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A Review On The Aspects Of Carnivore Conservation Using The Asiatic Lion (Panthera Leo Persica) In GIR As A Representative Species

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Abstract: ***Carnivores occupy the apex position in the food chain and thereby exert a top down control on the ecosystem. This makes the presence of the carnivores vital to the sustenance of the ecosystem. However, due to the growing human population and encroachments on the habitat of these carnivores, their numbers have decreased in the past two centuries. Furthermore, anthropogenic activities such as hunting and wildlife trade have also affected the carnivore populations. Conserving carnivores is a difficult task because of such reasons and due to certain characteristic features of the carnivores themselves. Carnivores are K-selected species and a large area is also required to sustain a viable carnivore population.***

The last free-ranging population of Asiatic lion (Panthera leo persica) in the Gir forests of Gujarat, India typifies all the challenges of carnivore conservation – small founder base, restricted to the single site, occur at higher trophic level, protein diet, large home range sizes and space utilization across human dominated landscapes resulting into human-lion interfaces. All these make the species vulnerable to extinction by stochastic events. Therefore, this paper reviews aspects of carnivore conservation in detail using the Asiatic Lion (Panthera leo persica) as a representative species. The study reveals that deforestation and habitat alterations are serious threats to wildlife. This study reveals that although the population of the carnivores increase through species-centric methods, isolation of populations consequentially lead to inbreeding, increased homozygosity and greater susceptibility to various environmental stresses. Establishing connectivity between the various Protected Areas is imperative as far as the conservation of large carnivores is concerned, landscape planning and management should be advocated.

Keywords: Carnivores, conservation, Asiatic lion, homozygosity, landscape planning.

I. INTRODUCTION

Carnivores comprise of 287 extant species in 123 genera which belong to 16 families (Karanth and Chellam, 2009). Most of these species are threatened by the loss and fragmentation of their habitat, and also by their hunting for food, trophies and curatives (Karanth and Chellam, 2009). An insidious threat to carnivores is the depletion of prey whose immediate effect many not be observed (Karanth and Chellam, 2009). These carnivores are charismatic animals which engage the attention of humans over a multitude of factors (Karanth and Chellam, 2009). Carnivores, across both historical and time scales have been in a state of conflict with humans over food and space (Inskip and Zimmermann, 2008). Furthermore, their cultural perceptions shaped by the fear, admiration and superstition, which poses a threat to their existence (Karanth and Chellam, 2009). However, the existence of carnivores is imperative to the functioning of the ecosystem primarily due their position in the trophic level, their functioning as Umbrella and Keystone species, and due to them being K-selected species. In light of this, the importance of the conservation of the carnivores is assessed.

POSITION IN THE TROPHIC STRUCTURE

Trophic levels refer to the functional classification of organisms according to feeding relationships, which range from first-level autotrophs, through the succeeding levels of herbivores, up to the carnivores (Odum, 1983) which are situated at the apex of the trophic structure. The trophic structure is an organization of a biological community based on the number of feeding levels present (Smith and Smith, 2015). The food web is constituted by the various organisms functioning in different food chains at various trophic levels. The food web has its effects on the ecosystem variability in the form of prey-predator interactions and it's control on the structure of the ecological community (Carpenter and Kitchell, 1987). Variability at the top of the food web cascades down to the organisms present in the lower trophic levels (Carpenter and Kitchell, 1996; Paine, 1980) Carnivores being tertiary consumers occupy the apex position in the food web and variability in their numbers cascade down to the lower levels exhibiting a top down control (Dorresteijn et al.,2014) on the structure of the ecological community. Carnivores, thus, are major controllers of the food chain dynamics. Carnivores keep the prey population in check and consequently control the dynamics of the vegetation communities (Ripple et al., 2014). Carnivores, thus, demand special attention and need to be conserved.

KEYSTONE SPECIES

A keystone is the wedge-shaped stone piece at the apex of a masonry arch. It is the final piece of construction and it locks all the pieces of stone in position. The role that keystone species play is analogous to the role played by the keystone in architecture. Keystone species in a community refers to those species in which has a disproportionately large effect on the environment with respect to their abundance (Paine, 1969) and keystone species has effects on the community structure, prey density and diversity of the community (Noss et al., 1996). As per a predictive study, if Grizzly bears (*Ursus arctos)* are to cover 34% of the State of Idaho in the United States of America, which is 10% or more of their statewide ranges; 71% of the mammalian species, 67% of the birds and 61% of the amphibian species would be conserved (Noss et al., 1996). Wolves (*Canis lupus*) in North America regulate prey populations (Noss et al., 1996). Medium sized predators are kept under a check by coyotes (*Canis latrans*), and it was observed that attack or heavy predation on birds' nests by those medium sized predators in some canyons in Southern California was due to the absence of coyotes or large predators in that region(Noss et al., 1996). Keystone species should also be of special importance to policy makers and environmental managers (Paine, 1995) as like the keystone in architecture, they hold the functioning and stability of the ecosystem in position. Keystone species with their importance in the ecosystem and their popularity make it easier for the policy makers to take decisions pertaining to conservation.

UMBRELLA SPECIES

The Umbrella species is a concept which presents us a notion that the conservation of certain species will consequentially lead to the conservation of many other species. Umbrella species maybe defined as such a species which has large area requirements and therefore with conservation of these species, many other species would be conserved in the process (Ozaki et al.,2006). The concept and the application of the idea of umbrella species is still controversial (Caro, 2003), but cases of such a phenomenon occurring have also been observed. The importance of large carnivores as umbrella species should be stressed upon as their large area requirements help in conserving other species (Caro, 2003). Reserves were designed in East Africa by using the concept of umbrella species (Caro, 2003). By using umbrella species as a tool for the designing of reserves, a large number of unknown and unidentified species which were under threat were discovered (Caro, 2003).

With regard to the aforementioned argument, it is important to assess the ecological attributes of carnivores, the challenges faced in the process of conserving them and the efforts undertaken to conserve them. For this, the Asiatic Lion (*Panthera leo persica*) in Gir, Gujarat, India has been taken as the representative species. The Lion (*Pantheraleo spp*.) is a charismatic carnivore, a key stone species, making it ideal to be a flagship or an umbrella species (Dalerum et al., 2008). The two present extant populations of the Lion are the African Lion (*Panthera leo senegalensis, Panthera leo bleyenberghi, Panthera leo melanochaita, Panthera leo krugeri, Panthera leo roosevelti)* and the Asiatic Lion (*Panthera leo persica)*. The Asiatic lion is listed as Endangered in the Red Data Book of the IUCN (Breitenmoser et al., 2008). This species typifies all the challenges of carnivore conservation – small founder base, restricted to the single site, occur at higher trophic level, protein diet, large home range sizes and space utilization across human dominated landscapes resulting into human-lion interfaces. All these make the species vulnerable to extinction by stochastic events. In light of this, the ecological attributes of the Asiatic lion, the overall challenges to carnivore conservation, and the efforts to conserve are reviewed, and the gaps in the process of conservation are tried to be evaluated.

II. ECOLOGY OF THE ASIATIC LION

HABITAT

To understand the ecological attributes of a particular species, it is important to study, understand and know the habitat preferences of the species, as the habitat is the address of that particular species. As far as Asiatic lions are concerned, lions prefer open forests over dense forests and prefer savanna type ecosystem (Jhala et al., 2009). However, due to extensive conservation efforts, the habitat in Gir has become denser making it slightly unsuitable for the Asiatic Lion (Singh and Kamboj, 1996).

The habitat types in Gir can be classified in the following way:

- ✓ Moist mixed forest: It includes the riverine habitats of Gir. The dominant species are *Tectona grandis* in the Gir west which was replaced by *Anogeissus spp.* and *Acacia spp.* in the Gir east and to a larger extent in Central Gir. The species associated are *Wrightia tinctoria, Syzigium spp., Mitragyna parviflora, Diospyros melanoxylon, Emblica officinalis and Ziziphus spp.* The understory is comprised of *Carissa carandas, Capparis sepiaria, Helicteres isora* etc. This habitat type is the densest and has the highest canopy cover.
- ✓ Mixed forest: The dominant species are *Tectona grandis* in the Gir west which was replaced by *Anogeissus spp.* and *Acacia spp.* in the Gir east and to a larger extent in Central Gir. The associated species are *Diospyros melanoxylon, Gmelina arborea and Mallotus phillipinensis*. The understory is comprised of *Ziziphus spp., Wrightia tinctoria, Grewiati liaefolia, Manilkara hexandra and Capparis sepiaria*. This habitat type is dense with good canopy cover.
- ✓ Teak-*Acacia-Ziziphus-Anogeissus* forest: The dominant species are *Tectona grandis* in the west which was replaced by *Anogeissus spp.* and *Acacia spp.* in the east and to a larger extent in Central Gir. The co-associates are *Ziziphus spp., Acacia spp.,* and *Terminalia spp.* The understory is composed of *Cappparis sepiaria* and *Carissa carandas.* This habitat type is moderately dense with sparse canopy cover.
- ✓ *Acacia-Lannea-Boswellia* forest: This forest type is found in hilly areas of Gir. The association is characterized by *Acacia spp., Boswellia serrata, Lannea coromandelica, Tectona grandis, Terminalia crenulata, Soyamida febrifuga, Wrightia tinctoria* and *Stercule aurens.* This habitat type is moderately open with sparse canopy cover.
- ✓ Thorn and scrubland: This association was characterized by patchy and stunted growth of scrub species like *Acacia catechu, Acacia leucophloea, Ziziphus numularia and Balanites aegyptica*. This habitat type is quite open with sparse to moderate cover.
- ✓ Savanna: It had scattered growth of trees like *Acacia spp., Terminalia crenulata, Tectona grandis, Bauhinia racemosa, Anogeissus spp., Boswellia serrata* and *Balanites aegyptica*. The grasses like *Apluda mutica, Heteropogon contotus, Themeda quadrivalvis* and *Sehima nervosum* formed the ground layer. This habitat type has very poor canopy cover.
- ✓ Agriculture: It includes the open agricultural fields, open grass meadows and wasteland patches in and around Gir National Park (Qureshi and Shah, 2004).

Among these habitats, the habitat preference of Lions in the day is: Moist Mixed forests >Mixed forests>Teak-*Acacia-Ziziphus-Anogeissus* forests>Savanna habitat>*Acacia-Lannea-Boswellia* forests>Thorn and scrub forests>Agriculture areas (Jhala et al., 2009).

The habitat preference of Lions during the night is: Mixed forests >Moist Mixed forests>*Acacia-Lannea-Boswellia*forests>Teak-*Acacia-Ziziphus-Anogeissus forests*>Savanna habitat>Thorn and scrub forests>Agriculture areas (Jhala et al., 2009).

BEHAVIOR

Lions live in groups and this is a trait which developed during the due course of evolution before they left Africa and this is a trait which has been retained by the subsequent populations too (Yamaguchi et al., 2004).

An important attribute of a carnivore is that they are territorial and in case of Asiatic lions, the territory size is dictated by the females (Jhala et al., 2009). The breeding females defend the resource based territories and the males, on the other hand, maximize the coverage of the female groups (Jhala et al., 2009). The mothers in case of the African lions keep their cubs in a creche and form highly stable maternity groups that are effective in defending cubs against infanticide males (Packer et al., 1990). Females live in social units (prides) and forage with the mother of members of their pride. Three types of foraging patterns have been observed, (a) refraining (non-participation of an individual), (b) confronting (active participation of all individuals in the pride and all individuals showing similar behaviour) and (c) pursuing (involves active participation but individual behaviour differs) (Scheel and Packer, 1991). Refraining is observed more for hunts of prey which are comparatively easier to catch (Scheel and Packer, 1991). Refraining is more commonly exhibited by males than females (Scheel and Packer, 1991). A large divisible prey provides food for all members in the group (Scheel and Packer, 1991). Female pride mates have equal access to the food (Packer and Pussey, 1985) as there is no social dominance among females in the same pride (Schaller, 1972).The population density of the lions is determined by the territory size and the group size.

The relative proportions of male coalitions and female prides are very important aspects in determining social structuring and cub survival in lions (Loveridge and Macdonald 2002, Cooper, 1991). Fewer male coalitions in relation to prides result in extensive, unrestrained movement of male lions between prides (Loveridgeand Macdonald, 2002) and also in making the prides to be more vulnerable to infanticide by other males (Cooper, 1991). Almost all lion populations show a slight bias towards females and have an adult population sex ratio of 1:2 (Schaller 1972; Mills et al., 1978; Packer et al.,1988; Stander, 1991; Creel and Creel, 1997). The fitness, reproductive rate and rate of cub survival are dependent on the pride size in lions (Packer et al., 1988). In Gir, females form small associations of 2-3 individuals. However, during mating, the female dissociates from the pride, and then rejoins the pride after the mating with the male is completed (Meena, 2008). Following cub births in Asiatic lions, the younger sub-adult females stay back to protect the cubs against infanticide males while the adult female mother goes on the hunt for prey (Meena, 2008). The population density of the lions is determined by the territory size and the group size. Territory marking is an important feature of a carnivore. The Asiatic lion males generally use roaring, scraping, defecation and spraying as the methods for marking territory (Meena, 2008). Asiatic lions, most commonly use the technique of spraying urine for the marking of their territory (Meena, 2008).

III. CHALLENGES OF CARNIVORE CONSERVATION

K-SELECTED SPECIES

Organisms show two distinct strategies with regard to their growth, the r-strategies and k-strategies (Krebs, 1972). The k-strategists are termed as k-selected species. The concept of r/K selection originated in the late 1960s as a result of extensive research on island biogeography (MacArthur and Wilson, 1967). Large carnivores are k-selected species and are characterized by their property of having more or less stable populations which are adapted to exist at or near the carrying capacity (Smith and Smith, 2014). Carnivores, being k-selected species show better competitive ability in conditions where resources are limited. K-selected species have their numbers around the carrying capacity. Therefore, carnivores have a well defined upper limit to their numbers (Santiapillai and Jayewardane, 2004) in an ecological community showing density dependent growth curve. K-selected species show the following properties in their life history:

Life History Feature	k-selected species
Intrinsic Rate of Increase	Low
Development	Slow
Reproductive Rate	Low
Reproductive Age	Late
Body Size	Large
Length of Life	Long
Competitive Ability	Strong
Survivorship	low mortality of Young(Type I)
Population Size	fairly constant
Dispersal Ability	Poor
Reproductive Strategy	Iteroparity
Habitat type	less disturbed.

(after Stiling, 2012).

Carnivores show k-selected traits such as iteroparity, low rate of increase, protein diet, long ranging. These make them more vulnerable to environmental and stochastic events in comparison to r-selected species. This makes conservation of carnivores considerably difficult.

RANGE, GENETICS AND METAPOPULATION DYNAMICS

Carnivores require a large area at their disposal to survive due to their behaviour. This makes the range that an animal inhabits an important aspect in conservation practices. For example, male lions are known to travel or disperse more than 200km in one or two years in Serengeti (Schaller, 1972).For example, tigers are long ranging animals and recorded data from the semi-arid landscape of western India show that the average distances dispersed by male and female tigers are 124.2 km and 78.4 kms respectively (Singh et al., 2013). However, under present conditions, tigers occupy only 7.1% of their historic range (Wikramanayake et al., 1998) and furthermore, the tigers like many other carnivores under threat have been restricted to isolated patches of Protected Areas(Kenny et al., 2014) surrounded by inhospitable land-use patches making individuals among patches difficult. With individuals being restricted to single sites, chances of inbreeding become higher resulting into a population with low heterozygosity and making them susceptible to diseases (O'Brien, 2003).

Tiger Reserves should ideally be of 800-1000 km^2 in area to support a viable tiger population and currently, the Protected Areas that exist are small to support a demographically viable population (Ranganathan et al., 2008), and hence it is important to ensure that there exists metapopulation dynamics for viability of the population (Hanski, 1994). A study shows that the average distance between two tiger reserves in the North-Western part of the country is 120km and in Central India it is even greater with 200km (Joshi et al., 2014). Maintaining corridor connectivity for such longer distance becomes a challenge with the current pace of linear development and urban sprawl. However, the increase inbreeding rate of carnivores would increase with the establishment of metapopulation dynamics between isolated patches. This gives rise to the necessity of establishing connectivity between Protected Areas (Joshi et al., 2014).

Lack of connectivity also increases the chances of population bottlenecks. A study on East African Cheetahs show polymorphism at 2-4% and an average heterozygosity of 0.0004-0.0014) establishing them as one of the least genetically variable felid (O'Brien et al., 1987). The Cheetahs have shown extreme paucity of genetic variation and monomorphism at MHCs (Major Histocompatibility Complex(a set of cell surface proteins) which are polymorphic in nearly all other mammals and 71% abnormalities in the sperm ejaculated (O'Brien et al., 1987). Such data reveals that cheetahs have decreased heterozygosity, they are inbred and it also shows the population bottleneck that it underwent.

Lions evolved from several Pleistocene refugia in sub-Saharan Africa and entered India almost concomitant with Aryan entry. The species once boasted of a wide distribution in terms of area. They were previously distributed from Syria in the western part of Asia, in Iraq, Iran, Pakistan and India(Jhala et al, 2009; Kinnear, 1920; Mac Donald, 1992), but due to a very low population level of mitochondrial DNA nucleotide diversity, lack of SRY genetic variation across male lions decreased their numbers in the late Pleistocene era (Antunes et al., 2008). In India they had an extensive distribution covering almost all the north Indian states (Singh, 2007). About 2600 years ago, Saurashtra peninsula became isolated from mainland India by Gulf of Cambay due to tidal activities and it got re-united with Indian mainland only in recent times (Driscoll et al., 2002). However, when it became part of mainland India; lion populations from rest of India became almost extinct (Kinnear, 1920 ; Pocock, 1930) due to hunting and habitat destruction (late 1880s). Lions are also long ranging carnivores. The pride lionesses in Serengeti have been known to have home ranges between 20 km^2 to 400 km^2 (Schaller, 1972). The female lions in Gir have been estimated to have a home range size between 72 to 81 km^2 (Joslin, 1973). In recent times, lions have been present only in the Gir National Park in Gujarat. This has not allowed any metapopulation dynamics to function in the present population as metapopulation dynamics involves immigration and emigration of individuals between populations and there would be gene flow between the populations. With only one viable population in an isolated location, the Asiatic lions have

mated among themselves in the region. This has led to the founders of modern day lions to be genetically inbred.

	YEARS			
Area	1974	1995	2010	2015
Core population – Gir forest, including Pania and Babaravidi	180	262	306	315
Satellite-I: Girnar	*	13	23	33
Satellite-II: Mitiyala	*	*	7	8
Satellite-III: Coastal Junagadh	–	10	9	32
Satellite-IV: Coastal Amreli	–	16	12	18
Satellite-V: Amardi–Lilia–Krankach– Savarkundala in Amreli district	–	*	31	80
Satellite-VI: Satrunji–Jesor–Hippavadli, coastal area in Bhavnagar district	–	–	23	37
Total	**180**	**304**	**411**	**523**

(After Singh, 2017)

Table 1: Population trend and lion dispersion

In the Gir landscape, there is presence of metapopulation dynamics at present with the population in the Gir landscape with the lion population in the Gir National Park functioning as the source population. The populations in the agropastoral regions around the Gir National Park are the sink population. In the table above (Table 1), the sink populations are referred to as satellite populations. Table 2 shows the growth of the lion and ungulate populations in the Gir forest landscape over the past four decades.

Year	Total population of lions	Lions in and around the Gir forest	Wild ungulates in the Gir forest	Ungulates per lion in the Gir forest
1974	180	180	9,640	54
1984	239	235	16,910	74
1995	304	265	38,220	146
2005	359	291	51,330	176
2015	523	315	83,150	264

(after Singh, 2017)

Table 2: Decadal growth of lion and wild ungulate population in the Gir forest

PREY DENSITY

For evaluating the role of carnivores in an ecosystem, the prey consumption mechanisms and the constraints of predation must be clearly understood (Chakrabarti et al., 2016). The phenomenon of predation is vital as it links all the trophic levels and is also responsible for important ecological and evolutionary processes (Fryxell et al., 2007). Predator densities are estimated or determined by the available prey biomass (Carbone and Gittleman, 2002). Therefore, understanding of predator consumption patterns is necessary for the estimation of their carrying capacities. Estimation of their carrying capacities would aid in the management efforts (Hayward et al., 2007) Tiger populations, for example, are dictated by the prey densities (Chapron et al., 2008). A model linking prey depletion and population persistence in tigers shows that when the prey density is low, the cub survival rate is low and it remains at the lower level as long as the prey density levels are low (Karanth and Stith, 1999). A carnivore's food habits are one of the major determining factors of the life history strategy adopted by the species (Krebs, 1978) and hence, clear understanding of the phenomenon is imperative.

In Asiatic lions, selective feeding is noted. Biomass model formed through the usage of the principles of allometry, has shown that for large carcasses, the species selectively feed on the highly digestible flesh and leave the bones untouched but for small carcasses, the entire carcass is consumed except a few bones and feathers (Chakrabarti et al., 2016). From studies conducted, lions showed varied preferences for different prey at different livestock biomass levels.

Human-Wildlife conflict also increases due to depletion in prey density as carnivores are forced to feed on livestock. It has been seen that a large percentage of the assessed scats of large felids show the presence of livestock at around 10-12% (Sunquist and Sunquist, 1989).

HUMAN-WILDLIFE CONFLICT

Human-Wildlife conflict can be defined as "any interaction between humans and wildlife that results in negative impacts on human social, economic or cultural life, on the conservation of wildlife populations, or on the environment"-World Wildlife Fund.

Carnivores compete and conflict on an intense level with humans over food and space (Karanth and Chellam, 2009). As a result of the growing human population, the number of carnivores in the world have decreased as they have now come in to close proximity with anthropogenic activities (Cardillo et al., 2004).In the Pine Ridge Forest Reserve, humans exist along with the endangered Puma (*Puma concolor*) and Jaguar(*Panthera onca*) and it has been observed that the animals are sensitive to humans and the disturbance caused by humans in around the forest(Davis et al., 2010). It can also be understood from the carnivores' choice of habitat as they prefer areas with lesser human interference (Davis et al., 2010).

Presently, it can be said that carnivore conservation is at the crossroads and at the helm of this creation of crossroad, lies human-wildlife conflict. With rapid habitat fragmentation taking place, conflict is inevitable, with many species being extirpated locally due to conflict (Dorresteijn et al, 2014). Major landscape management is the call of the hour with Asiatic Black Bear and Human interactions leading to attacks on humans, livestock depredation (7%), crop depredation (85%) (Charoo et al., 2011). Intensity of such attacks has increased in the recent years.

A large number of conflicts occur due to poor understanding of the social underpinnings of the Human-Wildlife conflict (Bagchi and Mishra, 2005). Human-Wildlife conflicts often manifests in the form of livestock depredation. For proper management of conflict, the understanding of the importance of livestock in carnivore diets is important (Bagchi and Mishra, 2005). It has been observed that conflict issues are more in those areas of South and Central Asia which have a higher livestock percentage. In areas with higher livestock(29.7/ $km^{2)}$ the incidence of human wildlife conflict is greater at 58% (Bagchi and Mishra, 2005).

Carnivores living in human dominated landscapes or in landscapes adjoining human inhabitation inevitably lead to interactions between two species which at times affect the

involved species leading to Human-Wildlife conflict in the region. The Gir National Park has regions of human inhabitation around its borders and this has in the past led to conflicts and repercussions from the side of the humans.

The conflicts have been affected by a large number of factors including the dissatisfaction of the affected people with the Government compensation, increase in the human population and thus their expansion of area, and the fact that the Asiatic Lions feed on livestock, thereby causing livestock damage (Sabrewal et al., 1994).

Even with the conflicts at play, Asiatic lions coexist with the Maldhari communities in the Gir forests suggesting that the coexistence is beneficial for the tribal community and the lions (Banerjee et al., 2013). Lion densities were actually found out to be higher in the areas where there were Maldhari livestock were present in comparison to areas where there weren't (Banerjee et al., 2013). The Maldharis incur a huge capital loss due to livestock depredation but 64% of this loss is compensated by the government. Furthermore, the Maldharis enjoy the advantage of using and exploiting the forest resources for free which is something the non-forest dwelling pastoralists cannot. These factors coupled with the general tolerance of Maldharis towards the lion have ensured proper conservation of Asiatic lions in the Gir National Park (Banerjee et al., 2013).

HUNTING AND POACHING

Hunting and poaching have a far reaching effect on wildlife, food webs and ecosystems. It is difficult to mitigate the impacts of hunting as associated with it are generally a variety of socioeconomic and cultural challenges. Six of the nine large mammals Tiger (*Panthera tigris tigris*), Lion (*Panthera leo persica*), Leopard (*Panthera pardus*), Elephant (*Elephas maximus*), One-horned Rhino (*Rhinoceros unicornis*) and Sloth bear (*Melorsus ursinus*) in India have faced tremendous decline due to hunting (Velho et al., 2012).

Asiatic lions have been slaughtered by both Indian and European game hunters in the past. Hunting was the reason behind the species almost being extinct at the beginning of the 20th century (Hazarika, 1994). The region where they existed was declared to be game reserve before India's independence in 1947 and at that time, permits for hunting were issued by the local administration (Hazarika, 1994). It is only after Gir was declared to be a National Park in 1970 that incidents of hunting decreased as anyone caught hunting the animal was prosecuted (Hazarika, 1994). The Wildlife Protection Act of India, 1972 prohibits hunting, but hunting activities still occur in India (Velho et al., 2012). Poachers killed eight lions in the Babaria range of Gir West Division in March, 2007 (Singh, 2007). Although, not poaching, but lions have been poisoned by villagers in retaliation to the livestock hunt by lions (Singh, 2007).

IV. CONSERVATION EFFORTS

GIR LION PROJECT

The Gir Lion Project was started by the Government of Gujarat for the conservation of Asiatic Lions when the species came closest to extinction with less than 50 lions being present within the boundary of the Gir National Park.

The implementation of the schemes began in the year 1972. The erstwhile Gir Sanctuary, the sole area left with lions was extended in 1974 and was upgraded to a National Park in 1975. In 1978, an additional area of 118.3 sq.km was declared as National Park, thereby increasing the total area under the National Park to 258.71 sq.km.

Human disturbances were decreased by the relocation of the families of resident grazers outside the sanctuary which minimized the human disturbances and helped the wildlife immensely (Khan, 1993).

The number of lions have increased to 523 at present which a large number of them migrating outside the borders of the National Park to neighbouring agropastoral regions (Banerjee et al., 2009).

REINTRODUCTION OF ASIATIC LION

Asiatic lion (*Panthera leo persica*) has only one extant population in the Gir National Park in the western state of Gujarat in India. The existence of one isolated population increases the chances of inbreeding in the population and increases the individuals' susceptibility to diseases. Such a case occurred in the lions in Serengeti in 1994 when about 1000 individuals died due to an outbreak of the Canine Distemper Virus (Roelke-Parker et al., 1996). To prevent such incidences from occurring, a plan to reintroduce lions in a region they formerly occupied in the Kuno Wildlife Sanctuary in the Indian state of Madhya Pradesh was chalked out.

"Reintroduction is the intentional movement and release of an organism inside its indigenous range from which it has disappeared."-IUCN.

Re-introduction has proved to be a valuable tool for the recovery of the species that have become either globally or locally extinct in the wild (Woodroffe, 1999). Reintroductions can also give us an insight into the reasons of disappearance of a species from the areas where they formerly occurred, but it requires that it is genuinely experimental and properly monitored (Sutherland, 2004). Reintroduction is one such promising tool which has an important role to play in the current carnivore restoration efforts. But reintroduction programmes are expensive and time consuming affair and corresponding success rates are low which makes it difficult to justify spending precious conservation money in favour of reintroductions as against other in situ conservation measures (Pullin, 2002). Therefore it becomes highly imperative that reintroductions are based on sound scientific principles and methodology so that the success rates are high and the efforts are fruitful enough. The reintroduction and recovery of the Florida Panther (*Puma concolor*) in Florida, USA during early 1980's (Shekhawat, 2012), reintroduction of African wild dog (*Lycaon pictus*) in Africa in 1990's (Shekhawat, 2012) are two such instances on large carnivores that enriched our

knowledge about the science and management of carnivore reintroductions. A reintroduction plan was formulated by the Wildlife Institute of India, Dehradun in 1995. The reintroduction plan was to reintroduce lions to Kuno Wildlife Sanctuary in Madhya Pradesh (Kabra, 2006)

KUNO WILDLIFE SANCTUARY: Kuno Wildlife Sanctuary (WLS) is spread over an area of 344.68 km2 and is situated in Sheopur district of Madhya Pradesh. The Sanctuary is part of the Kuno wildlife division which covers an area of 1235.39 km^2.

To assess whether the Sanctuary had sufficient wild ungulates to support a population of lions, 17 transects totaling 461 km were surveyed over an area of 280 km^2 in early 2005 (Johnsingh et al., 2007). The density of potential ungulate prey was found to be 13 animals/km^2 (Johnsingh et al., 2007). There were also present 2500 feral cattle, which were left behind by the translocated villagers. The cattle were also taken in to consideration as they would serve as buffer prey if droughts adversely affected the populations of wild ungulates (Johnsingh et al., 2007).

For the analysis of the conditions at Kuno Wildlife Sanctuary, a prey assessment of the region was done, and a plan to relocate the villages in the Sanctuary premises outside the sanctuary was also formulated. The prey assessment done in 2013 yielded the following results:

Species	3/4th of Female Body Weight(kg)	Population Density/km2 ± Standard error	Biomass(kg/km2)
Chital	30	69.36 +- 10.51	2080.8 +-315.3
Sambar	120	4.85 +- 1.19	582.0 +- 142.8
Nilgai	120	3.92 +- 0.97	470.4 +- 116.4
Wild Pig	27	3.05 +- 0.78	82.35 +- 21.06
Chinkara	12	0.86 +- 0.28	10.32 +- 3.36
Four-horned antelope	15	1.00 +- 0.44	15.0 +- 0.66
Gray Langur	7	40.14 +- 10.27	280.98 +- 71.89
Peafowl	3	13.84 +- 2.83	41.52 +- 8.46
Feral cattle	40	2.34 +- 1.2	93.6 +- 48
			Total= 3656.97 +- 733.7.

(after Sharma et al., 2013)

The demand for relocation of lions had been doing the rounds since the 1990s when the Wildlife Institute of India carried out a detailed study in the Kuno Wildlife Sanctuary in Madhya Pradesh to assess the suitability of the site for the proposed relocation of lions (Chellam et al., 1995).

On April 15, 2013, the Honorable Supreme Court of India directed the Ministry of Environment, Forest and Climate Change to "take urgent steps for the reintroduction of the Asiatic lion from Gir forests to Kuno" Wildlife Sanctuary in Madhya Pradesh, neighbouring the state of Gujarat. It had asked the authorities to carry out the order in its "letter and spirit" within six months. However, five years hence, the process has still not been initiated. The Asiatic lion is now strangled in the Gir National Park by a political deadlock with the Government of Gujarat opposing the order of the Honorable Supreme Court of India. Thus, the future of the species remains uncertain and the plan to reintroduce them has not yet been implemented.

V. CONCLUSION

Carnivores have been threatened by human activities such as game hunting and poaching for a long time now. Conservation efforts in the recent past have bettered the conditions but other important biological and socioeconomic factors need to be explored.

For the past thirty years or so, many countries have taken up legislations to protect their pristine wildlife and over the year, much light has been thrown on the contribution of the carnivores in the ecosystem and how their absence from the ecosystem will affect the dynamics of the ecosystem as predation links the trophic levels and is responsible for many ecological and evolutionary phenomena (Chakrabarti et al., 2016, Fryxell et al., 2007).

With the age of urbanization, and an ever growing human population, the human-wildlife interface has increased and thus the challenge of keeping the population of the large carnivores to socially acceptable and ecologically limits has increased manifolds (Mech, 1996). Habitat alteration, deforestation are serious threats to the wildlife.

Therefore, as this literature review reveals, detailed scientific study about the habitat and ecology of carnivores coupled with the active participation of the government and the public is required.

Extensive conservation efforts have yielded great results. However, there are gaps in those efforts which need to be filled in the coming days. This literature review reveals the problem of species-centric conservation which aims at conserving a single species in the wild in its pristine habitat only on the Protected Areas. Conserving in the Protected Areas does increase the number of individuals of the species, but lack of connectivity between the Protected Areas lead to isolation of the populations. Isolation of populations consequentially leads to inbreeding, increased homozygosity and greater susceptibility to various environmental stresses. Establishing connectivity between the various Protected Areas is imperative as far as the conservation of large carnivores is concerned (Miller and Hobbs, 2002).

Landscape level planning and conserving the landscape should also be advocated along with the promotion of the ecosystem services provided by the landscapes within the public so that conservation can be done at a greater level.

REFERENCES

[1] Antunes, A., Troyer, J.L., Roelke, M.E., Pecon-Slattery, J., Packer, C., Winterbach, C., Winterbach, H., Hemson, G., Frank, L., Stander, P., & Siefert, L. (2008). The evolutionary dynamics of the lion Panthera leo revealed by host and viral population genomics. PLoS Genetics, 4(11), e1000251.

[2] Bagchi, S & Mishra, C. (2006). Living with large carnivores: predation on livestock by the Snow Leopard (Uncia uncia). Journal of Zoology, 268, 217-224.
[3] Banerjee, K., Jhala, Y. V., Chauhan, K. S., & Dave, C. V. (2013). Living with lions: the economics of coexistence in the Gir forests, India. PLoS One, 8(1), e49457.
[4] Banerjee, K., Jhala, Y.V., & Pathak, B. (2009). Demographic structure and abundance of Asiatic lions Panthera leo persica in Girnar Wildlife Sanctuary, Gujarat, India. Oryx, 44(2), 1-4.
[5] Breitenmoser, U., Mallon, D.P., Ahmad Khan, J. & Driscoll, C. (2008). Panthera leo ssp. persica. The IUCN Red List of Threatened Species 2008, e.T15952A5327221.
[6] Carbone, C., & Gittleman, J. L. (2002). A common rule for the scaling of carnivore density. Science, 295(5563), 2273-2276.
[7] Cardillo, M., Purvis, A., Sechrest, W., Gittleman, J., Bielby, J., & Mace,G.M. (2004). Human Population Density and Extinction Risk in the World's Carnivores. PLOS Biology, 2(7), 909-914.
[8] Caro, T.M. (2003). Umbrella species: critique and lessons from East Africa. Animal Conservation, 6, 171-181.
[9] Carpenter, S. R., & Kitchell, J. F. (1996). The trophic cascade in lakes. Cambridge University Press.
[10] Carpenter, S.R., & Kitchell, J.F. (1987). The temporal scale of variance in limnetic primary production. The American Naturalist, 129(3), 417-433.
[11] Chakrabarti, S., Jhala, Y. V., Dutta, S., Qureshi, Q., Kadivar, R. F., & Rana, V. J. (2016). Adding constraints to predation through allometric relation of scats to consumption. Journal of Animal Ecology, 85(3), 660-670.
[12] Chapron, G., Miquelle, D. G., Lambert, A., Goodrich, J. M., Legendre, S., & Clobert, J. (2008). The impact on tigers of poaching versus prey depletion. Journal of Applied Ecology, 45(6), 1667-1674.
[13] Charoo, S.A., Sharma, L.K., & Sathyakumar,S. (2011). Asiatic black bear-human interactions around Dachigam National Park, Kashmir, India. Ursus, 22(2), 106-113.
[14] Chellam, R., Joshua, J., Williams, C. A., & Johnsingh, A. J. T. (1995). Survey of potential sites for reintroduction of Asiatic Lions. Unpublished Report, Wildlife Institute of India, Dehra Dun, India.
[15] Cooper, S.M. (1991). Optimal hunting group size: the need for lions to defend their kills against loss to spotted hyaenas. Afr. J. Ecol, 29, 130 -136.
[16] Creel, S., & Creel, N.M. (1997). Lion density and population structure in the Selous Game Reserve: evaluation of hunting quotas and offtake. Afr. J. Ecol, 35, 83–93.
[17] Dalerum, F., Somers, M.J., Kunkel, K.E., & Cameron, E.Z. (2008). The Potential for large carnivores to act as biodiversity surrogates in southern Africa. Biodiversity Conservation, 17, 2939–2949.
[18] Davis, M.L., Kelly. M., & Stauffer. D.F. (2010). Carnivore co-existence and habitat use in the Mountain Pine Ridge Forest Reserve, Belize. Animal Conservation, 1–10.
[19] Dorresteijn, I., Hanspach, J.,Kecskes, J., Latkova, H., Mezey, Z., Sugar, S., Wehrden, H.v., & Fischer, J. (2014). Human-carnivore coexistence in a traditional rural landscape. Landscape ecology, 29(7), 1145-1155.
[20] Driscoll, C. A., Menotti-Raymond, M., Nelson, G., Goldstein, D., & O'Brien, S. J. (2002). Genomic microsatellites as evolutionary chronometers: a test in wild cats. Genome research, 12(3), 414-423.
[21] Fryxell, J.M., Mosser, A., Sinclair, A.R., & Packer, C. (2007) Group formation stabilizes predator–prey dynamics. Nature, 449, 1041–1043
[22] Fuller,T.K. (1989). Population dynamics of wolves in north-central Minnesota. Wildlife monographs 105, The Wildlife Society, Bethesda, 7.
[23] Gotelli,N.J. (2001). A Primer of Ecology,3, 81-98.
[24] Hanski, I. (1994). Patch occupancy dynamics in fragmented landscapes. Trends in Ecology and Evolution, 9(4), 131-135.
[25] Hayward, M.W., O'Brien, J., & Kerley, G.I. (2007). Carrying capacity of large African predators: predictions and tests. Biological Conservation, (139), 219–229.
[26] Hazarika, S. (1994). Asiatic Lions Thrive in India Park. The New York Times.
[27] Inskip, C., & Zimmermann, A. (2008). Human-felid conflict: a review of patterns and priorities worldwide. Oryx, 43, 18–34.
[28] Jhala, Y.V., Mukherjee, S., Shah, N., Chauhan, K.S., Dave,C.V., Meena,V. & Banerjee, K. (2009). Home range and habitat preference of female lions (Panthera leo persica) in Gir forests, India. Biodiversity Conservation, 18, 3383-3394.
[29] Johnsingh, A. J. T., Goyal, S. P., & Qureshi, Q. (2007). Preparations for the reintroduction of Asiatic lion Panthera leo persica into Kuno Wildlife Sanctuary, Madhya Pradesh, India. Oryx, 41(1), 93-96.
[30] Joshi, A., Vaidyanathan, S., Mondol, S., Edgaonkar, A., & Ramakrishnan, U. (2013). Connectivity of Tiger (Panthera tigris) Populations in the Human-Influenced Forest Mosaic of Central India. PLoS ONE 8(11), e77980.
[31] Joslin, P. (1973). The Asiatic Lion; a study of ecology and behaviour. Phd Thesis. University of Edinburgh, Edinburgh, UK, 249.
[32] Kabra, A. (2006). Wildlife protection: Reintroduction and relocation. Economic and Political Weekly, 1309-1311.
[33] Karanth, K. U., & Stith, M.B. (1999). Prey depletion as a critical determinant of tiger population viability. Riding the Tiger: Tiger conservation in human dominated landscapes. Cambridge University Press, 383.
[34] Karanth, K.U., & Chellam, R. (2009). Carnivore conservation at the crossroads. Oryx, 43(2), 1-2.
[35] Kellert, S.R., Black, M, Rush, C.R., & Bath, A.J. (1996). Human culture and large carnivore conservation in North America. Conservation Biology, 10, 977–990.
[36] Kenney J., Allendorf, F.W., McDougal, C., & Smith, J.L.D. (2014). How much gene flow is needed to avoid inbreeding depression in wild tiger populations? Proceedings of the Royal Society B, 81, 1-5.
[37] Khan, J. A. (1993). Ungulate-habitat relationships in Gir forest ecosystem and its management implications (Doctoral dissertation, Aligarh Muslim University).

[38] Kinnear, N.B. (1920). The past and the present distribution of the lion in south eastern Asia. Journal of Bombay Natural History Society,27, 33–39.
[39] Krebs, C.J. (1972). ECOLOGY: The experimental analysis of distribution and abundance.
[40] Krebs, C. J. (1978). A review of the Chitty hypothesis of population regulation. Canadian journal of zoology, 56(12), 2463-2480.
[41] Loveridge, A.J. & Macdonald, D.W. Impact of trophy hunting, Hwange, Zimbabwe In: Loveridge, A.J., Lynam, A. and Macdonald, D.W. (2002). Lion Conservation Research Workshop 2: Modelling Conflict. Oxford: WildCRU and Darwin Initiative.
[42] Macdonald, D. (1992). The velvet claw: a natural history of the carnivores. BBC Books, London.
[43] Mech, L.D. (1996). A new era for carnivore conservation. Wildlife Society Bulletin, 24, 397–401.Meena, V.2008. Reproductive strategy and behaviour of male Asiatic lions. PhD dissertation, Forest Research Institute, Dehra Dun.
[44] Miller, J. R., & Hobbs, R. J. (2002). Conservation where people live and work. Conservation biology, 16(2), 330-337.
[45] Mills, M.G.L., Wolf, P., Le Riche, E.A.N., & Meyer, I.J. (1978). Some population characteristics of the lion Panthera leo in Kalahari Gemsbok National Park. Koedoe, 21, 163–171.
[46] Noss, R.F., Quigley, H.B., Hornocker, M.G., Merrill, T., & Paquet, P.C. (1996). Conservation Biology and Carnivore Conservation in the Rocky Mountains. Conservation Biology, 10(4), 949-963.
[47] O'Brien, S.J., Wildt, D.E., Bush, M., Caro, T.M., FitzGibbon, C., Aggundey, I., & Leakey, R.E. (1987). East African Cheetahs: Evidence for Two Population Bottlenecks? Proceedings of the National Academy of Sciences of the United States of America, 84(2), 508-511.
[48] O'Brien, S. J. (2003). Tears of the cheetah: and other tales from the genetic frontier. Macmillan.
[49] Odden, M., Wegge, P., & Fredriksen, T. (2010). Do tigers replace leopards ? If so, why ? The Ecological Society of Japan, 25, 875-881.
[50] Ozaki, K., Isono, M., Kawahara, T., Iida, S., Kudo, T., & Fukuyama, K. (2006). A mechanistic approach to evaluation of umbrella species as conservation surrogates. Conservation Biology, 20(5), 1507-1515.
[51] Packer, C., & Pusey, A. E. (1984). Infanticide in carnivores. Infanticide: comparative and evolutionary perspectives, 31–42.
[52] Packer, C. (1986). The ecology of sociality in felids. Ecological aspects of social evolution birds and mammals, 429–451.
[53] Packer, C., Herbst, L. Pusey, A.E., Bygott, J.D., Hanby, J.P., Cairns, S.J., & Borgerhoff-Mulder. (1988). Reproductive success of lions. In: Reproductive success. Ed. Clutton-Brock, T.H.. Univ.Chicago Press, Chicago, 363-383.
[54] Packer, C., Scheel, D., & Pusey, A. E. (1990). Why lions form groups: food is not enough. The American Naturalist, 136(1), 1-19.
[55] Paine, R. T. (1969). A Note on Trophic Complexity and Community Stability. The American Naturalist, 103 (929), 91–93.
[56] Paine,R.T. (1980). Food webs: linkage, interaction strength and community infrastructure. Journal of animal ecology,49(3), 667-685
[57] Paine, R. T. (1995). A Conversation on Refining the Concept of Keystone Species. Conservation Biology, 9(4), 962–964.
[58] Pullin A.S. (2002). Protecting Species through ex-situ conservation and reintroduction. Conservation Biology. Cambridge University Press, 345 pp.
[59] Qureshi, Q., & Shah, N. (2004). Vegetation and habitat monitoring. Jhala,Y.V. (ed) Monitoring of Gir. A technical report submitted to the Gujarat forest department under GEF-India ecodevelopment program. Wildlife Institute of India, Dehra Dun, 8–14.
[60] Ranganathan, J., Chan, K. M., Karanth, K. U., & Smith, J. L. D. (2008). Where can tigers persist in the future? A landscape-scale, density-based population model for the Indian subcontinent. Biological Conservation, 141(1), 67-77.
[61] Ripple, W.J., Estes, J.A., Beschta, R.L., Wilmers, C.C., Ritchie, E.G., Hebblewhite, M., Berger, J., Elmhagen, B., Letnic, M., Nelson, M.P., & Schmitz, O.J. (2014). Status and ecological effects of the world's largest carnivores. Science, 343(6167), 1241484.
[62] Roelke-Parker, M., Munson, Linda., Packer, C., Kock, R., Cleaveland, S., Carpenter, M.J., O'Brien, S., Pospischil, A., Hofmann-Lehmann, R., Lutz, H., Mwamengele, G.N., Mgasa, M., Machange, G.A., Summers, B.J.G., & Appel, M. (1996). A canine distemper virus epidemic in Serengeti lions (Panthera leo). Nature, 379, 441-445.
[63] Saberwal, V.K.,Gibbs, J.P., Chellam, R., & Johnsingh, A.J.T. (1994). Lion-Human Conflict in the Gir Forest, India. Conservation Biology, 8(2), 501-507.
[64] Santiapillai, C., & Jayewardene, R. (2004). Conservation of the leopard and other carnivores in Sri Lanka. Current Science, 86(8), 1023-1024.
[65] Schaller, G. B. (1972). The Serengeti lion. Chicago: University of Chicago Press.
[66] Scheel, D., & Packer, C. (1991). Group hunting behaviour of lions: A search for cooperation. Animal Behaviour, 41(4), 697-709.
[67] Sharma, S.V., Mishra, K.R., Jhala, Y., Chottekamada,B., Ghose, D., & Bhattacharjee, S. (2013). Status of prey in Kuno Wildlife Sanctuary, Madhya Pradesh. 10.13140/RG.2.1.1036.2005.
[68] Shekhawat, R. S. (2012). Reintroduction of Tigers in India: A case study from the Sariska Tiger Reserve.
[69] Singh, H.S. (2007). The Gir lion Panthera leo persica-A natural history, conservation status and future prospect.
[70] Singh, R., Qureshi, Q., Sankar, K., Krausman, P. R., & Goyal, S. P. (2013). Use of camera traps to determine dispersal of tigers in semi-arid landscape, western India. Journal of arid environments, 98, 105-108.
[71] Singh, H.S. (2007). The Gir Lion Panthera leo persica—a natural history, conservation status and future prospect. Pugmark Qumulus Consortium, Ahmedabad, 320

[72] Singh, H.S. (2017). Dispersion of the Asiatic lion Panthera leo persica and its survival in human-dominated landscape outside the Gir forest, Gujarat, India. Current Science, 112(5), 933-940.
[73] Singh, H.S., & Kamboj, D.R. (1996). Biodiversity conservation plan for Gir (a management plan for Gir sanctuary and national park), vol I. Forest Department, Gujarat, 242.
[74] Smith, T.M., & Smith, R.L. (2015). Elements of Ecology, 8, 365.
[75] Stander, P.E. (1991). Foraging Dynamics of lions in a semi-arid environment. Can. J. Zool, 70, 8 – 21.
[76] Stiling, P. (2012). Ecology: Global Insights and Investigation, 206.
[77] Sunquist, M.E., & Sunquist, F.C. 1989. Ecological constraints by predation on large felids. Carnivore Behavior, Ecology and Evolution: 283-301
[78] Sutherland, W.J. (2004). The Conservation Handbook: Research Management and Policy. Blackwell Science Limited.
[79] Wikramanayake, E.D., Dinerstein,E., Robinson, E.D., Karanth,U., Rabinowitz,A., Olson,D., Mathew, T., Hedao,P., Conner,M., Hemley, G., & Bolze, D. (1998). An Ecology-Based Method for Defining Priorities for Large Mammal Conservation: The Tiger as Case Study. Consevation Biology,12 (4), 865-878.
[80] Wikramanayake,E., Dinerstein,E., Seidensticker,J., Lumpkin,S., Pandav,B., Shrestha,M., Mishra,H., Ballou,J., Johnsingh, A.J.T., Chestin,I., Sunarto,S., Thinley,P., Thapa, K., Jiang,G., Elagupillay,S., Kafley,H., Pradhan,N.M.B., Jigme,K., Teak,S., Cutter,P., Aziz,M.A., & Than,U. 2011. A landscape-based conservation strategy to double the wild tiger population. Conservation Letters,00, 1-9.
[81] Wikramanayake,E.D., McKnight,M., Dinerstein,E., Joshi,A., Gurung,B. & Smith,D. (2004). Designing a Conservation Landscape for Tigers in Human-Dominated Environments. Conservation Biology,18(3), 839-844.
[82] Woodroffe, R., & Ginsberg, J.R. (1999). Conserving the African wild dog Lycaon pictus I. Diagnosing and treating causes of decline. Oryx, 33(2),132-42.
[83] Yamaguchi, N., Cooper,A., Werdelin, L., & Macdonald,D.W. (2004). Evolution of the mane and group-living in the lion (Panthera leo): a review. Journal of the Zoological Society of London, 263, 329–342.