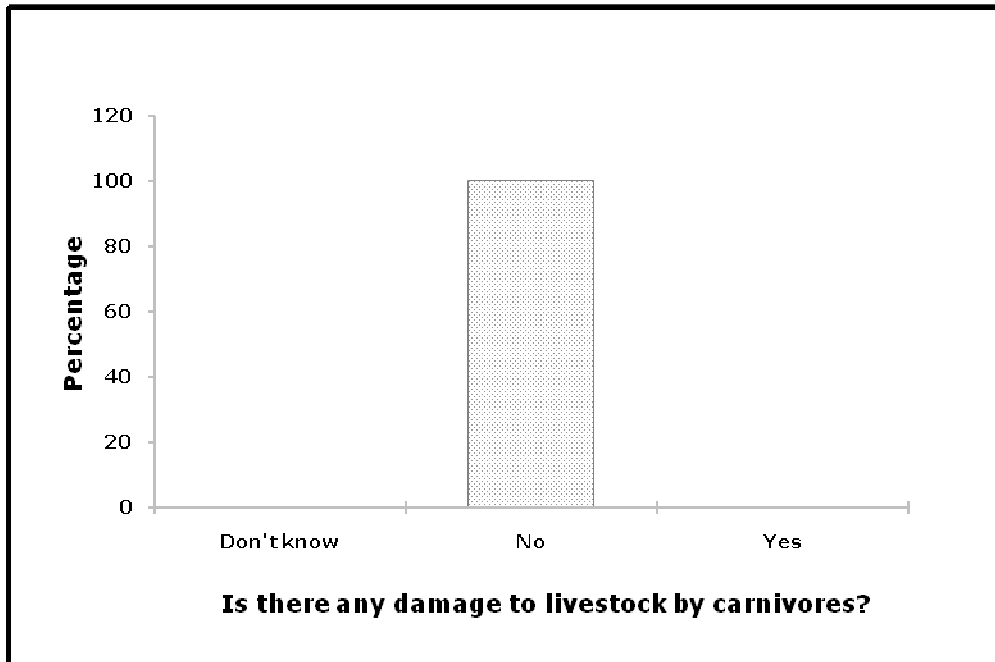
Percentage of respondents who think livestock depredation is a problem in Sanjay (n=64)



Percentage of respondents who think livestock depredation is a problem in Dubri (n=121)



Percentage of respondents who think livestock depredation is a problem in Guru Ghasidas (n=77)



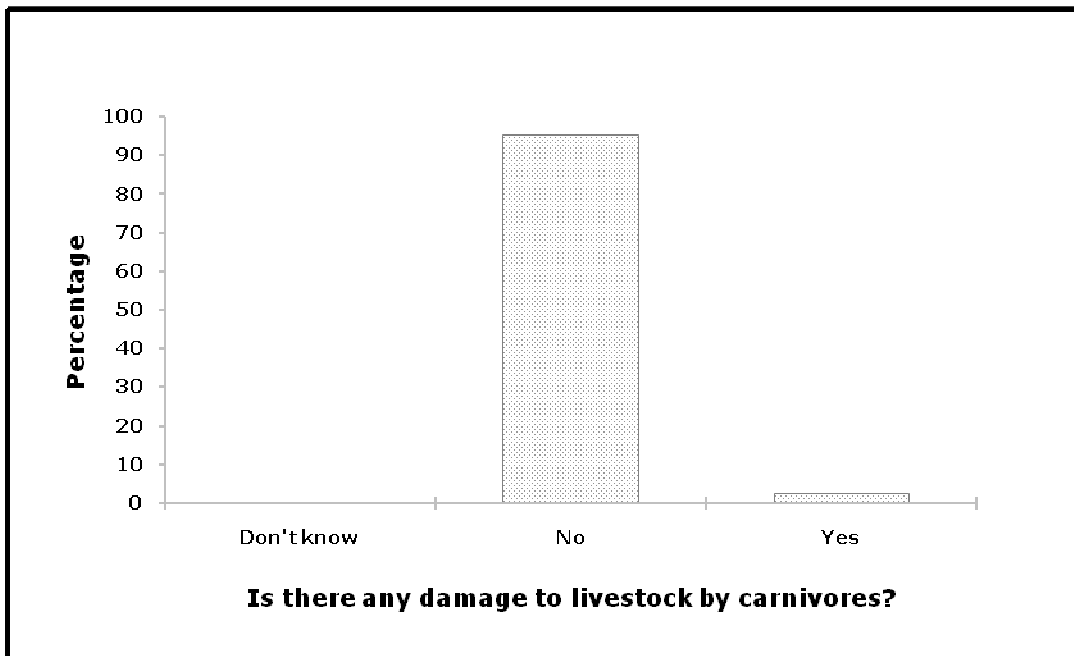
Percentage of respondents who think livestock depredation is a problem in Shahgarh (n=20)



Percentage of respondents who think livestock depredation is a problem in Nauradehi (n=181)

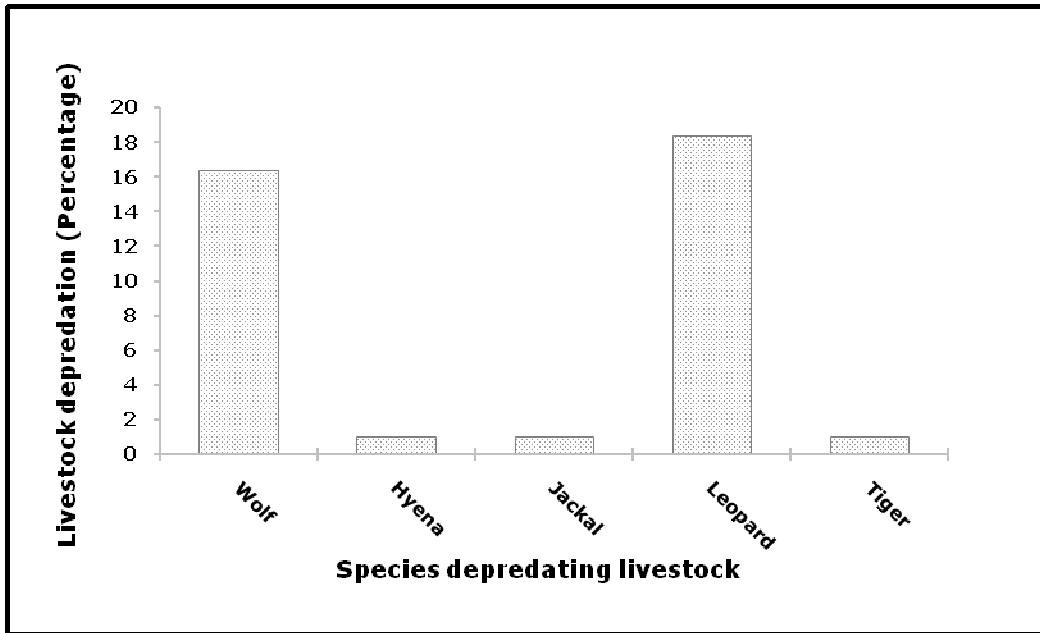


Percentage of respondents who think livestock depredation is a problem in Desert National Park (n=67)

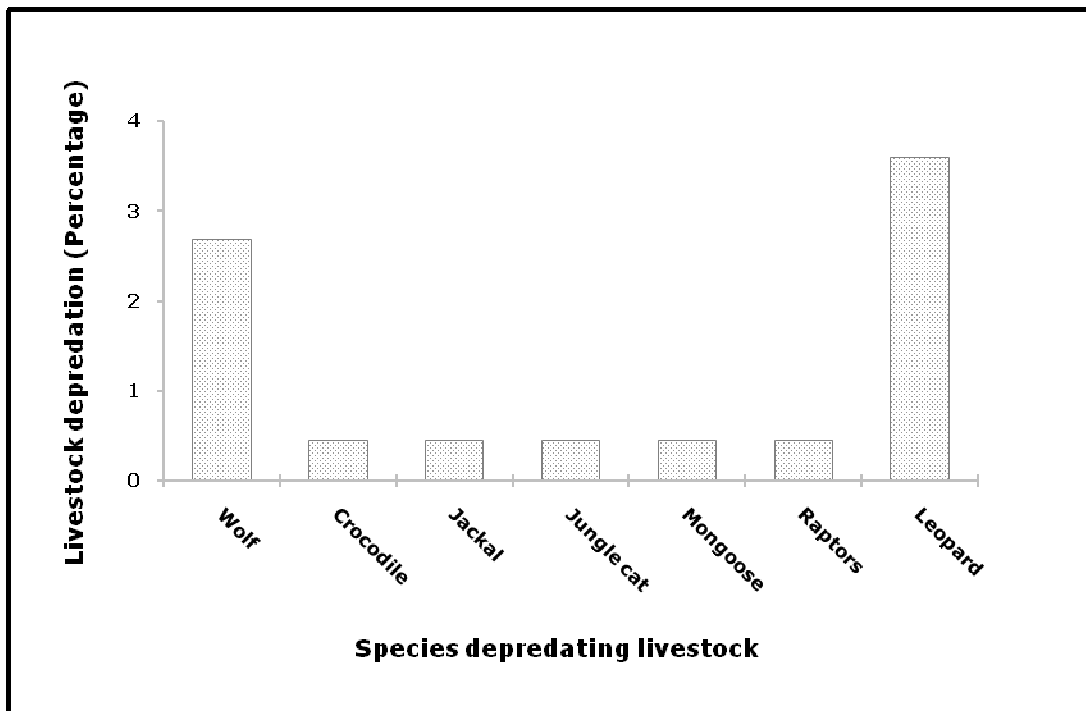


Percentage of respondents who think livestock depredation is a problem in Banni (n=42)

### 7.6: Species depredating livestock

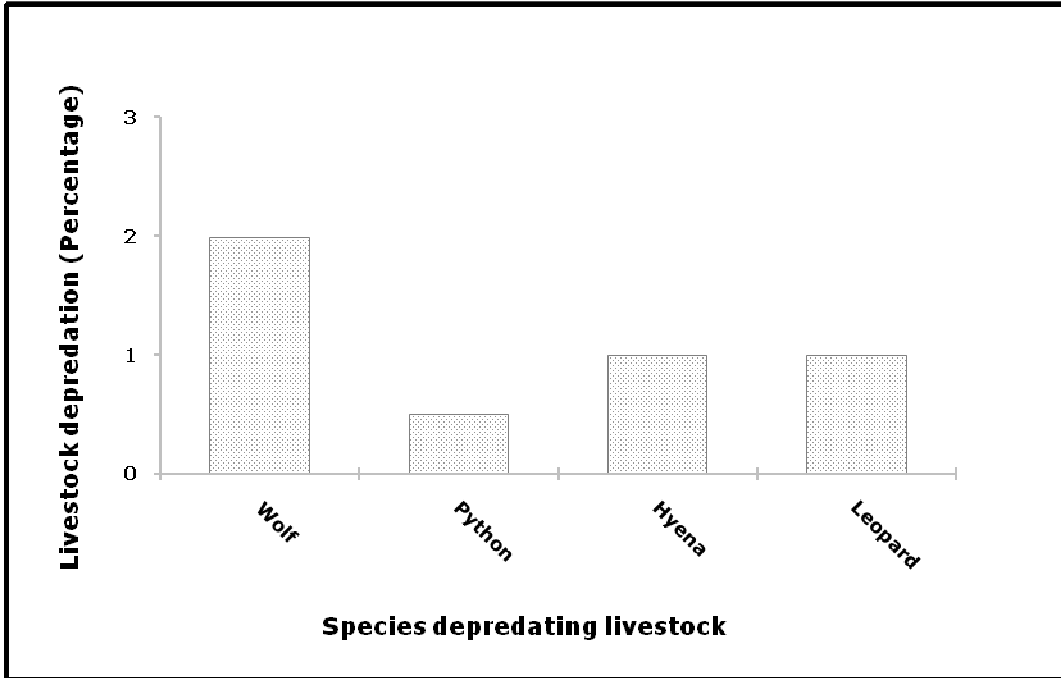


Species that cause damage by depredating livestock in Kuno (n=98)

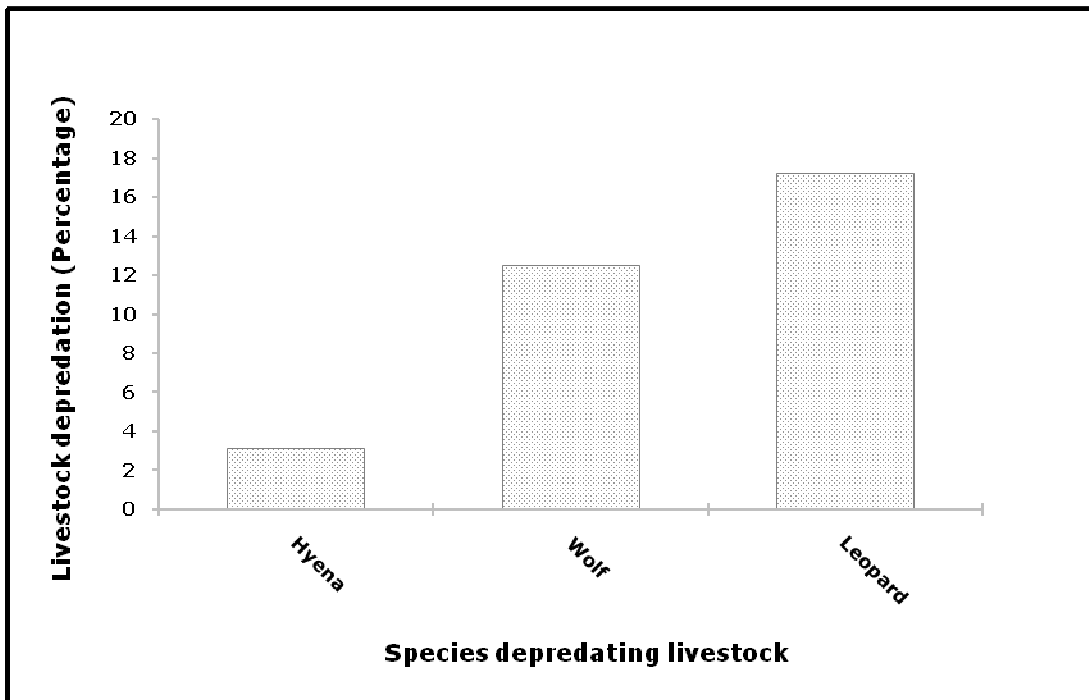


Species that cause damage by depredating livestock in Bagdara (n=223)

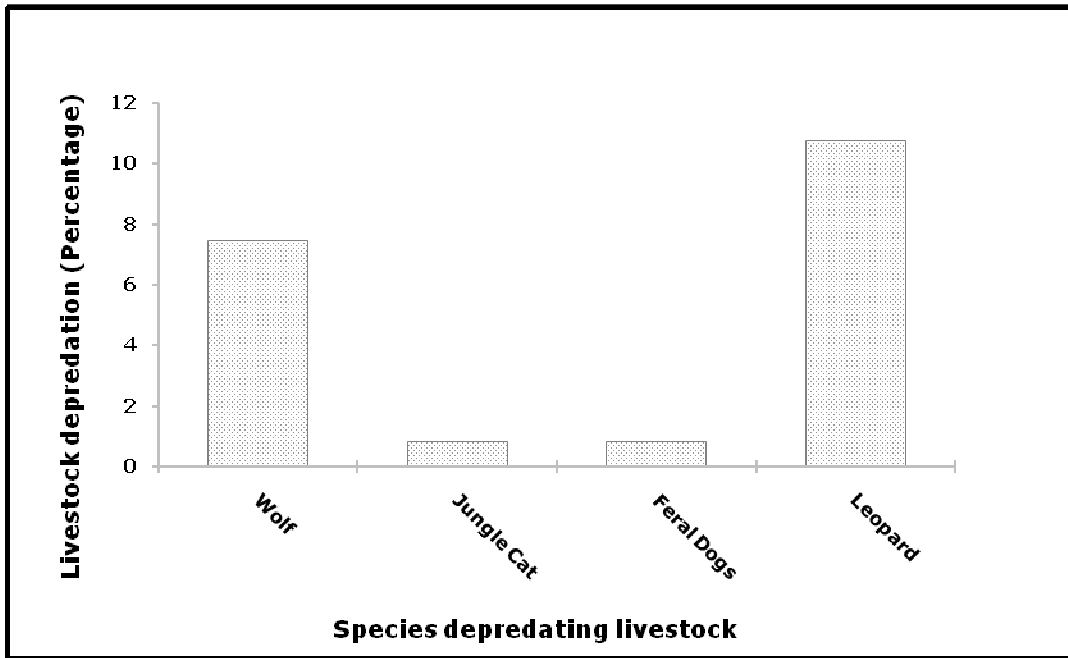




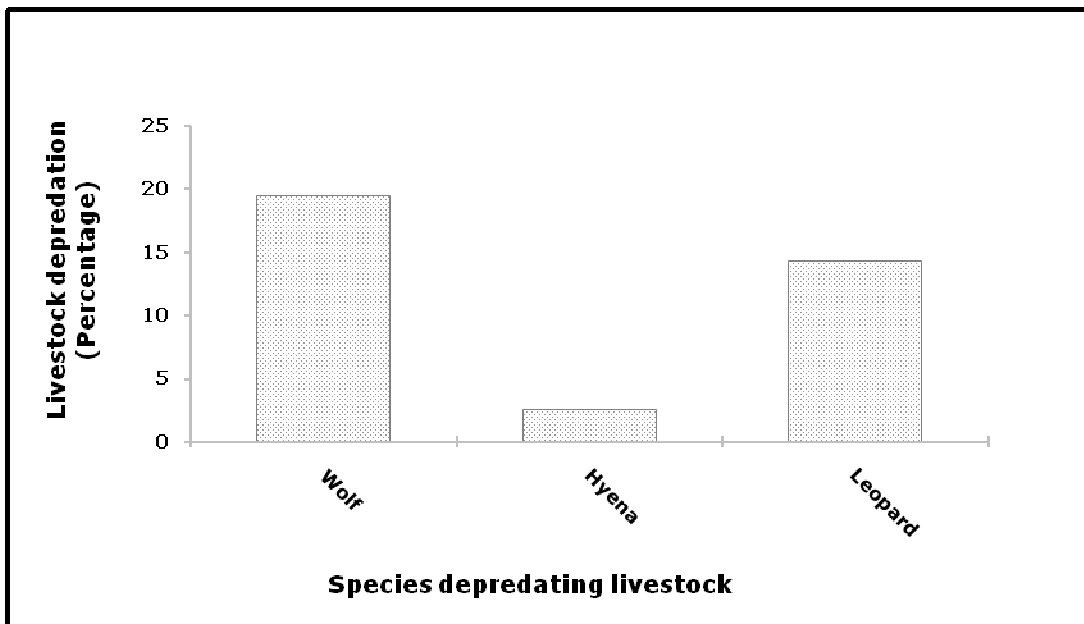
Species that cause damage by depredating livestock in Kaimur (n=202)



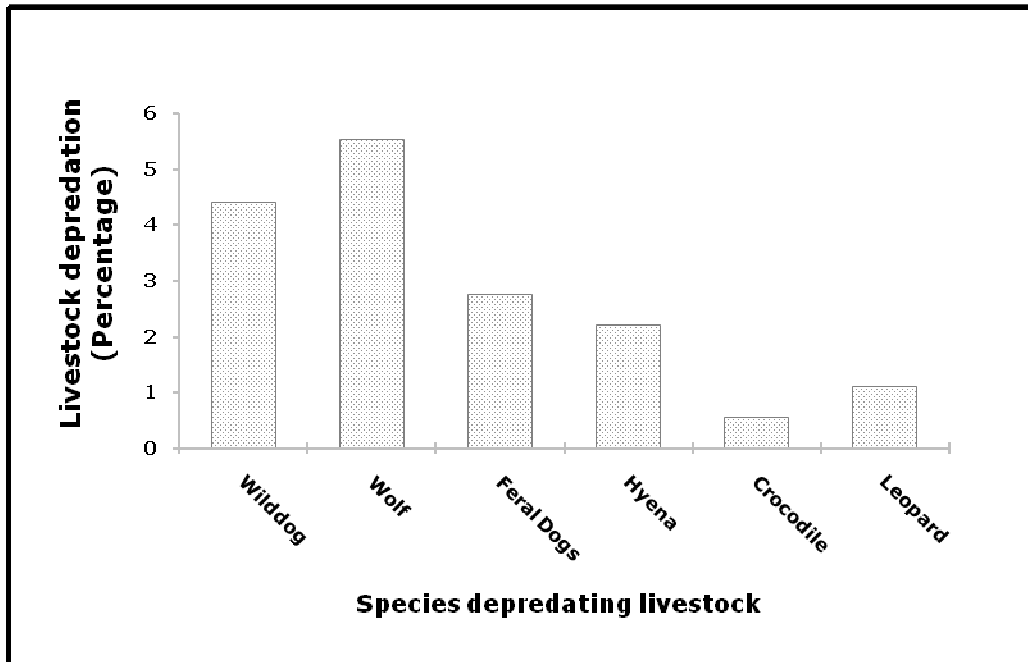
Species that cause damage by depredating livestock in Sanjay (n=64)



Species that cause damage by depredating livestock in Dubri (n=121)



Species that cause damage by depredating livestock in Guru Ghasidas (n=77)



Species that cause damage by depredating livestock in Nauradehi (n=181)



Species that cause damage by depredating livestock in Banni (n=42)



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