Human-Wolf Conflict in human dominated landscapes of Ahmednagar District, Maharashtra
&
Possible Mitigation Measures

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November 2009

The Ruffords Small Grants Foundation
www.ruffordsmallgrants.org

Krithivasan, R[1], Athreya V.R.[2], Odden M[3]. 2009. Human-Wolf conflict in human dominated landscapes of Ahmednagar District, Maharashtra, India & Possible Mitigation Measures. Submitted to the Rufford Small Grants Foundation.

Photograph on cover courtesy Ketil Skogen: A pack of wolves at Shendewadi village.

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ACKNOWLEDGEMENTS

This work would not have been possible without the generous help and support of a number of organizations and people. I would like to thank The Rufford Small Grants Foundation funded the entirety of this project. Morten Odden was supported by a NINA grant. The Chief Wildlife Warden of Maharashtra, Chief Conservator of Forests, Nashik, Deputy Conservator of Forests (Ahmednagar), Range Forest Officers Sangamner and Akole, all of who were very helpful in providing us with the requisite permissions to work in the field. Particularly we would like to thank Mr Shivaji Phatangare (RFO Akole) who made us aware of the presence of the wolves in this region and also helped us to avail of local logistic support via the Gunjalwadi Homoeopathic Medical College and Hospital, Sangamner, who very kindly allowed the use of their hostel for the duration of the field work. Many thanks to Nanabhau Ganjave for invaluable assistance in the field and his family for their hospitality. This project was made possible by the people who were kind enough to give their valuable time to participate in our surveys and interviews. We would like to thank our families, especially Saraswathi Krithivasan who looked over numerous drafts of this report. We would also like to thank John Linnell for reviewing a draft of this report.

While this was a collaborative effort involving significant inputs from Vidya Athreya and Morten Odden, as the compiler of this report I take full responsibility for any errors that may present themselves in this work.

Roopa Krithivasan

October 19, 2009

INTRODUCTION

With a population density of 336 per km2 (United Nations 2004) in a nation that also supports an incredible variety of habitats and biodiversity, it is no wonder that human-wildlife conflicts exist in many forms in India. Among others, blackbuck (Jhala 1993) and elephants (Sukumar 1990) are known to damage crops; leopards (Athreya 2004), snow leopards Mishra 1997) and wolves (Shahi 1983) prey on livestock; leopards (Athreya 2004), wolves (Shahi 1983), sloth bears (Rajpurohit and Krausman 2000)and elephants (Williams et al. 2001) are responsible for loss of human lives.

Human-wildlife conflicts pose a complex and sensitive problem, to policy makers, conservationists, the general public, and of course the inhabitants of human-wildlife interfaces themselves. With growing attention on the need to protect and conserve our wild areas and wild species, the needs of people who bear the brunt of human-wildlife conflicts are often marginalized. Conversely, the fact that a conflict exists is often ignored, until irreparable damage has been done to wildlife. Clearly, there is a pressing need to study the issues that exist at such places, and put forward means to mitigate these conflicts to the advantage of both the major stakeholders: humans and wildlife.

In this report, we will be looking at wolf-livestock conflicts in India, in Ahmednagar District, Maharashtra. Wolf-human conflicts are by no means unique to India. Wolves have historically inhabited much of the northern hemisphere, and conflicts between pastoralists and wolves have been the primary cause for their extirpation from much of the western world (Fritts et al. 2003). In India too, wolves come into constant conflict with livestock owners, possibly to a greater extent than anywhere else in the world because of the high density of humans and domestic animals [see map 1]. Yet the impact of wolves on human lives and livelihoods in India is poorly understood. Therefore, it is imperative that we understand the wolf-pastoralist dynamics and implement measures that will ensure the continued existence of the wolf; a key step in this direction will be to minimize the losses that humans sustain due to wolf depredations, and thus reduce their ill-will towards these animals.

In this paper, we have attempted the following:

- ***Assess the impact of wolf depredation on pastoralists in an entirely human dominated landscapes***: we used general surveys of livestock owners to estimate the economic impact of wolf depredations and determine which people are affected the most;
- ***Explore factors that affect depredations***: we used the results of the surveys to assess which livestock owners suffered losses in the past two years and tried to understand which factors are associated with higher levels of depredation
- ***Suggest measures for minimizing losses due to depredation***: we present the results of our work and using them we suggest measures by which losses to the locals may be reduced.

Two young herders near Gunjalwadi, Sangamner.

REVIEW OF HUMAN-WOLF CONFLICT

Overview of wolf-livestock conflicts around the world

Textual evidence of human-livestock conflict in India dates back to circa 1000 BCE, in the form of verses in ancient texts including the Rig Veda (6, 51) and the Atharva Veda (5, 21) describing goats and sheep fleeing before hunting wolves. Nor are such accounts limited to ancient Indian texts – evidence from the bible (Matthew 10:16) and folklore ranging from the Americas to East Asia attest to both the constant intersections of wolves and pastoral societies, as well as the conflict that ensues at their interfaces worldwide.

With the historical range of wolves covering much of the northern hemisphere, wolf-livestock conflicts have been documented in every country where both wolves and domesticated livestock exist (Fritts et al. 2003). Today, the wolf is regionally extinct in the United Kingdom, Ireland, a number of other European countries, Japan, and possibly Bangladesh (IUCN 2000). In all cases, actual or perceived conflict with livestock was the driving factor behind extermination (Fritts et al. 2003).

The case in Japan for example clearly illustrates how attitudes play a large role in the fate of the wolf. Formerly home of the two smallest wolf subspecies (*C.l. hodophylax and C.l. attai*), Japan now holds the dubious distinction of having wiped out both its native subspecies. Traditionally revered throughout the nation, deification of the wolf most probably owed to its role as an exterminator of agricultural pests (Fritts et al. 2003). The transition from Shogun to Western rule in the mid 1800s brought about a sudden and drastic change in attitudes and practices regarding wildlife and agriculture. Reflecting Western views of wolves as dangerous vermin, recommendations were made by the new ruling power to poison wolves (Walker 2005). Accelerated by a rabies epidemic at the beginning of the century, both subspecies were extinct by 1910. In recent times, with a global shift towards environmental accountability and conservation, the re-introduction of wolves in Japan is being considered (Knight 2003).

In North America, wolves were commonly trapped for fur by a number of native American peoples prior to European settlement, and sometimes killed to reduce competition for scarce prey (Fritts et al. 2003). Nevertheless, wolves were generally respected and sometimes even revered. Large-scale wolf exterminations did not begin until Europeans, who had faced problems with wolf depredation in the Old World, settled on the continent. Apart from being viewed as threats to their livestock, wolves rapidly became a symbol of the worst aspects of the unknown, untamed New World wilderness (Fritts et al. 2003). The widespread over-hunting of native ungulate prey coupled with rapid increase in livestock numbers further forced wolves into contact with humans. Bounties were offered for wolves, and in 1915 the U.S. Biological Survey initiated targeted programs to completely wipe out wolves and other wild predators. By the mid-20th century, wolves had been exterminated from most of their original range in the United States, outside of Alaska. Hardly a decade after their local extinction, attitudes towards native wildlife and environment in general began to shift drastically, spearheaded by major conservation organizations (Fritts et al. 2003). Steps to restore wolves have taken the form of legal protection (IUCN 2000), reintroductions of wolves (including the well-known example at Yellowstone National Park) (Bangs et al. 1996), re-introduction of native prey (Fritts et al. 2003), and campaigns to increase awareness about wolf ecology. Nevertheless, ranchers and other livestock owners still maintain negative attitudes toward wolves. If anything, wolf conservation has increased the rift between environmentalists and pastoralists, and matters such as reintroduction and lethal control remain a sensitive and turbulent political issue (Johnson 2008).

In Sweden and Norway, concerted and intensive wolf removal was the norm from the mid 1600s onwards. Here too, the removal of the wolf's native prey - moose and reindeer - along with increases in livestock were the main cause for high levels of conflict. In 1966, the wolf was declared functionally extinct in the Scandinavian Peninsula. (Wabakken et al. 2001), following which they were accorded legal protection. Since then, wolves have re-colonized Scandinavia (Wabakken et al. 2001). Indeed, re-colonisations have been noted in many parts of Europe from which wolves had completely disappeared (Boitani 2000), due to shifts in pastoral practices in the last 50 years. A steady decrease in rural populations and livestock numbers, coupled with changes in husbandry and agricultural practices, greatly reduced contact between humans and wolves and the likelihood of conflict, allowing wolves from other parts of Europe to re-enter some of their original habitats (Fritts et al. 2003). Simultaneously, mindsets of the increasing urban population promoted a favourable outlook towards wolves, garnered by the fact that people who have had the least contact or experience with wolves and other carnivores are those who have the most positive and tolerant attitude toward them (Williams et al. 2002).

These are only some of the examples of the conflict around the world, and merely serve to indicate that the issue is widespread and relatively common, and that livestock depredation is often the main proximate reason why wolves face persecution; these also illustrate some of the ways to attempt to rectify their disappearance. Further, they attest to the fact that while wolves are surprisingly resilient in the face of persecution, their conservation is heavily dependent on attitudes towards them at any given time.

Wolves and humans in India

Although wolves have faced persecution in India throughout history, large scale, systematic bounty hunting was introduced only with the advent of British rule. According to Rangarajan (1996):

> "The British came to the Indian subcontinent with a long history of systematic campaigns to exterminate carnivores in the British Isle. The elimination of wolves in England by 1500 had given people and stock a degree of physical security. Successive governments and landowners provided rewards for killing wolves. In 17th century Ireland, the reward for a wild wolf was three pounds, comparable to that offered for the head of a rebel. This led to the extinction of the wolf in Ireland by 1770. The British thus had a historical legacy of state campaigns to eliminate large predators. This was in complete contrast to the Indian experience."

Today, while sanctioned wolf-killing occurs in only very specific cases (such as after spates of attacks on humans), illegal extermination of wolves occurs in some form or other in most of the Indian wolf's range (Jhala 2003). While the use of firearms is still to have a major impact on wolves in India due to the relative difficulty in procuring them (Jhala 2003), other methods have been employed regularly to kill wolves. This has included blocking and/or smoking out dens containing pups and sometimes adults (Shahi 1982, Jhala and Giles 1992, Kumar and Rahmani 2000, Singh and Kumara 2005), dynamiting pups (Mishra 1997), and more recently using poisons (Jhala 2003). Wolves are also sometimes killed opportunistically when they become entangled in mesh pens used by shepherds (Singh and Kumara 2005, this report).

At the same time, tolerance levels are remarkably high in many parts of India, which perhaps contributes to the continued presence of wolves outside of protected areas and in human-dominated landscapes. The reason for this may lie in deep-rooted animistic traditions which show greater tolerance towards wildlife, including predators (Boitani 1992). In many areas, loss of livestock to wolves is regarded as an "occupational hazard" (Shahi 1982), or a matter of fate (Singh and Kumara 2005). The tolerance of Indian pastoralists is a chief reason why wolves have

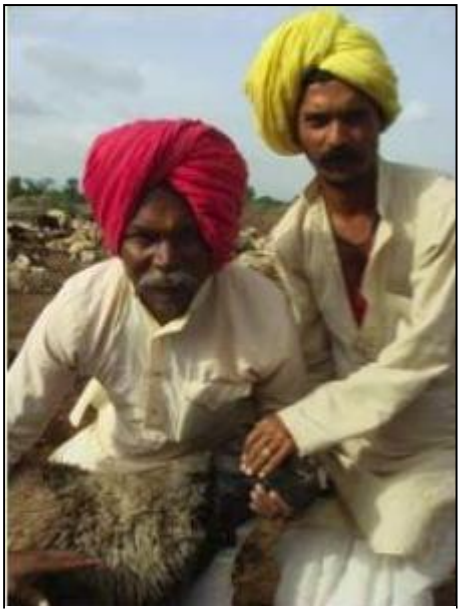
maintained a presence in India (Singh and Kumara 2005), despite levels of conflict that are considerably higher than in regions of the world from which the wolf has been eliminated.

In India, the wolf-human conflict has two primary facets: on the one hand, there is the issue of wolves preying on domesticated livestock, leading to financial losses in communities where livestock husbandry is the primary means of income. On the other hand, there are the highly publicized but sporadic instances of wolves attacking humans. This report deals mainly with the former problem, but the latter will be discussed in some detail here, as the public debate about human attacks has a great impact on attitudes towards wolves more on a global scale than national.

Attacks on livestock

Wolf depredation of livestock has a long history throughout India, though it is apparent that the problem has escalated in recent times as native prey species have disappeared from most of their original range. Currently, the main prey of wolves throughout the country consists of livestock, and the few exceptions to this are within protected areas, where native ungulate prey such as blackbuck (*Antilope cervipera*) and chinkara (*Gazella bennettii*) exist (Kumar and Rahmani 1997, Jhala 2003). However, it appears that in places where wild prey is abundant, livestock depredation is low (Kumar and Rahmani 2000).

In most areas, sheep and goats form the bulk of wolf prey; in some areas cattle are also scavenged (Jhala 2003). It has been estimated that in areas with stable wolf populations, losses due to livestock would average Rs.30, 000 per 100sq.km (Jhala 2003). A study at Nannaj in the Great Indian Bustard Sanctuary, Maharashtra where blackbuck are also available as prey, 77 goats and 24 sheep were attacked over a period of 36 months by a single pack of wolves, pack size ranging from 2-7 individuals (Kumar and Rahmani 2000).



Two semi-nomadic herders of the Dhangar community with a sheep with healed wounds inflicted by a wolf

Interestingly, the habit of scavenging at garbage dumps has not been recorded in Indian wolves, although this behaviour is common elsewhere in the world (Kumar and Rahmani 2000).

Issues related to temporal patterns in attacks, ways to reducing livestock depredation, and the impact of losses will be dealt with in greater detail in later parts of this report.

Attacks on humans

Attacks on humans by wolves are classified into three categories (Linnell et al. 2002). “Rabid attacks” are cases in which a single wolf infected with rabies may be responsible for a number of deaths in a short span of time; kills are not consumed in such cases, and many people may be attacked within a short period of time. “Predatory attacks” occur when humans are considered prey; in such cases, children are the usual victims, and kills are mostly consumed. Attacks by wolves that are threatened or cornered are “defensive attacks”. All three have been documented in India. Official records exist from the 19th century onwards, (Shahi 1982, Linnell et al. 2002), but only a handful of attacks within the last 50 years have been scientifically evaluated.

The two best-known cases of rabid wolf attacks are from the state of Maharashtra (from Linnell et al. 2002). Over 40 people were attacked and while many survived after being administered post-bite treatment, those who had suffered injuries to the head succumbed. An estimated 19, 700 people die of rabies each year (Knobel et al. 2005), primarily due to dog bites; dogs serve as a source of rabies to wild carnivores, and it is generally recommended that feral or free-ranging dogs be vaccinated and/or lethally controlled as a means to reduce the probability of deaths due to rabies from both dogs and wild predators (Linnell et al. 2002).

A number of predatory cases from recent times in India are well documented. One of the earliest systematic studies was carried out in the 1980s (Shahi 1982), wherein a number of cases of human attacks are described in the states of Rajasthan, Bihar (including attacks on 13 children in Hazaribagh in 1981), Andhra Pradesh, and Karnataka. This author also noted that wolves had been known to feed on human remains at crematoria. In March 1996, 76 children were killed by wolves in the state of Uttar Pradesh (Jhala and Sharma 1997). In the Hazaribagh area, 80 children were attacked - 60 of them fatally - between April 1993 and April 1995 (Rajpurohit 1999). It was thought that five wolf packs were responsible for the attacks. Indeed, Hazaribagh appears to be particularly prone to wolf attacks on children; as attacks have been a regular occurrence over a large area in Hazaribagh from the 1930s onwards (and perhaps even before this), it seems likely that a number of packs have been in operation over the years (Linnell et al. 2002).

A combination of factors seem common to areas where predatory attacks have been recorded. In such places humans live on fringes of settlements, instead of in densely populated villages, and bush cover is easily available for wolves to hide in. Children are often left unattended, or sleep outside. Additionally, there is little or no native prey available, nor is there easy access to livestock either because they are scarce or too well protected (Jhala and Sharma 1997). It is probable that a single chance attack on a child (due to difficulty in procuring other food) established a culture of child lifting among wolves of this area (Jhala and Sharma 1997). Another possibility is that the "child lifters" are abnormal in some way, which is suggested by the unusually large size of a few skulls belonging to wolves known to have attacked humans (Shahi 1982).

One issue that has been stressed by many authors is that while these and similar incidents have received much media attention both in India and internationally, the extent to which wolves contribute to human deaths is miniscule when one considers the magnitude of overlap in areas of human and wolf activity in India, as well as the physical potential of wolves to easily kill people (Jhala and Sharma 1997, Linnell et al. 2002). Nevertheless, human deaths due to wildlife should be dealt with sensitively; such incidents, however rare, play an important role in shaping the attitudes of people towards wildlife, and influence their willingness to support and adhere to wildlife policies.

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Indian wolf distribution and ecology

Classification

Of over 30 wolf subspecies that are recognized, two are found on the Indian sub-continent (Wayne and Vila 2003). The Indian wolf *Canis lupus pallipes* ranges over much of peninsular India and is believed to be the same sub-species found in Iran and Israel (Mednelssohn 1982). Another subspecies, the Tibetan wolf *Canis lupus chanco* is found in the northern reaches of the subcontinent in the Trans- Himalaya, as well as in Tibet, China and Mongolia. Recent studies (Sharma et al. 2004) suggest the peninsular Indian population of the wolf diverged from the wolf-dog clade around 400,000 years ago and has not mixed with other populations of the clade, while the Tibetan wolves of Himachal Pradesh and Nepal branched off 800,000 years ago. In the face of these new findings, it has been suggested that the peninsular Indian *Canis lupus pallipes* be accorded species status (Sharma et al. 2004), which may have implications on their conservation status as well. This report concerns the peninsular Indian wolf.

Distribution and range

The Indian wolf occupies the southernmost range of wolves worldwide, and is most commonly found in semi-arid habitats consisting of agro-pastoral lands, scrub forests and grasslands, and with a few exceptions are found outside of protected areas (Jhala 2003).

Surveys conducted in the 1980s estimated the Indian wolf population to be around 700-800 individuals over a discontinuous range (Shahi 1983). Recent studies involving more thorough sampling indicate that the population may be closer to 2000-3000 individuals (Jhala 2003), and continuous throughout its range in the states of Gujarat, Rajasthan, Uttar Pradesh, Madhya Pradesh,

Haryana, Maharashtra, Karnataka and Andhra Pradesh (Jhala 2003). However, Singh and Kumara (2006) believe that these wolf populations may be fragmented and isolated.

Jhala (2003) estimated that the territory sizes of wolves ranged from 100 sq. km for wolves feeding on wild prey in areas of high prey density, to 250-300 sq. km in areas where livestock depredation and scavenging were more common. Similarly, larger packs (11-12 individuals) were more common in areas of wild prey abundance, although packs of similar size have been observed where only domesticated prey is available (Kumar and Rahmani 2000, this study). Thus prey type and availability greatly influence wolf densities.

Diet

Livestock contribute to a majority of the wolf's diet, except within protected areas (Jhala 2003, see Appendix C). The daily diet of an Indian wolf has been estimated to be 1.01kg (Kumar and Rahmani 2000) to 1.88kg (Jhala and Jhetva 2004) per day per wolf. Livestock kills are usually not wholly consumed, due to disturbance during feeding by herders, dogs, or scavengers (Kumar and Rahmani 2000). In areas where mainly wild prey is present, kills are utilized to a higher extent (Jhala 2003). Wolves in India probably do not kill dogs often (although see Jhala and Jethva 1991), though this is a common behaviour elsewhere (Fritts et al. 2003) and can be responsible for negative attitudes when pet dogs and hunting dogs are killed (Mech 1998).

Breeding, denning and dispersal

Indian wolves mate between October and November (Jhala 2003) and give birth in winter (Kumar and Rahmani 2000). Wolves' are generally tolerant to human presence, even during denning and lactation (Thiel et al. 1998), but high levels of disturbance may lead to den-shifting (Habib and Kumar 2007) which at times can be fatal to pups. Access to water is also a critical factor during lactation (Habib and Kumar 2007). Young of the year disperse after they are at least 7-8 months old (Jhala 2003), and attempt to establish breeding pairs or displace alpha adults (Jhala 2003).

Conservation status and threats

While the Grey wolf species has been classified as Least Concern for conservation (IUCN 2000), the *pallipes* sub-species is protected under the Schedule 1 of Indian Wildlife (Protection) Act of 1972 and CITES; hunting, trapping, or killing of Indian wolves is illegal.

The biggest long term threat to the survival of Indian wolves is the loss and degradation of habitat (Jhala 2003). As agricultural practices shift from dry farming to irrigated, intensive farming, and traditional grazing lands are converted into industrial and agricultural land, undisturbed denning and rendezvous sites become scarcer. Canine diseases are also a threat, particularly rabies and distemper (Jhala 2003). Killings by humans, as described earlier, are widespread and can be expected to increase as habitats shrink, and attitudes shift away from traditional value systems (Jhala 2003).

STUDY AREA

The study area (19°17'35.88"-19°27'48.96"N and 74° 7'9.76"E-74°27'22.28"E) covers an area of 121 sq. km in the Northwest corner of Ahmednagar district, Maharashtra (See Fig. 1, 2 and 3). Twenty seven villages in Sangamner sub-district and two villages in Parner sub-district were studied. There is no Protected Area in the vicinity of the study site and neither natural forests nor wild prey are present. The wolf populations we studied thus inhabited an entirely human dominated landscape. The area lies in the drought-prone Western Maharashtra Scarcity Zone (www.ahmednagar.nic.in) of the Deccan plateau, created by the rain-shadow of the eastern extension of the Western Ghats. It receives 416.6mm of rainfall per year, (ahmednagar.nic.in) with a bimodal rain distribution with peaks in June/July and September (Chavan 2006). Rainfall is erratic and often inadequate, leading to low productivity and high agricultural losses in drought years. Seasons can be classified as summer (March to mid-June), monsoon (mid-June to late September) and winter (October to February). Maximum temperatures reach 40oC in May, and minimum temperatures of 10oC in December.

Figure 1: Map of districts in Maharashtra (images from Google Earth)

Figure 2. Map of the Ahmednagar District (images from Google Earth)

Fig 3. Study site indicated by pink markers (images from Google Earth)

The substrate consists of partially decomposed basalt formations (Kumar and Rahmani 2000). Agricultural soils are predominantly moisture-retentive black clay soils, which characteristically swell when wet and form cracks on drying (Chavan 2006).

The area is a combination of agricultural patches, dry grass and scrub-lands, interspersed with clustered settlements. Grazing areas consist of grassy areas along the tops and slopes of hillocks, which may be private or government owned. 70.5% of Sangamner sub-district consists of agricultural lands, of which not more than 6.1% is irrigated. Forest land constitutes another 11.4% of the total area (ahmednagar.nic.in).

Sangamner sub-district (Sangamner has a human population of 439806 people and a density of 234 persons/km2).

Area	170506 Hectares
Agriculture Land	120290 Hectares
Forest Land	19489 Hectares

The agricultural system can be considered a "mixed crop-livestock farming system" (Bernan 2002), wherein crops and livestock both contribute to household incomes. Major crops are sorghum (jowar) accounting for 40% of the Gross Cropped Area, with average productivity of 537kg/hectare in Ahmednagar district (Chavan 2006) and pearl millet (Bajra). Husbandry constitutes from 15% to over 60% of a family's income; the relative contribution from livestock sales is highest for the poorest/landless households (Puskur et al. 2004). Usually, large ruminants (cattle and buffalo) can only be afforded by large land owners due to high maintenance costs. For farmers with small to medium land holdings, small ungulate livestock (goats and sheep) serve as drought insurance in bad agricultural years (Puskur et al. 2004), and such families may also own a small number of cattle to serve their household needs for milk and yogurt. Landless shepherds, marginalized farmers, and women may depend wholly on goats and sheep for income (Puskur et al. 2004).

In Sangamner sub district 19.4% of the population are farmers, and another 6.5% are involved in some form of farm labour (ahmednagar.nic.in). Determining the number of people involved in livestock husbandry (or estimating the number of livestock) is considerably more difficult, since a large proportion of livestock are owned by semi-nomadic/nomadic families who leave the area for 3-9 months of the year; thus there are huge fluctuations in these numbers. However, based on studies in nearby villages with similar land profiles and rainfall, it is estimated that the study area could support in the region of 0.81 small ruminants per hectare (Puskur et al. 2004).

In this study, we are concerned with owners of small ruminant livestock, as wolves regularly prey on goats and sheep; there were no reports of large livestock being depredated in the study area. Livestock owners may belong to one of three categories: goat herders, local shepherds, and semi nomadic/ nomadic shepherds.

Small-scale herders have flocks consisting almost entirely of goats, and graze in the same village year round. Resident shepherds have flocks consisting of mostly sheep, and also remain in their villages, while semi-nomadic/nomadic shepherds migrate to better grazing areas, usually well irrigated valleys within the state for 3-8 months of the year. An overview of demographics of interviewees can be found in Appendix A.

METHODS

The field work for this study was carried out between February and August 2007. A total of 369 people were interviewed or surveyed; details of which are given below.

Initially we had intended to use Forest Department records to get an idea of the extent of wolf depredation on livestock as well as attacks on people and then interview the affected people who had filed for compensation. However, perusal of the records indicated that no wolf attacks had been reported in the past year from the study area despite a definite presence of wolves and depredations on livestock by wolves. Therefore, given the lack of officially recorded data we decided to use two methods to understand wolf depredation. One method was a quick one in which a large number of people were sampled from a large area and we did this by visiting the weekly livestock market and interviewing the livestock owners. These interviews have been classed as market survey. To get more detailed information on livestock depredation by wolves we interviewed people in an area where wolves are present and these are titled the attack survey.

MARKET SURVEY:

In order to obtain an idea of losses on a larger spatial scale, we made a total of eight visits to a weekly livestock market and surveyed all owners present about their current small livestock ownership, guard dog ownership, and total losses in the previous year (see appendix A for survey details). There was an outdoor market in the village of Sakor (lat long), to which goats and sheep were brought and sold to butchers and middlemen, mostly from Nashik district. Livestock owners lined up on either side of a street with their animals and we surveyed all livestock owners present. The areas these people came from would have been within a 25 km radius from the surrounding landscape. A total of 227 people were interviewed over four months.

ATTACK SURVEY:

Seven preliminary open-ended interviews were conducted in the 121 km2 study area, and based on the interviews, specific villages were chosen as starting points to conduct structured surveys in the following months, from February to April, then again in late July and early August. We conducted a survey whenever we encountered a livestock owner who had suffered losses in the previous year. We also asked locals about any accounts of recent attacks they may have heard about, and followed up on this information by visits to the location. Twenty nine villages within the study area were visited in the following months, and 149 structured surveys were conducted. Owners who had not suffered losses within the past two years were not interviewed.

Details were recorded regarding the ownership, protection practices, and losses incurred during the last year due to wolf attacks as well as other causes. (See appendix B for survey). We also asked the owner to recount details of the most recent attack(s), including time of day, presence and proximity of people and guard dogs, number of wolves seen (see Appendix B).

The following measures were taken to maximize the likelihood that the given answers were genuine: Firstly, a local guide familiar with the dialect was used as a translator, and interviewees were assured that their names would not be associated with their answers. As often as possible, information given about guarding practices and ownership (such as number of people guarding herds, number of livestock owned, etc) were verified directly by observation. Next, the veracity of an interviewee's comments regarding wolf depredations were verified by asking other members of the village (immediately after the interview and without the knowledge of the interviewee) about the extent and nature of the interviewees losses. As predation by jackals, hyenas, leopards and stray dogs occur in this area, the interviewee was questioned about the physical appearance (size,

coloration, and appearance of snout, ears and tail, etc) of the predator, and asked to identify the animal from a set of photographs, to increase the likelihood that the predator was correctly identified. As often as possible, attack accounts were taken from eye-witnesses; in a few cases where a witness was not present at the interview, a family member who had heard the account first-hand was asked to provide details. Interviews were discarded if we suspected that the answers were not legitimate. Additionally, for all interviews and surveys, I introduced myself as a college student from Mumbai, and did not claim affiliation to any group.

DIETARY ANALYSIS:

115 scats were collected over a period of 4 months, to analyze the diet of wolves in this area. Based on survey data and conversations with locals and forest guards, we visited areas where wolf attacks and wolf presence were most often reported. These areas would then be covered on foot to search for scats, and also pugmarks and potential den sites. Searched areas and locations of collected scats were marked using a GPS unit, and date, time, diameter and freshness of scats were recorded. A total of 72 km was covered to search for scats.

Wolf ranges nearly always overlap with areas of human use (Jhala 2003), and given that this study site was a human dominated landscape, there was a high likelihood of dog presence as well. This made it very difficult at times to be certain that wolf scats, and not dogs scats, were being collected. Additionally, the presence of other predators such as jackals and jungle cats made it impossible to determine with complete certainty the species from which the scat originated; this would only be possible using DNA analysis. As DNA methods were beyond the scope of this project, to the best of our ability we attempted to collect wolf scats only, based on shape, size, odour, and diameter.

Collected scats were thoroughly dried, then washed and sieved to obtain indigestible macroelements from prey including hair, bones, claws and feathers. These materials were then used to determine the prey items in each scat. A minimum of 15 randomly selected hairs from each scat were examined. If fewer hairs were present in the scat, then all were examined. Hairs were washed with Xylol, then mounted in Xylene and examined under a microscope at 40X x 10X magnification. Medullary and cuticular patterns of hairs were compared with reference hairs mounted in DPX of common prey items. Additionally, the presence of plant matter in the scat was recorded as well.

Wolf pugmarks found near Shendewadi Village.

RESULTS

MARKET SURVEY:

Patterns of livestock ownership and mortality

Livestock has a strong presence in the landscape with an average of at least 10 animals owned per herder (Table 2). The people could be broadly divided into three kinds of livestock owners based on the total numbers of livestock (goats + sheep), goats, sheep and guard dogs (Table 1). The goat herders had the smallest number of livestock and rarely owned sheep. The two sheep herder categories owned larger numbers of livestock that were dominated by sheep. The nomadic sheep herders had the largest number of guard dogs, followed by resident sheep herders and goat herders.

The annual mortality of livestock among all the interviewees did not differ significantly among the ownership categories (Table 1). Moreover, the proportion of livestock losses due to disease and accidents did not differ significantly among the categories of ownership, but the proportion of losses due to wolf did (Table 1). The highest average loss to wolf was observed among the nomadic sheep herders, and the smallest among resident sheep herders. Nevertheless, among all the 227 interviewees, a total of 261 sheep and goats were claimed to have been killed by wolf, whereas the total number lost due to all mortality causes was 1382. Hence, wolf depredation constituted less than 20% of all livestock mortality.

Table 1. Trends in livestock ownership and mortality among different ownership categories in the Sangamner sub-district, Nagar district, Maharashtra, India. The data are presented as mean values ± 1 SE. Non-parametric tests (Kruskall-Wallis) were used when assumptions concerning normality and homogeneity of variance were violated (From market survey).

		Goat herders (N = 122)	Resident sheep herders (N = 31)	Nomadic sheep herders (N = 74)	Tests for differences among ownership categories
Ownership (number of stock)	Goats + Sheep	13.8 ± 1.1	48.8 ± 7.7	76.0 ± 8.8	€ DF = 2/224, F = 130.5, P < 0.001
	Goats	11.5 ± 0.9	6.1 ± 1.4	7.7 ± 1.0	€ DF = 2/224, F = 22.2, P < 0.001
	Sheep	< 0.1 ± <0.1	35.3 ± 5.6	56.4 ± 7.4	¥ DF = 2, X2 = 179.8, P < 0.001
	Guard dogs	0.6 ± 0.1	1.2 ± 0.2	1.6 ± 0.1	¥DF = 2, X2 = 179.8, P < 0.001
Mortality (%)	All causes	14.4 ± 1.4	12.9 ± 1.8	15.7 ± 0.9	¥DF = 2, X2 = 3.4, P = 0.180
	Disease + Accident	11.12 ± 1.24	10.43 ± 1.63	11.79 ± 0.79	¥DF = 2, X2 = 3.6, P = 0.166
	Wolf	2.9 ± 0.6	2.2 ± 0.6	3.6 ± 0.4	¥DF = 2, X2 = 20.7, P < 0.001

The annual wolf depredation rate on livestock among the people we sampled can be assumed to be a product of two entities; (i) the proportion of owners that experienced a deadly wolf

€ One-Way ANOVA
¥ Kruskall-Wallis Test,

attack and (ii) the proportion of livestock lost once attacks had occurred. Proportion of livestock lost once attacks had occurred equals the number of livestock lost divided by the total number of livestock. The proportion of owners who had experienced a wolf attack on their livestock was highest among the nomadic shepherds (76%), and relatively similar among resident shepherds (35%) and goat herders (30%). The goat herders showed the smallest average number of livestock lost (1.42), but the highest proportion of livestock lost once attacks occurred (10.0%), whereas the nomadic sheep herders exhibited the highest number of livestock lost (3.24) and the smallest proportion of animals lost once attacks happened (4.8%). The resident sheep herders showed intermediate values (number of livestock lost = 2.67, proportion of livestock lost = 4.8%). We compared GLM models of proportion of owners who faced an attack, number of livestock lost and proportion of livestock lost once an attack occurred to further investigate the causes of the differences described above. For each response variable, we compared six sets of models that are listed in Table 2.

A comparison of AICc values showed that the probability of experiencing a wolf attack depended mainly on whether the owner was nomadic or resident. Once attacks had occurred, the numbers lost depended first and foremost on the size of the herd. However, the proportion lost depended mainly on the composition of the herd, i.e. goat herders lost a higher proportion of their livestock than the sheep owners.

Table 2. Patterns of wolf attacks on livestock in the Sangamner sub-district, Ahmedagar district, Maharashtra, India. GLM models of (a) the probability of experiencing wolf attacks, and (b) the numbers and(c) proportion of livestock lost once attacks had occurred. The predictors were ownership category (goat herders, resident sheep herders or nomadic sheep herders), herd composition (herd dominated by goats or sheep), nomadic vs. resident (if the owner grazed the herd for more than 3 months away from home each year), the number of guard dogs and the total number of livestock (From market survey).

	Model terms	(a) Attack probability			(b) Numbers lost			(c) Proportion lost		
		AICc	ΔAICc	w	AICc	ΔAICc	w	AICc	ΔAICc	w
M1	Ownership category	304,75	31,11	0,000	211,41	47,65	0,000	180,97	7,77	0,0017
M2	Herd composition	286,24	12,60	0,002	203,75	39,99	0,000	101,20	0,00	0,849
M3	Nomadic vs. resident	273,64	0,00	0,996	208,56	44,80	0,000	106,94	5,75	0,048
M4	# Guard dogs	298,41	24,77	0,000	198,53	34,77	0,000	111,53	10,33	0,005
M5	# Livestock	285,91	12,27	0,002	163,76	0,00	1,000	105,89	4,69	0,081
M6	NULL model	313,89	40,25	0,000	221,68	57,92	0,000	120,44	19,25	0,000

ATTACK SURVEY

Attack accounts

The total number of goats and sheep owned by all the interviewed households was 1675 and 9016, respectively. The numbers reported killed in one year between February 2007 and February 2008 were 127 goats and 177 sheep. The proportion of goats vs. sheep killed by wolfs was significantly higher than expected from the relative numbers of goats and sheep owned by the interviewees ($X^2 = 154.40$, df = 1, $P<0.001$). However, while nearly all households owned goats, i.e. 138 of 145, only 90 owned sheep. Hence, the apparent preference for goats among wolfs could simply be due to a

higher availability of herds comprised of only goats. To further investigate the selection between goats and sheep among wolf, we extracted a sub-sample of households that owned both goats and sheep (N = 80), and compared the observed numbers of goats depredated with expected numbers lost if there was no selection (expected number of goats lost = total number of sheep + goat lost * number of sheep owned/number of sheep + goats owned). A pair-wise comparison showed no significant difference between the predicted and the observed number of goats lost (Wilcoxon Signed Rank test, Z = -0.14, P = 0.989).

On average, 2.4 ± 1.8(SD) wolves were seen during an attack. The majority of livestock killed by wolves (58.5%) could not be retrieved by the owners, as they had been taken by wolves. In most cases if a carcass was left behind by a wolf, it was discarded at or near the attack site (27.7%). In rare cases, killed animals were buried (2.7%), consumed by humans (2.1%), or poisoned (1.1%). The fate of 8% of the carcasses was unknown.

Table 3: Overview of ownership, protection and losses by category. (From Attack survey).

	Overall		**Goat herder**		**Resident shepherd**		**Semi nomadic /nomadic shepherd**	
Number of interviews	**143**		**56**		**28**		**59**	
	Average	*SE*	*Average*	*SE*	*Average*	*SE*	*Average*	*SE*
Average age of interviewee	39.81	1.16	42.39	1.92	37.96	2.61	37.96	1.74
Family size	6.52	0.31	5.70	0.33	5.88	0.39	7.61	0.62
OWNERSHIP								
Large livestock	3.19	0.26	2.73	0.34	3.63	0.77	4.14	0.40
Goats	11.71	0.88	11.84	1.37	9.36	1.31	12.71	1.57
Sheep	63.05	7.52	1.25	0.89	75.50 3	8.98	115.80	14.3
goats sold in previous year	4.16	0.49	3.52	0.58	2.88	1.37	5.54	0.82
sheep sold in previous year	15.86	2.01	0.63	0.34	17.32	3.38	32.88	3.76
land owned	10.49	3.75	5.08	0.68	22.57	17.70	9.52	2.90
PROPORTION OF HERD LOST TO:								
Disease/illness	0.12	0.02	0.14	0.33	0.10	0.02	0.11	0.08
wolf attack	0.04	0.00	0.04	0.09	0.03	0.01	0.04	0.04
Other/unknown causes	0.04	0.01	0.05	0.12	0.04	0.01	0.04	0.06

Livestock protection

Livestock are pastured from late morning (approximately 10am) until 0.5-1 hour before sunset. At least one person, and often at least one guard dog, is present while animals are grazed. An average of 1.72 ± 0.08 (SE) people and 1.13 ± 0.09 guard dogs are present with the herds during the day. Animals are kept in enclosures between sunset and late morning. Night-time guards are sometimes

present, sleeping near the enclosure (within 10m). The number of people and dogs guarding varied significantly among ownership groups (Kruskall-Wallis test, X2 = 64.15, df=2, P<0.001); nomadic shepherds had more people and dogs guarding than the other groups (Table 4).

Different types of pens are commonly used for protecting animals at night (Table x.6). Stone roofed enclosures are 6-10 feet in height, with thatch, corrugated metal, or tile roofs. Stone unroofed enclosures are 4-7 feet in height, with no roof.

Dry scrub pens such as this are often near tall vegetation, which provides hiding ground for predators.

This is most commonly used for small herds year round. Dry scrub pens are 4-5 feet high, made by stacking and tying together sticks, thorny scrub branches and hay. They are uncovered, and are used throughout the year. Mesh pens are temporary enclosures that are set up every night and dismantled every morning. Cotton fibre or (less often) synthetic fibre is used for the mesh material. This is most commonly used for large herds during the dry seasons or for very large nomadic herds year round. For attacks that occurred during the night (N = 46), most occurred within mesh pens (67.4%) or dry scrub pens (26.1%). None occurred within stone roofed enclosures. The most parsimonious GLM predicting whether attacks occurred during day or night included two predictors, ownership category and season (Table 3). A larger proportion of the attacks occurred during the night among nomadic shepherds than among resident shepherds and goat herders (Fig 1). Furthermore, nighttimes attacks seemed more common in the dry season than in the monsoon among all ownership categories.

In over 50% of cases, guard dogs chased wolf (this includes pursuits of short distances to chasing over long ranges). In 35.8% of cases, although a guard dog was owned, it was not present during the attack.

Table 4: Guarding practices by category. (From attack survey)

	Overall		**Goat herder**		**Resident shepherd**		**Semi nomadic /nomadic shepherd**	
Number of interviews	**143**		**56**		**28**		**59**	
	Average	*SE*	*Average*	*SE*	*Average*	*SE*	*Average*	*SE*
people guarding – day	1.72	0.08	1.15	0.05	1.75	0.17	2.35	0.13
people guarding – night	1.34	0.18	0.08	0.04	1.45	0.25	2.76	0.34
dogs guarding	1.13	0.09	0.62	0.09	1.21	0.17	1.56	0.17

Table 5: Types of enclosures used. (From attack survey)

	Goat herder	Resident shepherd	Semi nomadic /nomadic shepherd
Stone roofed enclosure	46%	0	0
Stone unroofed enclosure	22%	13%	4.3%
Dry scrub pen	22%	20%	18%
Mesh pen	0	55%	70%

Table 6: Types of enclosures that were used when an attack by wolves took place. (From attack survey)

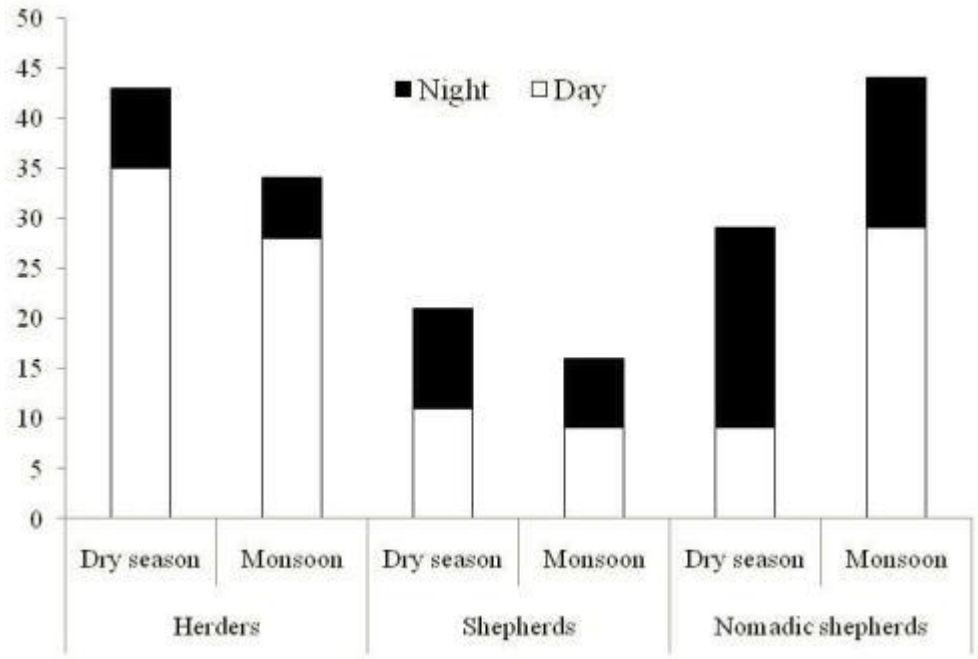
Type of livestock enclosure:	
mesh pen	67.4%
dry scrub pen	26.1%
stone unroofed enclosure	4.3%
steel mesh pen	2.2%
stone roofed enclosure	0.0%

Mesh pens are used primarily for large herds, and require regular repairs. They provide no visual barriers between livestock and the exterior, and are made of easily breakable fibres.

Table 7. Generalized Linear Models predicting whether wolf attacks on livestock occurred during day or night in the Sangamner sub-district, Nagar district, Maharashtra, India. O = ownership category, i.e. goat herders (small herds of goats), resident shepherds (larger herds of sheep) and nomadic shepherds (large sheep herds that were moved to grazing areas away from the home village for more than X months each year). S = season (Dry: November – April, Monsoon: June-October). (From attack survey)

Predictors	AICc	ΔAICc	W
O	236,28	2,50	0,17
S	244,36	10,59	0,00
O + S	233,78	0,00	0,60
O + S + O*S	235,77	1,99	0,22
NULL	245,71	11,93	0,00

Figure 4. Temporal distribution of wolf attacks on livestock in the Sangamner sub-district, Nagar district, Maharashtra, India. (From attack survey)



Economic impact

The amount of land owned on average, by the goat herders averaged 2.1 ± 0.28 (SE) hectares, whereas the nomadic shepherds and the resident shepherds owned 3.85 ± 1.18 and 9.13 ± 7.16 hectares, on an average, respectively. However, the difference in the amount of land owned among the three ownership categories was not significant (Kruskall-Wallis test, DF = 2, X2 = 0.58, P = 0.749). The total numbers of family members in each household averaged 7.39±0.53 SE among the goat herders, 6.7± 0.49 SE among the resident shepherds and 7.93 ±0.64 SE among the nomadic shepherds. The ln-transformed numbers of family members did not differ significantly among the three categories (One-Way ANOVA, DF = 2/138, F = 0.35, P = 0.706).

ATTITUDES:

In response to the question "what should be done to reduce losses due to wolves?" 40 – 60% of the resident shepherds indicated that they do not want the animals compared to only 30% of the nomadic shepherds stating the same. Similarly, 56% of the nomadic shepherds indicated that

nothing needs to be done with the wolves compared to 20 – 30 % of the other two groups (Table 8). Detailed comments made by interviewees on their attitudes can be found in Appendix A.

Table 8: Attitudes of livestock owners with depredation losses in the past year. (From attack survey

What should be done to reduce losses due to wolves?	Overall	Goat herder	Resident shepherd	Semi nomadic /nomadic shepherd
Number interviewed	**114**	**45**	**28**	**41**
Kill	20%	22%	21%	17%
Trap/move	21%	20%	39%	10%
Nothing can be done	17%	18%	18%	15%
Do nothing/let them be	38%	31%	21%	56%
Compensate	3%	7%	0%	0%
Don't know	2%	2%	0%	2%

SHENDEWADI: A CLOSE STUDY

In Shendewadi, the authors observed 11-12 wolves on four separate occasions during the study period. According to residents, wolves can be seen in this village at least every other day, and we saw on three 33 occasions a maximum of 12 wolves since April 2007. The locals mentioned that wolves are present throughout the year.

One resident lives within 250m of the location where wolves were spotted on all three occasions. According to this resident, wolves come to his property at least once a day during the dry season to drink from a small watering hole he has dug for his livestock. He has lost 8 sheep to wolves in the past two years, out of a total of 72 owned.

Twenty-one pastoralists were interviewed in Shendewadi (See Table 9). None of the residents interviewed knew of any attacks on humans within the past 20 years. In at least two known interactions with wolves in the past two years, a human encountered 5-7 wolves within 50m. In both cases, wolves displayed aggressive behaviour (bared teeth, growling), following which the person ran away and was not pursued by the wolves.

None of the interviewees in Shendewadi (both men and women) expressed fear for their lives or their children's lives due to the wolves. On at least five occasions, children under the age of 15 were seen herding animals on the outskirts of the village with no adult supervision.

Shendewadi demographics

Table 9: Distribution of individuals surveyed in Shendewadi. (from attack survey)

By occupation	Goat herder	2
	Resident shepherd	5
	Semi-nomadic/nomadic shepherd	14
Total:		**21**

Table 10: Losses to individuals surveyed in Shendewadi (February 2007 – February 2008). Goat herders and resident shepherds are not shown separately in this table, as there were very few interviews from these groups. (from attack survey)

	Overall		**Semi nomadic /nomadic shepherd**	
Number of interviews	**21**		**14**	
	Average	*SE*	*Average*	*SE*
Family size	7,57	0,76	7,74	0,97
small livestock owned	106,71	13,94	112,57	17,21
Average number of livestock lost to:				
non-wolf	19,71	3,61	19,63	4,55
non-wolf	2,98	0,65	3,07	0,83

ATTACKS ON HUMANS:

Attacks in study area

Within the 121 km2 study area, there was one confirmed attack on a human by a wolf during the period of February 2006 – July 2008. In the village of Rankhamb in February 2008 around 2:00 PM, a female aged 45 was grazing her herd of 120 animals on the top of a hill about 1.5 km from home. Two wolves attacked her sheep, and she attempted to chase the wolves off with a stick, hitting one of them. The wolf lunged up and scratched the woman's throat and face. The woman left her herd in the care of another herder nearby, and ran home. The next day she sought medical treatment, and her wounds were bandaged; no stitches were required. The attack was not reported to the Forest Department.

FROM STATE RECORDS:

Ahmednagar records on attacks by wild animals were obtained from the Forest Department for 2006 - 2007. Records often did not differentiate between attacks by jackals and by wolves, and included both in a single category. The records, provided below, include both attacks on humans and livestock.

	Wolf	Wolf/jackal
Sangamner Sub-district	0	1
Rest of Ahmednagar District	1	33
Total attacks reported in Ahmednagar District	1	34

One wolf attack was reported from Shrigonda District. One cow was killed by a wolf on 15 June 2005, and compensation was received on 20 Nov. 2005.

There were no reports of wolf attacks on humans from Ahmednagar district. There were 6 reports of attacks by jackals on humans in Ahmednagar District, none of them fatal. Compensation was received in all 6 cases.

There were no wolf attacks on humans or livestock reported to the Forest Department from Sangamner sub-district, including from any of the villages included in this study.

Reported Attacks on humans in Maharashtra (2005-2008):

Solapur District:

In July 2008 near Nannaj in Solapur district, a wolf attacked five people, a few livestock, and a dog. All humans had wounds to the face. All were administered with anti-rabies treatment, and there were no fatalities. One calf which was attacked died, possibly of rabies. The dog which was attacked also tested positive for rabies (Aniruddh Belsare, Pers. Comm.) indicating that it was likely that the wolf had rabies.

Satara District:

- From Dec. 2005 to Feb. 2006, three incidences of wolf attacks on humans were reported from the Phaltan Sub-district of Satara district.
- On17 Dec. 2005, 12 people and 15 livestock were attacked in Mauje (Asauli), resulting in three human deaths
- On 27 Jan. 2006, two adult females were attacked by two wolves in Mauje (Pirachiwadi).
- On 10 Feb. 2006, one adult male was attacked in the village of Tatwada. (Aniruddh Belsare, Pers. Comm.)

Pune District:

On December 15th 2005, a local newspaper reported that 12 people had been injured by a wolf in Asavali village, Bhor sub-district in Pune District. Four wolves had been spotted in the area for the past few days. At 10:30 AM, one wolf reportedly "went berserk", and began biting people who were warming themselves outdoors. 12 people were injured before villagers killed the wolf. There were no fatalities reported. (http://cities.expressindia.com/fullstory.php?newsid=161815).

Dietary Analysis:

Of 115 scats collected, samples that had a greater probability of being correctly identified wolf scats were selected for analysis. This selection was based on diameter (greater than or equal to 21mm), and/or proximity of scat collection site to wolf-sighting location (if applicable). A total of 65 samples were selected for analysis.

Most scats contained a single prey type (73.54%). 24.62% contained two or more and 3.08% contained no prey remains, but did contain plant matter (see table 12). The most commonly found prey type was goat (78.46%), followed by chicken (24.62%). 40% of scats contained some plant matter, primarily *Zyziphus mauritiana* (27.69%), see table 13 and 14.

Table 12: Number of prey types in scats

Number of prey types in scat	Number of occurrences	% occurrences
0	2	3.08%
1	47	72.31%
2	14	21.54%
3	2	3.08%
3+	0	0.00%
Total	**65**	**100.00%**

Table 13: Types of prey in scats

Prey types	Number of occurrences	% occurrences
Chicken	16	24.62%
Goat/Calf[4]	51	78.46%
Rodent/lagomorphs	4	6.15%
Sheep	6	9.23%
Total	**79**	**118.46%**

Table 14: Types of vegetation in scats

Plant matter	Number of occurrences	% occurrences
Zyziphus	18	27.69%
Grass	4	6.15%
Other	4	6.15%
Total	**26**	**40.00%**

[4]It was not possible to consistently differentiate between goat and calf hair using Medullary patterns

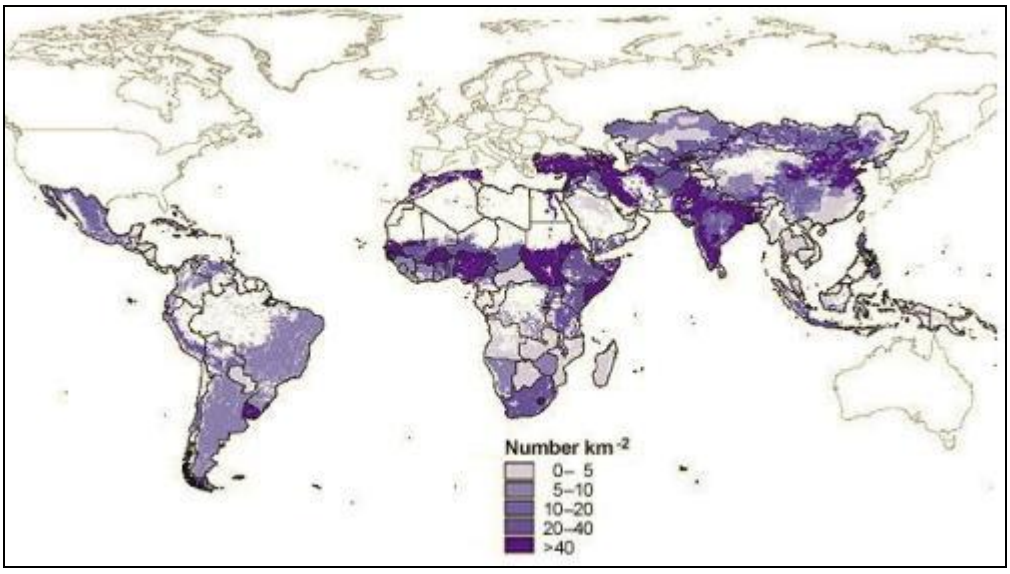
DISCUSSION

WOLVES AND PEOPLE:

The association of wolf and man is an ancient one but makes for a tenuous relationship, even if we domesticated the species to provide us with our faithful dog. The interaction with this species ranges from loathing to tolerance based on social, cultural and economic factors (Linnell 2002). Unfortunately for humans and wolves, domesticated sheep and goat are important resources for both (Table 1) and given that the wolves range over large areas, it is inevitable that they will share spaces with humans. This is especially true in a country like India with a human population density greater than 300 people per sq. km who tend poorly protected, dense congregations of medium sized livestock. The current study site has traditionally had wolves and has had people as well but in recent times is devoid of any wild prey species and natural vegetation. It is an entirely human dominated landscape with a density of people greater than 200 per sq. km and livestock (only sheep and goat) density of over 20 per km2. (http://www.ilri.org/InfoServ/Webpub/Fulldocs/Mappoverty/media/32.htm). A long-term research project on wolves in a Wildlife Sanctuary in the state, which is contiguous in habitat with our current study site, found the density of sheep and goats outside the Park to be much higher than wild prey inside (Bilal 2004). Furthermore in recent years the presence of poultry farms has increased. The lack of proper waste disposal methods leads to poultry waste thrown in the open which in turn attracts and provides food to wild carnivores (and domestic dogs as well) (personal communication Abi Tamim Vanak).

Our work also indicates that wolves are not uncommon in a completely human dominated landscape and where people face losses due to the wolves' presence. One of our villages had wolves coming daily to the waterhole at a farmer's house in the dry season. It was a remote area and he could have easily done away with the animals and has not – indicating that some part of our cultural tolerance still remains. During lactation, water is the most important factor determining location of denning sites (Habib and Kumar 2007); that is, wolves are forced to den in areas which are close to water sources and the village we sampled could well be one such site as we saw 10 young animals as well with the adults.

Figure 3: Sheep and goat density
(from http://www.ilri.org/InfoServ/Webpub/Fulldocs/Mappoverty/media/32.htm)



No lethal control of wildlife is allowed in India and given the historical spatial overlap between people and wildlife, it is inevitable that carnivores will live among people in India. Unfortunately, sheep and goats provide sustenance and occupation to a large number of people especially in these dry landscapes where only rain fed agriculture is practiced in the rainy season.

The sharing of space is not without conflict and the local people, often poor, lose their livestock to wolves. Rarely people are also attacked but in the current study area where a wolf pack of 12 was operational during our work, there has never been a single instance of a purposeful attack on a person with intent to kill and feed off the person. Serial man-eating cases have been reported in central India (Jhala 2003). It has also been suggested (Jhala 2003), that areas of low wild and domestic prey density, coupled with heavy protection of livestock, are more likely to have attacks on humans, particularly on unattended children.

However attacks on humans by rabid dogs and wolves are reported in the southeastern districts, which are contiguous with this study area (Aniruddha Belsare personal communication). The adjoining irrigated valleys also report attacks on people by rabid dogs (Ahtreya et al, *Unpublished*). Attacks on livestock are ubiquitous and more common than reported as is evident from our market survey. Of the 227 people interviewed at the market, the nomadic shepherds reported more attacks but the goat herders lost proportionately more animals. This could be either due to better protection by the shepherds (who have more people and dogs on average) or it could be that the nomadic shepherds are not present in the landscape for most of the year and so their losses due to wolves are relatively less. They for instance lose their sheep to leopards when they move to the valleys in the dry season (Athreya et al, *Unpublished*). The results of the diet analysis in this study found more goats than sheep that were present in wolf scats, however we think this is probably due to the lack of resolution to differentiate between the canid scats based on visual evidence alone. DNA based studies to differentiate the species are required given that all the four species of canids are present in our study area (domestic dog, wolf, jackal and fox). That size alone is not sufficient to distinguish even between varied body size species is well known (Farrell 2000).

The inhabitants of our study site do not think of the wolves as anything out of ordinary for they have always lived in the presence of this species. Complete extermination of wolves or any carnivore as an administrative exercise has not been part of our cultural ethos (Ranagarajan 1996). Large scale killing commenced in India after the British arrived. Present day conservation ethics also dictates that wolf populations should be conserved. Legally the wolf has been accorded the highest level of protection in India and orders to kill have been given by the administrative body only in case of serial attacks on people. The law does not allow the public to kill wolves and although dens are known to be smoked, it can invoke stringent action if noticed by the authorities. Thus the protection accorded on one side allow this species to persist in human dominated landscape given the of domestic livestock available to them as prey.

However results from our work indicate a strong underlying antipathy among our respondents, to the presence of the wolves. Forty one percent (n = 114) of the respondents (from the attack survey) wanted the wolves to be removed and 38 % wanted nothing to be done. What should be noted is that a large number of nomadic shepherds are more tolerant towards the wolves compared to the resident livestock owners and this could be due to the proportionately lower losses they face as well as the fact that they do not encounter wolves for much of year when they are away.

The results of our work also indicate that livestock losses to wolves are a fraction of what these people lose to disease and accidents.

Discussion of Mitigation Methods

Most studies on wolves have been carried out within or near protected areas (Jhala 1993, Manakadan and Rahmani 1997, Kumar et al. 1997, Kumar et al. 1998); however, it is widely acknowledged that conflict exists at varying levels far from protected areas as well (Jhala 2003). A quick review of papers concerning attitudes of people incurring livestock losses to wolves near protected areas suggests that they have regular contact with Forest Department employees, they have knowledge of Forest Department policies regarding loss compensation, and are aware that non-domesticated prey is available for wolves in the form of wild ungulates. These are important factors impacting how they respond to wolf attacks (Jhala 2003, Habib and Kumar 2007, Linnell et al. 2002, Singh and Kumara 2005). We will discuss below some of the commonly used strategies which are used in India in response to depredation of livestock.

Compensation

The underlying assumption behind providing compensation is that by alleviating the economic losses to livestock owners caused by wild predators, resentment towards the animal will be reduced, and there will be a smaller chance of retaliatory measures. Compensation is provided in many parts of the world for losses due to wolves (Fritts et al. 2003), and in many parts of India for losses due to tigers, lions, elephants, leopards and snow leopards (Madhusudhan 2003, Sabarwal et al. 1994, Athreya et al. 2004, Mishra 1997). Wolf attack compensation is supposed to be available in the state of Maharashtra, although very few people are aware of this fact apart from those who live very close to protected areas (there are no published reports on this, but it seems to be the case based on a number of conversations with Forest Department officials and ecologists working in Maharashtra). Many authors who have studied wolf-human conflicts in India state that compensation is a very important measure that should be implemented for ensuring wolf conservation (Jhala 2003, Kumar and Rahmani 2000, Singh and Kumara 2005); however, none discuss in detail the success, obstacles, and repercussions such schemes have had in the past.

Unfortunately, compensation for wolf attacks is a difficult, if not impossible way to resolve wolf-livestock conflict. In order to claim compensation, it is necessary that the claimant produce photographic documentation of the kill. Since carcasses are very often not retrieved, in most cases compensation cannot be sought in the first place. If the carcass is left behind, obtaining a photograph of the kill involves finding a photographer (which can be difficult in rural areas). A veterinarian is also required to attest that the kill was indeed due to a wolf. Following this, paperwork must be filled and filed involving long lines and red tape, and finally there is an indefinite waiting period before compensation is received. In this process, quite a bit of money (veterinarians report, camera man's costs, time, and effort will be spent simply to submit a claim. In many cases, the value of compensation when it is finally received is considerably less than the value of the killed animal. Also, many of those affected are nomadic shepherds, who cannot file for compensation in any case due to their itinerant lifestyle (our observations).

Further, while meant to reduce animosity, compensation schemes can in fact lead to the deterioration of attitudes toward wild predators. Shahi (1983) says that a number of local pastoralists consider losses due to wolves as an "occupational hazard". Similarly, in other parts of India, wolf depredations are considered a "matter of fate", an "expected cause of loss", etc. When actions are implemented by the state department to alleviate losses, the animal ceases to be a party beyond anyone's control, and becomes a party controlled by the state (This is not based on our study but are our observations). Depredation shifts from being viewed as an inevitable natural act for which no recourse can be taken, to an incident for which equivalent reciprocal measures are expected. These expectations may be in the form of monetary compensation, extermination of the "problem" animal, or trapping and moving the culprit (as with leopards in Maharashtra, Athreya et

al. 2004). However, if the results of these actions are not fully achieved (for example, if compensation funds are denied, delayed or insufficient; or if depredation does not cease following trapping or extermination), anger towards the state increases for its ineffectiveness, and the animal is "blamed" for its behaviour. This drives people to become less tolerant, and in the worst case take matters into their own hands.

Another difficulty is that the availability of compensation often leads people to believe that they are not required to protect their livestock. This is not surprising, as there is little point in protecting something that has the same/similar value whether it is protected or unprotected; since keeping livestock unprotected involves less effort, compensation could ultimately becomes the *preferred* way to make money. If this continues for long, funding for compensation programs will in no way be able to meet all claims; similar problems have caused bankruptcy of compensation programs in the past (for example, see Naughton-Treves 1999). One way to prevent laxity in protection is to evaluate the protection methods being used at the time of the attack, and deny compensation if protection is found to have been insufficient. But this too would be very difficult, since most wolf attacks occur in secluded areas with few or no eye-witnesses present except for the owner(s), and there would be no way to validate claims of sufficient protection (This report).

One of the most glaring faults in compensation schemes is that claims can only be made if the carcass is left behind by the wolf (Maharashtra Forest Department, 2007). Thus an owner must attempt to drive away a wolf from its kill, if she/he hopes to claim compensation. When a wolf is forced to abandon a carcass, it will of course be forced to seek food elsewhere, and more depredations will be inevitable in areas where only domesticated prey is available. So implementing compensation will in fact propagate livestock depredations, the very problem it aims to rectify.

Similar problems would be faced by community-based insurance programs, such as the one that has been quite successful in Baltistan, Pakistan, for snow leopard conservation (Hussain 2000), since this also requires the presence of a carcass or some other proof of depredation.

Supplementing water

Often construction of water projects is thought to be the panacea for dry habitat conflict mitigation. The rationale being that if the water is provided inside a Protected Area then the wild animals will not leave the area. However, in a landscape like our study area where "outside" and "inside" are often blurred we will always have wolves going to a farmer's house to drink, if that house is within their range. Providing water at artificially constructed water holes could also have associated problems. For instance in Melkote, Karnataka, a major aforestation program was undertaken in the 1990s, and included the construction of a number of check dams, tanks, and other water sources, all primarily with the view of protecting wolves and increasing their numbers (Singh and Kumara 2005). Instead, the combination of increased vegetation and water availability made conditions more favourable for leopard occupancy, and it is suspected that leopards displaced and preyed on wolves in Melkote. Thus, if the building of water sources is undertaken, it should be kept in mind that Indian wolves inhabit arid scrub and grass lands, and over-modification of this habitat may be detrimental.

Replenishment of wild prey

It has been demonstrated in a number of cases, that there is very little wolf depredation on livestock in areas where wild ungulate prey populations are healthy and abundant. In Portugal, areas with high native prey density experience considerable livestock loss (Promberger and Schroder 1993), while areas with very little native prey lost a large number of goats every year (Vos 2000). Similarly, areas where native prey has been restored, livestock depredations have witnessed large

drops. This has been seen in a number of examples from North America (Bangs et al. 1998, Treves et al. 2002), Southern Europe (Meriggi et al. 2007), Poland, Romania, and Finland (Fritts et al. 2003). In India as well, it has been noted in the few areas where wild ungulate prey is readily available, livestock constitutes a much lower proportion of the wolf's diet (Jhala 2003). Wolves apparently prefer wild prey over livestock, when both are available. However in an entirely human dominated like our study site, there is no wild habitat nor is there wild prey and reintroduction of wild prey can have a number of limitations.

First of all, while wolves are capable of surviving even in overgrazed, industrialized areas (Habib 2007), their wild prey are much more sensitive to altered habitats (Jhala 2003); reintroduction may not be possible at all in areas where the habitat is too degraded, or where restoration of habitat would not be feasible. Secondly, it may be possible that after reintroduction, if livestock remains locally abundant and easily available, livestock depredations will remain high (Meriggi et al. 2007). Additionally, grazing pressure from livestock may be too excessive to allow wild prey to successfully breed and re-establish in the long run (Jhala 1997). The large numbers of domestic dogs present in the landscape could also affect the recruitment of wild ungulates in human dominated landscapes where no refugias are present for the wild ungulates. Lastly, re-introduction of wild ungulates, especially if it will also require habitat restoration, would entail a long-term, effort-intensive, expensive project. In turn it could lead to crop depredation by the wild herbivores and yet another cause of conflict. Even if successful initially, constant and continuous monitoring would be absolutely vital to ensure its prolonged success. It will be necessary to ensure that herders do not graze their animals on protected land, that poachers do not kill ungulates, and that the habitat remains as undisturbed as possible.

In conclusion, the current methods of mitigation seem to have serious problems both for people and the wild carnivores. New methods which focus on increasing the acceptance of the local people towards sharing spaces with carnivores like the wolves are perhaps required. The results of our work indicates that a large number of people who depend on even larger numbers of medium sized livestock have to live with wolves in their midst. The only way that the local people, to whom the presence of wolves living among them is not a novelty, would not want to persecute the wolves is if their problems are paid attention to by the administration (who is seen as the protector of the wolves) and positive measures to ease their losses are carried out. The current methods do not allow for any positive feelings towards the administration or the species that are associated with them. Perhaps insurance schemes which are facilitated by the Forest Department could be one option. The other could be reducing losses to the people due to diseases which account to five times of what they lose to wolves per year. Any of these above interventions should be done only while reinforcing the fact that this is being done to ease the losses the locals have due to the presence of the wolves. In event of the above two, a working plan has to be drawn up and taken forward only after consultation with the local village bodies.

RECOMMENDATIONS:

Policy on dealing with wildlife that live in human dominated landscape needs to be formulated keeping in mind the fact that wild carnivores also live among humans in human dominated landscapes and that the people, often poor, incur losses due to the presence of these endangered and potentially dangerous species.

1. Similarly, conservation oriented research should be encouraged in human dominated landscapes so that context specific knowledge on the issue is available for the managers to act upon. Currently most of the research is focused within and around Protected Areas and extrapolation of the results to outside PA's is unlikely to be of much relevance.

2. In this specific case, we would recommend that
    a) The Forest Department proactively assist the local people to prevent losses
    b) The methods have to decided based upon consultation with the field level staff (who are often locals of the area) and the local administration of the village
    c) The attitude of policing by the administration has to be accompanied by an empathy driven approach which acknowledges that the people have traditionally tolerated the carnivores and are suffering real losses due to their presence.
    d) For example, in this specific case we recommend
        i. That the services of a veterinarian be provided. These villages are remote and they lose a large part of their livestock to diseases.
        ii. Logistics to approach the village of Shendewadi could be improved by the Forest Department so that wildlife tourists could come to watch the wolves – which would benefit the farmer whose water the wolves come to drink daily and who has lost sheep to the wolves.
        iii. Facilitation of insurance based schemes for the local herders could be carried out by/in conjunction with the Forest Department.
        iv. We also would like to consider a pilot project to obtain livestock guarding dogs to test if the shepherds can take care of them and if the dogs can survive in Indian conditions.
        v. Finally, areas which are crucial for denning should be identified and protected with the help of the local communities. But this can be achieved successfully only if the local people perceive that their real losses are being fairly compensated. These small refugias would also help in the long term conservation of many other dry land species as well.

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APPENDIX A. Attitudes and comments on wolves and conflict in study area

A number of people interviewed chose to add further comments to their answers in what should be done to reduce losses due to wolves.

In the occupation column, *h* is Herder, *s* is Shepherd, and *ns* is Nomadic Shepherd.

Gender	Occupation	What should be done to reduce losses due to wolves?	Comments
f	h	kill	They should be killed, but they're hard to find
m	m	kill	Wolves should be killed, but we have no way to kill wolves ourselves
m	h	Do nothing	Government should provide compensation
m	s	kill	Either compensate or let us kill wolves
m	h	Do nothing	Depredation due to wolves is OK as long as they only take a few every year. They are a problem for our animals, but not for us. [i.e., they are not expected t harm humans]
f	h	Do nothing	There should be compensation available
m	h	kill	I want to poison them, but it's not allowed
f	h	Nothing can be done	I want better guard dogs
m	s	Nothing can be done	We shouldn't kill wolves, because we'll be punished for it
m	s	Nothing can be done	Government doesn't allow us to kill them
m	s	Nothing can be done	I know someone who was caught for trying to kill a wolf in a village nearby
m	s	Nothing can be done	It is not possible to kill them because of where they live… they are difficult to find
m	s	Kill	I wish there was permission to kill them
m	s	kill	I don't know how I would go about killing a wolf
m	s	Nothing can be done	The Forest Department won't let us do anything [against wolves] ourselves
m	h	Do nothing	Even if you move them, they'll come back. This is what happens with the leopards
m	ns	Do nothing	Dogs are good at making sure there aren't too many wolf attacks
m	ns	Kill	We should try poisoning if we can
m	ns	Do nothing	Dogs with spiked collars are good because wolves go for the throat
m	ns	Do nothing	If you poison them, wolves will get angry and come back and cause more trouble
m	ns	kill	Wolves are more dangerous than leopards
m	ns	Trap/move	Wolves always attack in pairs, not in groups
m	h	Do nothing	We should have better dogs for protection
m	s	Do nothing	Wolves are afraid of flashlights
m	ns	Do nothing	We can build better pens; but we can't do anything about attacks during the day
m	ns	Nothing can be done	I can't kill wolves, because there are fines and punishments for that

m	ns	Do nothing	Dogs are good for chasing
m	ns	Do nothing	I want a wire compound
m	ns	Do nothing	The best thing would be better protection
m	ns	x	We don't do anything, because if you let them take one, they won't come back again
m	ns	kill	The best way to kill would be poison. I have never done it though Wolves are preferred to disease. Wolves will only kill a few animals every year, but diseases kill many, even half the herd sometimes
m	ns	Do nothing	I want steel compounds, but they are very expensive
m	ns	Do nothing	I want better guard dogs
m	ns	Do nothing	What is most important is that there should be medicines for diseases
f	h	Nothing can be done	The only thing that we can do is chase wolves away if we see them
f	h	Nothing can be done	It would be nice if wolves could be caught, but they can't be
m	ns	Do nothing	We tell ourselves that if a wolf takes our animals, it is a sacrifice [to nature], so we will have fewer incidents of disease that year

APPENDIX B. Demographics of interviewees (from village data)

Education	**Total**	**Goat herder**	**Resident shepherd**	**Semi nomadic /nomadic shepherd**
None	66	24	14	28
1-4 years	21	10	5	6
5-8 years	20	13	3	4
9-12 years	23	6	5	12
Some college	2	1	1	0
Unknown	11	1	1	9
Total	**143**	**55**	**29**	**59**

Community	**Total**	**Goat herder**	**Resident shepherd**	**Semi nomadic /nomadic shepherd**
Dhangar	34	3	3	28
Dalit	23	16	1	6
Maratha	58	20	20	18
Thakkar	14	8	3	3
Other	14	8	2	4
Total	**143**	**55**	**29**	**59**

Appendix C. Food habits of wolves

Food habits of wolves reported as percent occurrence of prey in scats, or percent of kills. Modified from Jhala 2003. Notes: Prey contributing maximally (in terms of biomass) to diet are in bold. In some cases, two prey species may be in bold, as estimated biomass consumed are very similar for both. Sums of percentages in studies where scats were used may exceed 100, as some scat samples may contain remains of more than one species.

Location	Source	Samples	Livestock				Wild Prey					Source
			Sheep	Goat	Pig	Cattle	Chinkara	Blackbuck	Rodent	Hare	Others	
Protected Areas												
Velavadar NP	scats	601	0.3	5	0	0.3	0	84.4	11.2	5.8	10.1	**Jhala 1993**
Rollapadu	kills	6	33	16	0	0	0	50	0	0	0	**Manakadan and Rahmani, 1997**
Nannaj	kills	175	13.6	43.8	0	0	0	42	0	0	0	**Kumar et al. 1997, 1998**
Non-Protected Areas												
Bihar	scats	130	0	30	43.1	0	0	0	3.1	7.7	16	**Shahi 1982**
Bhal	scats	1245	1	1.1	0	25.7	0	55.5	7.7	7.4	24	**Jethva and Jhala 200**
Ojhar-Nashik	scats	100	6.4	17.3	0	12.1	7	0	18.5	5.2	34	**Jhala, unpubl. data**
Lakhpat-Kutch	scats	104	32.6	9.6	0	0	0	0	14.4	35.5	7.7	**Jethva et al. 1997**
Abdasa-Kutch	scats	550	22	51	0	7.1	6.8	0	3	8.3	1.6	**Jhala 2001**

PIGS, SHEEP AND WOLVES (PAUL SIMON)

Big and fat
Pig′s supposed to look like that
Barnyard thug
Sleeps on straw and calls it a rug
Yeah that's a rug, ok
He's walking down the street
And nobody's gonna argue with him
He's a half-a-ton of pig meat

Up in the hills above the farm
Lives a pack of wolves
Never did no harm
Sleep all day
Hunt till four
Maybe catch a couple of rodents
You know a carnivore

Sheep in the meadow
Nibbling on some clover
One of the sheep just wanders over
Sits by a rock
Separated from the flock
He's just sitting by a rock

Where'd he go? I don't know
Well he was here a minute ago
I don't know
Sheep's dead
Got a gash as big as a wolfs head
Oh god
Big and fat
Pig′s supposed to look like that
Wallowing in lanolin
He's rubbing it into his pigskin
Police are going crazy
Saying′ let's get him
Let's get that wolf
Let's get him
Let's get that wolf
Let's get him
Let's kill him, let's get him
Let's kill him

Court-appointed lawyer wasn't very bright
Maybe he was bright
Maybe he just had a late night
Yeah it was just a late night
And he files some feeble appeal
And the governor says forget it
It's a done deal
Its election, i don't care, election
Let's give that wolf a lethal injection
Let's get him, let's get him,
Let's kill him, let's get him
Let's kill him, let's get him, kill him
Let's get him and kill him

Whew, slow
Here comes the media
With their camera
Asking everybody's opinion

About pigs, sheep and wolves

Big and fat
Pig′s supposed to laugh like that
This is hilarious
What a great time
I'm the pig who committed
The perfect crime

All around the world
France, Scandinavia
There's candle light vigils
Protesting this behaviour
It s animal behaviour
Animal behaviour

Its pigs, sheep and wolves
Pigs, sheep and wolves
Pigs, sheep and wolves
Its animal behaviour
Its pigs, sheep and wolves