

Conservation of India's endangered mega animals: Tiger and lion

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In the first half of the century, lion and in particular tiger have been decimated by the British and the Indian royalty for purposes of sport. At present tiger is being killed on account of the sale of its bones and other parts to meet the unprecedented demand for traditional Chinese medicine. Even so, India has the largest number of tigers in the world. It also harbours the only living population of the Asian lion existing in the world today. Both these charismatic animals are interwoven with India's history, culture, religion and philosophy and are no doubt endangered but as yet have not entered in an extinction vortex. These animals can be saved provided, however, we adopt a conservation strategy based on genetic-evolutionary principles.

In the wildlife parlance, India is a unique country because it hosts five mega wild animals (lion, tiger, rhinoceros, elephant and leopard). All these are endangered to varying degree on account of habitat loss due to increasing deforestation, agriculturalization and urbanization, and poaching of these animals for pecuniary interests. This has happened even when compassion for all life is instinctively ingrained in the psyche of the average Indian from her/his childhood. Indian civilization being very old, has indeed a long history of conservation ethic starting from the vedic period. Furthermore, most of the Hindu gods and goddesses are linked with one or the other plant and/or animal. Tiger is the mode of transport of *Shiv Durga*, while lion is that of *Vishnu Durga*¹. Such associations were a subtle, but an effective way, of giving sanctity to at least some of the prominent species of wildlife (plants and animals) and thereby help to conserve the same effortlessly.

The recent analytical study made by Dinerstein *et al.*² has revealed that the largest number (16) of tiger conservation units with highest (11) and second highest (5) rating is in India. This country not only tops in the number of tiger habitats but also in variability of the habitats ranging from alluvial grasslands and subtropical moist deciduous to subtropical and temperate upland forests, tropical dry forests, tropical moist deciduous forests, tropical moist evergreen forests, and last, but not the least, mangroves. Such variation in tiger habitats exists in no other country. Furthermore, India being a predominantly vegetarian country, medicaments based on tiger bones and parts including soups of tiger genitalia are items that have been unknown in this country. In addition, the laws are sufficiently strict.

Both tiger and lion are high-profile charismatic species which though endangered, are not yet nearing extinction. These can be saved for posterity following a science-based conservation strategy.

Wildlife has remained largely out of the scientific and technological mainstream not only in India but also in many parts of the world. The wildlifers are indeed very dedicated people but rather possessive of their subject. There is a considerable amount of very interesting data available with Zoo Authority of India, Wildlife Wing of the Ministry of Environment and Forests and the World Wide Fund for Nature-India. Such data are not available ordinarily to scientists and technologists. Conversely, evolutionary implications of the newer approaches to the study of genetic variability have remained largely out of reach of wildlifers. In fact some wildlifers both in India and abroad refuse to recognize the importance of such genetic-evolutionary aspects of conservation.

With this in mind, it was in 1982 that I had, for the first time, invited the late John Barnabas (a biochemist) to take up a study on genetic variability in tiger and lion using isozyme analysis. The idea was to have some estimation about the extent and nature of genetic variability in the populations of these animals and then bring in genetic-evolutionary approaches in the conservation of these species. He could not take up the work even though he was convinced about the utility of such a study. However, in the intervening years in USA, wildlife attracted molecular geneticists and some very interesting work was done beginning with cheetah. An analysis of 55 South African cheetahs from geographically-isolated populations revealed this species to be monomorphic at each of the 47 allozyme loci. This was a significant finding³.

The purpose of the present paper is to stress the need to collate traditional conservation knowledge with the

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genetic-evolutionary approaches so that these charismatic species are saved in time and space. This would be possible only if more and more scientists and technologists work out the extent and nature of genetic variability existing in these animals using newer approaches. It is indeed heartening to note that at the request of the Zoo Authority of India, Lalji Singh (CCMB) has taken the lead.

The tiger crises

In the past, destruction of India's wildlife has not been done by common people but by the royalty (Mughal, British and Indian). Abundant historical records exist which show that a royal or any aristocratic home in Britain and India, during colonial rule, was incomplete without stuffed felines, large ornamental birds and such other trophies. Indeed these became status symbols. All this happened in the name of 'sport' in the pre-independence era (before 1947). Furthermore, a trip to India by any British royal family member and other dignitaries was incomplete without *shikar* of tiger. It is recorded that 39 tigers were shot in 11 days in 1911 when King George the V visited Nepal. Furthermore, the Maharaja of Surguja claimed the record-shoot of only 1150 tigers in his life time⁴. Actually these killings fed the ego and vanity of the then aristocracy. This also happened in Russia. After the construction of eastern rail road in the late 19th century, the Russians were encouraged to shoot tigers as a part of military training and for boosting morale of soldiers and settlers moving East. Thus in the 1930s, the population of the Siberian tiger was reduced to a mere 30 animals which has now risen to 150–200. In China and Russia, the tiger was regarded as a menace and wanton killings took place⁴. Furthermore, official records also indicate that 480 tigers were shot as sport in India during 1966–69 by European and American tourists. It is not unexpected that many more may have been shot and/or poisoned and their skins exported. No doubt there was large scale and wanton shooting of tigers throughout its range.

Along with tigers, countless leopards, bears, rhinoceros, wild boars and crocodiles were also shot during *shikar* during the British Raj. This resulted in a serious demographic decline in the mega wildlife of India. For instance, about 500 years ago, Babur used to go for *shikar* of rhino near Peshawar⁵ (now in Pakistan). Then its range was from Western to Eastern India. But today rhino is found only in eastern parts of Nepal and India. The maximum concentration of rhino is in two small localities like Chitwan (Nepal) and Kaziranga (Eastern India). It is only when the population of tigers and other mega wild animals like rhino and lion became subcritical, that the royalty became conservators. But, in the meantime, incalculable damage was done to several

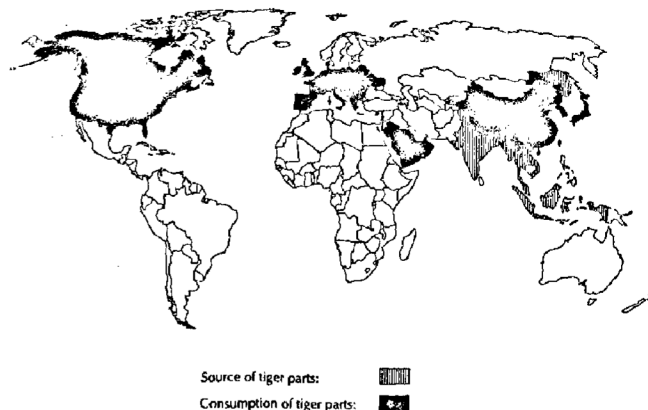


Figure 1. Trade in tiger hides, bones and parts, and tiger-based medicines¹¹.

species especially cheetah, tiger, rhinoceros and lion. Such destruction of mega wildlife took place even when destruction of wildlife (be it plant or animal) has *not* been in the ethos of an average Indian.

Therefore, while the *first* cycle of decimation of tiger was on account of wanton shooting by the royalty of India, the *second* cycle of reduction in number of tigers has been on account of the unprecedented demand for tiger parts in China, Korea and Taiwan, and demand for the products from these in Hongkong, Japan, Singapore and the entire South East Asia, Middle East (particularly Saudi Arabia), Western Europe and USA (Figure 1). The rich Chinese in some of the South-East Asian countries are willing to pay US\$ 300 for a soup based on the penis of a tiger. Therefore, as long as such male vanity for so-called aphrodisiacs (based on tiger bones and organs) will continue, the tiger will continue to live in peril. This is particularly true of China where the new-found affluence, particularly in the coastal belt, has led to unprecedented demand and surreptitious trade in tiger bones and organs. If such killings go unheeded, the human population in these countries will consume all the world's mega cats that exist today in the wild. *Therefore, something tangible needs to be done at the international level to curb the unofficial trade in products based on tiger bones and organs for making aphrodisiacs, lotions and potions.* The poor people living in and around tiger reserves in India and South East Asia are enticed by agents involved in such illicit trade. On account of this, the situation has become extremely precarious for the tiger, and India cannot be singled out and accused of not discharging its responsibility.

Historically, tiger had a very wide range from Caspian sea in the west to Siberia in the north, to South China in the East, down to Bali (Indonesia) in the South and covered almost whole of the tropical and subtropical India and Indo-China (Figure 2). Obviously, tiger though zoologically one species (*Panthera tigris*), had eight subspecies at the turn of this century⁶⁻⁸. These are: Caspian

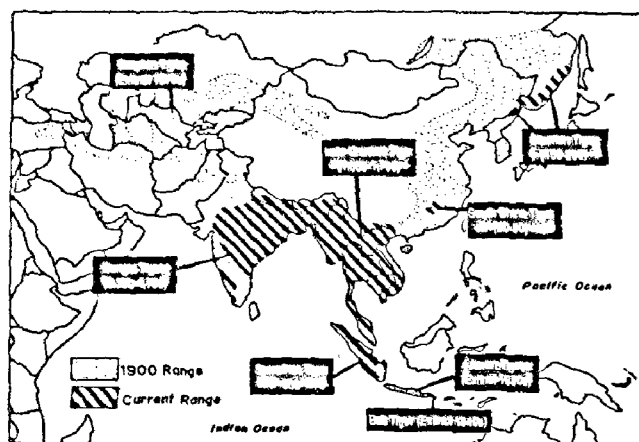


Figure 2 Distribution of tiger in the world¹⁰.

tiger (*P.t. virgata*), Siberian tiger (*P.t. altaica*), South Chinese tiger (*P.t. amoyensis*), Indo-Chinese tiger (*P.t. corbetti*), Bengal tiger (*P.t. tigris*), Javan tiger (*P.t. sondaica*), Sumatran tiger (*P.t. sumatrae*) and Bali tiger (*P.t. balica*). This differentiation probably took place after the late Pleistocene glaciation (10,000 years ago), and was inevitably followed by isolation and genetic drift with no possibility of gene exchange between the subspecies⁹.

Three subspecies namely Caspian, Bali and Javan tigers have become extinct in 1970s, 1940s and 1980s respectively¹⁰. Two other subspecies, namely, Siberian (150–200 animals) and South Chinese (30–80 animals) are on their way to becoming extinct, not only on account of drastic reduction in their numbers but also due to a lack of local commitment for their conservation. This is abundantly clear from the horror stories televised about Siberian and Chinese tigers on the *Discovery Channel* and the *Earth Files* of the BBC and other international agencies. Sumatran tiger is also not in good shape with a population of only 650 animals. Of the two remaining subspecies, the prospect for Indochinese tiger (1000–1700) is not rosy on account of the tremendous demand for tiger bones and organs in China, Korea, Taiwan and other countries, together with weak local laws and little commitment to conservation.

The only hope for tiger, as a species (in its own right), is in India where there are still 3750 tigers (Table 1; Figure 3). The largest number (912) is in Madhya Pradesh. There is adequate national commitment for saving this animal. The reason is that tiger is interwoven with India's history, culture, religion and philosophy. As pointed out earlier, tiger is the mode of transport (*vahana*) of Goddess *Shiv Durga*¹. Equally important is the fact that globally the best scenario is that altogether there are 7230 tigers and the worst scenario is that of 5180 (refs 4, 11, 12). Of these, India alone accounts for 64 to 65% of tiger population. Thus the only country

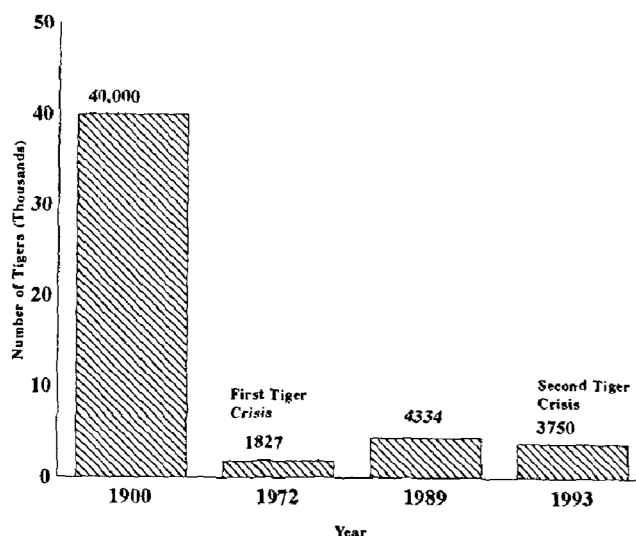


Figure 3. Decline in numbers of tigers in India¹².

which offers the best prospect of saving the tiger for posterity is India and it is not unexpected that this country is, therefore, under international pressure to save this magnificent animal. This is possible only if there is parallel action taken in the countries listed above where tiger bone-based medicines are manufactured, exported and used. Equally important is to mount a campaign by IUCN, WWF (International), FAO, UNESCO and UN Security Council and the General Assembly in this regard, India cannot absolve itself from the biological responsibility of saving the tiger. Furthermore, the saving grace is that the prevailing ethic of Indians is one of non-violence and compassion not only for tiger but for all life.

India also has provided to the world unique albino line in tiger which began with Mohan – a white tiger caught from the wild in Rewa⁶. This trait is a simple monogenic recessive. The colour is off-white, stripes are brown and eyes are icy blue. There are now a large number of white tigers as celebrities in many zoos of the world. Another mutant is the black tiger, again from India. Originally, this is based on an illegally obtained tiger skin in which back and head are deep black in colour which extends down as black stripes⁶. There have been reports about black tigers since March 1889 to the present times⁷. However, the genetics of black tigers is yet to be worked out.

Conservation of tiger in India

Conservation of tiger has been going on in India in a subdued manner for sometime, but it got a fillip on account of the Resolution of the Tenth General Assembly of IUCN held in November 1969 in New Delhi. For the first time, it recommended a moratorium on killing of

Table 1. Tiger population in Indian states by census years

State	1972	1979	1984	1989	1993
Andhra Pradesh [†]	35	148	164	235	197
Goa	—	—	—	2	3
Bihar [†]	85	110	138	157	137
Mizoram	—	65	33	18	28
Orissa [†]	142	173	202	243	226
Rajasthan [†]	74	79	96	99	64
Gujarat	8	7	9	9	5
Maharashtra [†]	160	174	301	417	276
Karnataka [†]	102	156	202	257	305
Meghalaya	32	35	125	34	53
Uttar Pradesh [†]	262	487	698	735	465
Arunachal Pradesh [†]	69	139	176	135	180
Madhya Pradesh [†]	457	529	786	985	912
Kerala	60	134	89	45	57
Tamil Nadu [†]	33	65	97	95	97
West Bengal [†]	73	296	352	353	335
Assam [†]	147	300	376	376*	325
Tripura	7	6	5	5*	NA
Nagaland	80	104	102	102*	83
Sikkim	—	—	2	4	2
Manipur	1	10	6	31	NA
Total	1,827	4,005	3,015	4,334	3,750

—, Information not available.

NA, Tiger census undertaken, but figures not yet available.

*Tiger census not undertaken during 1989 in Assam, Tripura and Nagaland. Hence figures for 1984 have been used.

[†]States (12) together having about 93% of the total tiger population of the country.

Source: Dey⁸.

tigers and sale of tiger skins, trophies, etc. At that time tiger bones and organs were not in such great demand. In 1970 India imposed a total ban on tiger shooting followed by adoption of Wildlife (Protection) Act of 1972. Soon after, in 1973 Project Tiger was launched^{11,12}.

Given the commitment of the Indian Government at the level of the then Prime Minister (Indira Gandhi), positive results followed soon. A network of tiger reserves which today number 23 and cover an area of 82,615 hectare (Kishore Rao, personal communication), accounts for 1079 tigers, i.e. about 29% of the total tiger population (Table 2). Each tiger reserve has a core area around which is the buffer zone. More recently, on the occasion of Tenth Anniversary of Project Tiger (1993), there was the adoption of *Delhi Declaration* regarding tiger by the Government of India, and a *National Tiger Action Plan* (NTAP) was also chalked out at an international symposium held in February, 1994. The NTAP spelt out international and India's intents. The international intent envisaged formation of a *Global Tiger Forum* (1993) with provision for India entering into agreements with the neighbouring countries so as to prevent illegal trade in tiger hides, bones and organs, exchange of information and help one another in capacity building for protection of tiger. It also emphasized evolving NTAP with a network of viable tiger reserves, together with their management capabilities, research

and monitoring and also management of lesser cats and other endangered species in these reserves. The Plan was holistic in character.

In addition, administrative restructuring and collaboration with voluntary agencies was also envisaged. The local agencies were to be involved in a meaningful ecodevelopment programme. However, underlying science and technology of conservation has not been stressed. Furthermore, decisions have not been implemented in their entirety.

The number of Indian tigers (*P. tigris tigris*) at the turn of this century was around 40,000 (refs 8, 13). However, as indicated earlier, by 1972, in the name of sport, the number of tigers came down to mere 1872 (Figure 3). *This was the first tiger crisis in this century in India.* Thus in 72 years (1900–1972) atleast 38,128 tigers were killed which means about 530 tigers per year, i.e. atleast three tigers in every two days were killed for sport (*shikar*) during this period. This was the biggest decimation of tigers done not by common people of India, but by the British and Indian royalty. However, in 1970, thanks to the then Prime Minister, Indira Gandhi, some very definitive actions were taken inasmuch as tiger was declared as India's *National Animal* and Project Tiger was launched in 1973. The Indian Board for Wildlife (IBWL) was also constituted with Karan Singh as its first Chairperson and followed by Indira

Table 2. Tiger population in project tiger reserves by census years

Project tiger reserves: see Figure 4	Established in	1972	1979	1984	1989	1993	1995
Bandipur	1973	10	39	53	50	66	74
Corbett	1973	44	84	90	90	123	128
Kanha	1973	43	71	109	97	100	97
Manas	1973	31	69	123	77	81	94
Melghat	1973	27	63	80	55	72	71
Palamau	1973	22	37	62	44	44	47
Ranthambhore	1973	14	25	38	93	36	38
Simlipal	1973	17	65	71	269	95	97
Sunderbans	1973	60	205	264	45	251	NA
Periyar	1978-79	—	34	44	19	30	39
Sariska	1978-79	—	19	26	38	24	25
Buxa	1982-83	—	—	15	28	29	31
Indravati	1982-83	—	—	38	94	18	15
Nagarjunasagar	1982-83	—	—	65	47	44	34
Namdapha	1982-83	—	—	43	90	47	52
Dudhwa	1988	—	—	—	22	94	98
Kalakad-Mundanthurai	1988	—	—	—	81	17	NA
Valmiki	1990	—	—	—	—	49	NA
Pench	1992	—	—	—	—	39	27
Tadoba-Andhari	1994-95	—	—	—	—	34	36
Bandhavgarh	1994-95	—	—	—	—	41	46
Panna	1994-95	—	—	—	—	—	26
Dampa	1994-95	—	—	—	—	7	4
Total		268	711	1121	1258	1178	1079

— Was declared a tiger reserve subsequently.

NA, Tiger census undertaken, but figures not yet available.

Sources: Dey⁸.

Gandhi as the next Chairperson. The objective was that every single animal was to be saved. The result was that by 1989 the number rose from mere 1872 (in 1972) to 4334 (refs 8, 12). The progress was indeed very impressive. To be exact, there was an addition of 2462 tigers in the intervening 17 years.

After Indira Gandhi's assassination in 1984, the number fell to 3750 by 1993 (ref. 12). This was the *second tiger crisis*, the country lost at least 584 tigers in four years (1989-1993), i.e. about one tiger was lost every alternate day. No census has been taken after 1993, but the pace of decimation may have increased and not decreased. This being so on account of an unprecedented extraneous demand for tiger bones and organs for Chinese medicine, coupled with a perceptible decline in the level of conservation effort in India after the demise of Indira Gandhi. The loss was dramatic during 1989-93 when India's political commitment regarding conservation in general and tiger in particular was at the lowest ebb.

This led to holding an International Symposium in 1993 which ended in the *Delhi Declaration* on tiger conservation and recommended setting up of a *Global Tiger Forum* and starting a global campaign to save the tiger. Thanks to Kamal Nath (the then Minister of State, Environment and Forests), an *Indo-Chinese Protocol on Tiger Conservation* was also signed between India and

China in 1993 (ref. 12). With declining political commitment to conservation, all these decisions, remained only on paper.

Bones and skins have been regularly smuggled out of India via Nepal and sometimes also via Singapore. The final destination has been China. There are very harrowing accounts published abroad day in and day out about the serious decline in number of tigers in India. Some of these have not been officially accepted, but the heart of the matter is that conservationists and conservation organizations, all over the world, are interested in saving this charismatic species.

Poachers involved in clandestine trade in tiger hides, bones and organs are posing the biggest threat for this species. These offenders are rarely caught red-handed because the local people do not reveal information to park authorities for fear of reprisal. In addition, the park authorities do not have magisterial powers to book offenders after summary trials. Poaching is done in the peripheral areas. It is basically a hit-and-run operation. In spite of these drawbacks, there have been successes in catching several culprits. Unless a poacher is caught red-handed, most cases of poaching go unreported and unpunished. This is so because people are reluctant to provide timely information. Between 1993 and 1995, 117 to 133 tigers were poached^{11,12}.

It has been suggested that there should be anti-poaching Strike Force organized with the help of the local villagers in core areas. Such a force needs to have modern weapons, and such vigilance groups need to be organized from among villagers who should act as secret informers. Side by side, the service conditions of staff need improvement. Special courts need to be appointed which should dispose such cases expeditiously. The knowledge base of conservation for postal and custom staff needs to be regularly updated.

Additional reasons for the decline of tiger and wildlife populations are land diversion for human settlements, agriculture, grazing, roads, mining, etc. which have led to habitat loss^{12,14}. There have to be well-organized and well-thought out education programmes for the ecosystem people and villagers about the importance of conserving tiger for long-range ecological security.

Today, for different reasons, there is a renewed interest in tiger conservation even at the global level. Tiger is the National Animal of India and during Indira Gandhi's time has been a symbol of successful conservation effort launched in the country. Thereafter, there has been considerable laxity and conservationists have been impressing successive Governments of India to take up the conservation of tiger very seriously.

Even the Indian Board for Wildlife became totally defunct after the death of Indira Gandhi. The Honourable Supreme Court had to intervene at the behest of WWF-India to urge the Government of India to reconstitute this Board, which had met only once after the demise of Indira Gandhi. The Court has also directed that the states should also constitute Wildlife Advisory Boards and appoint Honorary Wildlife Wardens. The Board was reconstituted in 1996 after a lapse of over 8 years and two meetings have been taken, one each in March and July 1997 by the Prime Minister. The general apathy and inaction by the Government has led to a thinking that wildlife is unimportant and the result has been that the wildlife conservation has been totally neglected. To say the least, this is very sad.

Tiger being a charismatic species, has attracted considerable world attention and WWF (International) is reported to have collected large sums of money in the name of Tiger Conservation. The donors are now pressing WWF (International) to prepare and implement a credible plan of action and do some work on the ground. The performance of WWF (International) needs to be closely watched.

As pointed out above, the only hope for tiger conservation on Planet Earth, is in India. This being so on account of the fact that India is the land of Buddha, Mahavira and Gandhi, where people are predominantly vegetarian and believe in non-violence. Being a poor country, the pecuniary interests dominate in some areas and in some very poor strata of Indian society, where actually it pays to kill a tiger (Figure 1).

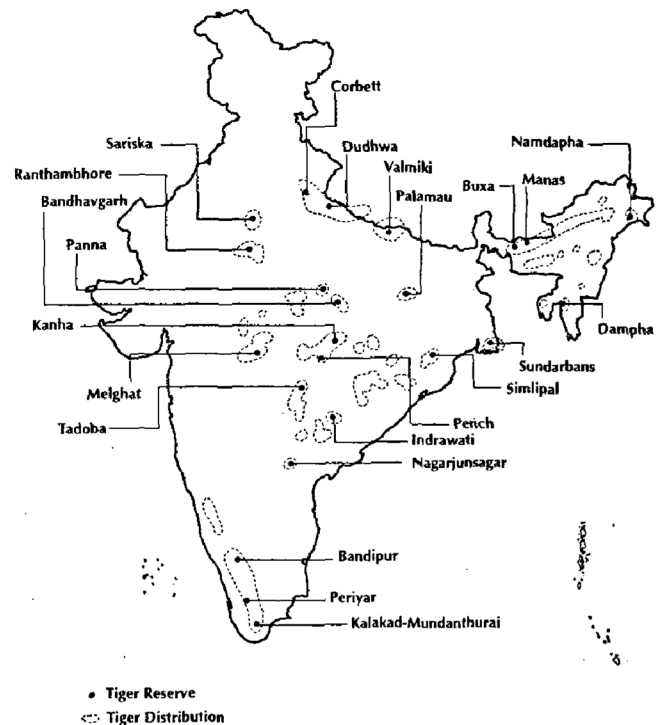


Figure 4. Tiger reserves in India. Note the unwitting fragmentation of the habitats¹¹.

In sum and substance, in India there have been two tiger crises in this century: the first one due to indiscriminate and wanton shooting by royalty, and the second due to unprecedented commercial poaching. The situation has been aggravated by habitat destruction and fragmentation (Figure 4) due to increase in human population and clearance of forests for non-forestry use; and reduction in prey-base leading to reduction in tiger population. This is likely to result in progressive inbreeding. No professional studies are available in this regard. There is need for a minimal area which is critical for the genetically-viable tiger populations because small populations generally lead to loss of genetic variability. All these factors have led to declining number of tigers from a large panmictic population to fragmentation of population in 23 tiger reserves with a total of only 1079 tigers¹² (Figure 4). Therefore, there is needed a long-term monitoring of tiger habitats. There has to be establishment of new populations and augmentation of old ones for otherwise tiger may enter into an extinction vortex¹⁵ (Figure 5). The situation may lead to such a state. This imposes tremendous responsibility on conservation community of India to take proper and expeditious action.

Asian lion

In the historical past, Asian lion ranged from Southern Europe (where it became extinct 2000 years ago),

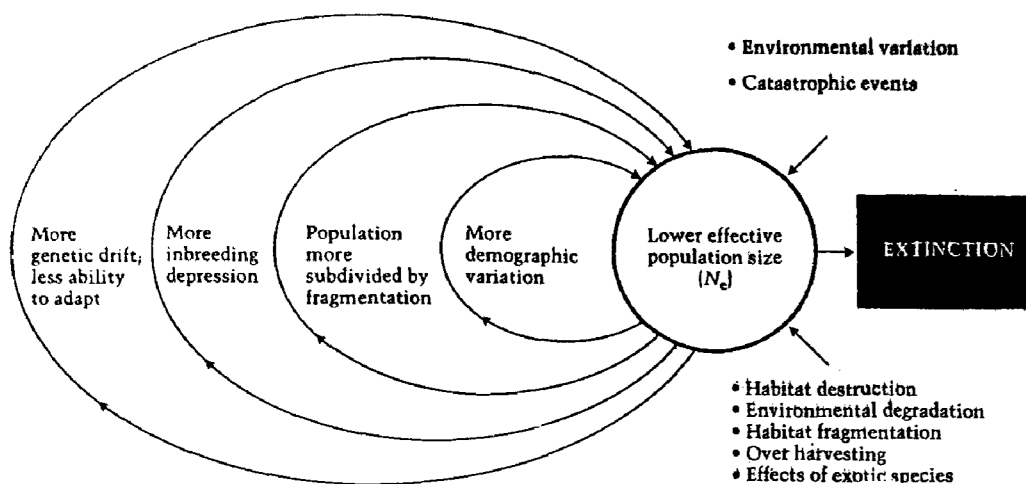


Figure 5. Possible pattern of Extinction Vortex¹⁵.

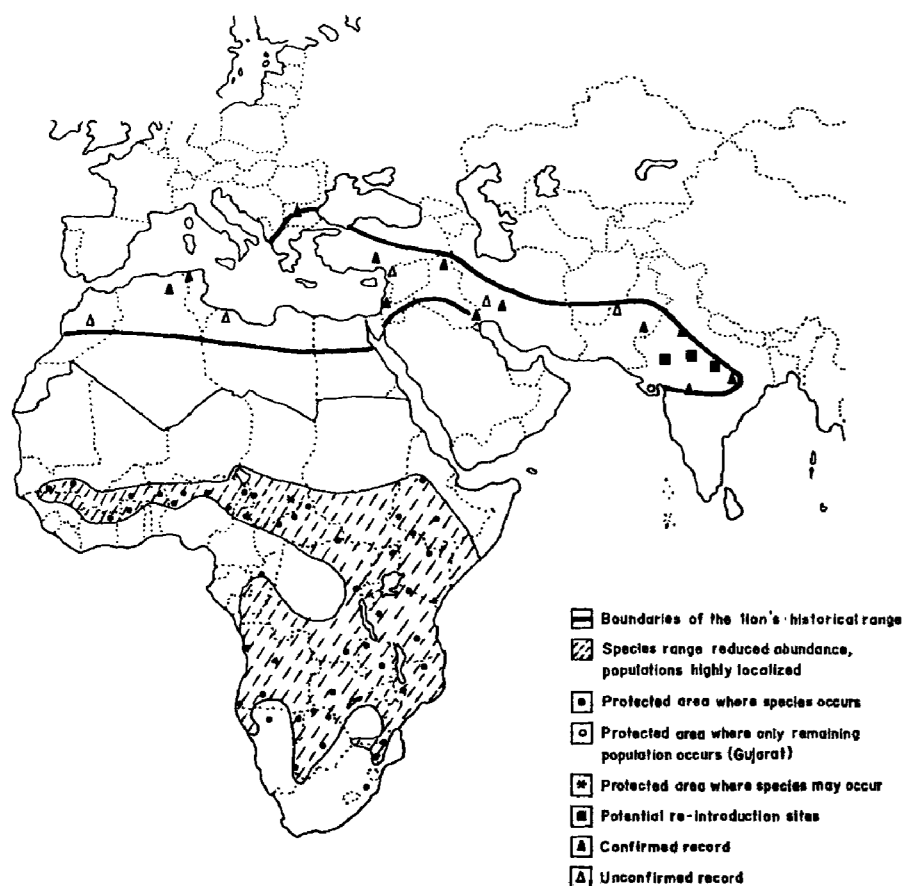


Figure 6. Past and present distribution of lion in the world. Note today Asian lion exists only in Gir in Gujarat in India (open circle)⁴.

Northern Africa (disappeared some 50 years ago), Persia including South Asia into India up to Bihar where the last lion was killed in 1814. It is also recorded that 50 lions were killed between 1856 and 1858 around Delhi⁴.

The present situation is that lion has disappeared in Asia except in the Gir Forest in Gujarat (India). Therefore, the Gir lion is the world's only population of Asian lion which is indeed relict in character. African lion

(*Panthera leo leo*) is found in sub-Saharan Africa where it is abundant. Its Asian counterpart (*P. leo persica*) in Gir forest (Figure 6) has separated from the former about 100,000 years ago and has some genetic differences with African lion⁴. These are coupled with some morphological differences in mane and body size. Albinos in lion are reported in African lion in the vicinity of Kruger National Park and Umfolzi Game Reserve in South Africa⁴.

Apart from being the mode of transport of *Shiv Durga*, the lion is also linked with Hindu mythology through *Narasimha*, the fourth incarnation of Lord *Vishnu* (the preserver). *Narasimha* has upper half as lion and lower half as man. It is an embodiment of valour and strength. Added importance of lion is the Ashoka seal which was adopted by Government of India as the State Emblem after independence in 1947.

According to the report of Forest Department of Gujarat, there were only 20 lions in 1913 in Gir. Thereafter, a complete ban was imposed on shooting of lion by the then Junagadh State of which Gir was a part. But now the population of lions is about 280 animals restricted to the Gir forest dominated by dry teak in the western part, and by *Acacia* in the eastern.

Rashid¹⁶ feels that the carrying capacity of Gir is between 200 and 250. O'Brien *et al.*¹⁷ and Widt *et al.*¹⁸ have found considerable genetic uniformity in the population. This does not auger well for the Gir lion. Lalji Singh and his associates from Centre for Cellular and Molecular Biology (CCMB), Hyderabad are in the process of making detailed analysis of African and Asian lions and their hybrids.

Apart from large number of livestock (14,000) and ecosystem people (7500 Maldharis) found within the Gir sanctuary, there are four major temples and the associated roads, and one rail road within the Gir sanctuary. The number of visitors to Gir is around 30,000 per year. All these are a source of major interference to lion because, like humans, animals also love privacy, which is missing in Gir.

The above description indicates that the only population of Asian lion in Gir is indeed in danger and there is a need for an alternate habitat. Based on habitat viability analysis, a prospective site has been identified keeping in view the habitat and availability of the prey base. The new site is Palpur Kuno Wildlife Sanctuary in northern Madhya Pradesh. This is the most promising site⁴ but the State Government of Gujarat does not want to lose the distinction of harbouring in its State the only population of the Asian lion. Gujarat also does not want to lose the tourist traffic. It would be indeed incorrect for Gujarat to continue to harbour such a feeling, because lion, like tiger, is a national concern as epitomized by our State Emblem, history, culture and heritage.

Strategies to save tiger and lion

What should be the broad contours of a short and a long term strategies to save the two charismatic species? All the agencies concerned with tiger and lion at the level of Central and State Government must meet and chalk out a strategy which is implementable and result-oriented both in the short and long terms.

Ecosystem approach

Tiger and lion are integral parts of the respective ecosystems. Therefore, an attempt has to be made to strengthen the concerned ecosystems where a natural herbivore prey-base has to be ensured. Ranjit Talwar (WWF, India) has estimated that for its sustenance, one tiger needs 60–65 animals per year. To ensure this, there are needed atleast 300 animals (a mixture of chital, sambar or swamp deer and wild boar). Some feel that the number of animals needed is about 500 so as to ensure a comfortable prey-base.

In turn it means ensuring a good tree and ground cover on which the herbivore base can flourish, and finally ensure water availability. There has to be minimal human interference. To achieve this, and, without sounding heartless, there is a need to translocate *ecosystem people* living in the core areas. These people have to be ensured food and fuel and other basic requirements on a sustained basis. They need to grow these in the vicinity of their habitations. In the eyes of ecofundamentalists, it may appear an anti-people act, but it is not so, and has to be accomplished in record time and with success. As long as people live in the core area, the people and the mega-animals will always be in conflict. Furthermore, anti-social elements will continue to entice the innocent ecosystem people to kill the animals under the pretext of self-defence. It pays them to kill a tiger. Translocation will also help the concerned ecosystem people to come into the social and economic mainstream of the country including education so that they take to some vocations and also enjoy atleast some of the good fruits of modernity.

There is need to make all-out effort to fortify vigilance, providing better weapons and other equipment including better footwear, and proper uniforms. Furthermore, there is needed training of personnel and providing respectable pay scales for the field staff commensurate with importance of the job and the risks involved. These people are at a high risk from commercial poachers. There is a need to educate them about the higher responsibility and ensuring commitment by a system of awards and rewards. It is also very necessary to take the ecosystem and other local people into confidence and elicit their cooperation and encourage them to

join as guards and protectors of the tiger and lion reserves. Equally important is to prevent habitat destruction and soil erosion on account of expanding agriculture, industry, tourism and urbanization and avoidable defence needs. It is important to ensure good vegetational cover, at the same time prevent uncontrolled grazing.

It is necessary to conduct periodic census of tigers in priority tiger reserves. Such information is critical for reasons more than one. Equally important is the problem of predation by tiger and lion on livestock belonging to local communities. In this process, tigers also attack humans, thus become man-eaters. Once tiger and lion get the taste of livestock and/or human flesh, the result is alienation of the local people.

Tiger reserves and one lion reserve are in reality small islands (Figures 4 and 6). There is demographic decline on account of habitat destruction, encroachment and illegal poaching. The basic question is: Are these islands viable from genetic-evolutionary point of view? *There are no critical scientific studies on minimum size of the population, minimum area demand and the size of prey base to sustain a population of a feline.* This information is critical in the case of tiger because corridors connecting adjacent reserves will not be possible (Figure 4). The population of tigers within a reserve varies from 4 to 128 (refs 11, 12), average being 47 (Table 2). Data on minimum viable population size is something very critical because of the implicit vulnerability of a population that is too small and isolated. Small populations lead to change in gene frequencies and become vulnerable to extinction on account of increasing inbreeding depression. These are not viable either ecologically or evolutionally. Data need to be generated on these aspects including the consequences of possible inbreeding degeneration. Use of molecular methods must become common. Equally important is the extent and nature of prey base.

By and large the fact is that ecosystem people living in core and/or buffer zones, has not worked to the advantage of either these people themselves or the felines. On account of their poverty and penury, these people are prone to the temptation of trading tiger hides, bones and organs for money. The demand for these items is not in India but in China.

A very close centre-state relationship is needed for effective conservation because land, forests, water are state subjects. Equally important is sustained political will and commitment regarding conservation. Therefore, concerned political authorities need to be kept informed about the upstream and downstream ill-consequences of not attending to conservation on proper scientific lines. In turn, it also means that there is a need for informed bureaucracy.

Long-term strategy

Not too long ago, tiger has been a symbol of successful conservation effort in India. It became a success story of which the then enlightened politicians, bureaucrats, wildlifers, scientists, technologists and people at large were justly proud. But, this is not the situation today. Our strategy must be to strengthen conservation effort both at macro- and micro-levels. Secondly, there has to be no let-up in conservation effort because otherwise the whole work done so far will fall apart. Therefore, India has to be ever-vigilant. A lot of populism has entered in this otherwise totally professional area. No consideration has been given to evolutionary biology, genetical aspects, concept of minimum population size, minimum area demand, prey-base, forest cover, water availability, etc. Generally the importance of these aspects is not fully realized. Furthermore, there is a direct confrontation for space between humans on the one side and tiger and lion on the other. All these questions need professional solutions. There is need to do hard and dedicated conservation work so that it becomes useful in time to come.

There has to be an underlying philosophy of ecological management of tiger, based on principles of conservation biology. This approach has to be anticipatory in character. It should be possible to foresee problems before they become crises. Efforts have to be made to activate self-sustaining and regeneration capacity of such natural areas. In simple words, it means understanding ecologically the habitats and biology of tiger and lion on a holistic basis. One cannot concentrate only on increasing one species, but will have to enhance a set of interdependent but interrelated plant and animal species and revitalize and enhance all other connected biological processes. Thus to ensure tiger and lion we need to ensure plenty of herbivorous prey-base and vegetation. This has to be done through credible ecodevelopment programmes so that there is drastic decrease in soil loss and deforestation, and finally there is sustained supply of water. The bottom line is that we need augmentation and maintenance of a whole range of ecological processes before we can ensure conservation of any charismatic species like tiger and lion. In turn, this would ensure minimization of many types of threats so as to maximize outputs. A long-term strategy does not mean merely increasing numbers of tigers and lions, but also ensuring their survival in perpetuity. The latter can be ensured *on the basis of underlying genetic-evolutionary approaches which have not been a part of conservation strategy of mega animals.* There is a general lack of appreciation and understanding on this account and, therefore, is a high priority.

There is need to map tiger populations and also the only population of lion in Gir for genetic variability.

Based on such data, one may think of saving the tiger and the lion in space and time. This will also require setting up of most modern facilities for genetic fingerprinting. Furthermore, it will involve close liaison between evolutionists, geneticists, wildlife experts, tiger and lion lovers and other personnel involved in the field and above all, people at large.

Genetic approaches to conservation

Mapping genetic variability will not require killing these animals but very small amounts of blood, skin or may be only a few hair follicles. It is done all the time in the case of human beings and animals for health reasons, estimation of genetic variability and establishing paternity: because while maternity is a fact, paternity has been only a conjecture so far.

In addition there is also needed an understanding of the dynamics of the concerned ecosystems and the human communities that live in tiger and lion habitats. Such studies would bring out both adverse and beneficial role of the human-animal relationship. *Restricting conservation effort only to 23 tiger reserves has unwittingly led to fragmentation of the habitat of Indian tiger as a whole* (Figure 4). Nearly 70% tigers exist outside these reserves. This means that in time to come, larger panmictic populations would be needed for conservation work. Otherwise these are likely to be progressively converted into pockets of small inbred populations. This may end up in replication of same or similar genotypes and progressively lead to genetic homogeneity within each reserve. In principle such a danger exists. In turn it would increase vulnerability of tiger and lion (Figures 4, 6). Therefore, it is obligatory to have an idea about extent and nature of genetic variation in the important tiger reserves located in different parts of India and in Gir sanctuary in the case of lion. Such an estimate of genetic variability is indeed a prerequisite for drawing a meaningful conservation strategy. This cannot be done following the conventional approach but through a whole range of DNA fingerprinting techniques available today which are not only quick but also highly reliable.

The general conclusion arrived by Soule¹⁹ regarding genetic variation and population size in wildlife is that the two are directly related. Furthermore, widespread species have greater genetic variation than those with restricted ranges; genetic variation is negatively correlated with body size in mammals; endangered species have less genetic variation than non-endangered ones; and small population size reduces evolutionary potential of wildlife species. Though these are generally accepted principles, they can by no means be cited as laws. There is, however, not much controversy about small population size reducing the evolutionary potential of the

wildlife species²⁰. There are in-built lessons for using these principles for captive breeding and subsequent release in nature of a proper 'genetic mix' of the species concerned. Molecular approaches as applied to tiger and lion would help to clear taxonomic uncertainties regarding species, subspecies, hybrids, inbred population in the wild stock. Such studies would be of help in captive breeding of wild populations. Lastly, these approaches will also help in proper management of these animals.

There is a genuine feeling among wildlife experts like Samar Singh that natural hunting skills of captive-bred tigers are not as good as in the naturally-bred tigers. Besides, the captive-bred tigers lose fear of man. Thus their 'wild' traits are impaired. This has also been the conclusion of Billy Arjun Singh. Therefore, the technique of captive breeding has to be such that 'ferocity' of these animals is not lost. One needs to replicate an identical 'genetic mix' in captive bred populations, which could be released into specific reserves so as to augment natural populations of tiger.

There are two ways of estimating genetic variability. One involves classical breeding approaches, which are not only time-consuming and cumbersome but also manipulation of mega-felines with long generation is difficult. The other approach is to use molecular approaches so as to estimate *intra-subspecific genetic variability* taking note of the pioneering work done by Stephen J. O'Brien and co-workers which is more at the *gross specific and subspecific levels*. The future work of Lalji Singh's group²¹ at CCMB would involve very detailed and intensive genetic profiles at the population level throughout its range. To begin with, this can be undertaken only in the habitats of tiger and lion (Gir) selected after careful consideration. If needed, the work could be extended throughout tiger range in India. This technique is highly reliable for estimating the extent and nature of genetic variation using molecular genetic approaches like DNA fingerprinting, RAPD analysis, microsatellite analysis and mitochondrial D-loop sequencing. The second approach would be semen analysis. The Wildlife Wing and the Zoo Authority of India under the Ministry of Environment and Forests have already sponsored such work at CCMB with Lalji Singh's Group. The results obtained so far are very revealing.

Wentzel *et al.*⁹ utilizing micro-satellite analysis revealed significant phylogenetic differentiation between the five living subspecies of tiger. These are indeed fragmented and with hardly any gene exchange between them. Thus differentiation began on account of geographical isolation and then led to morphological differentiation.

The second line of action that can emanate from the genetic approach is to organize a *Tiger and Lion Gene Bank*, an idea mooted by Lalji Singh²¹ (CCMB). This Bank would store for posterity, sperms, eggs, embryos

and tissues of representative populations of tiger and Gir lion. It would be something similar to the repository or bank(s) envisaged under Human Genome. The materials thus collected need to be ultimately stored under Permafrost conditions at an appropriate place selected in the Central Himalaya. In this way maintenance costs would indeed be low. The materials thus stored may be of use in future. Jurassic Park was only a fictional but an imaginative episode which may become somewhat of a reality in future: we may be able to raise full organisms in future. In this regard, the recent work on Dolly (lamb) and a pair of monkeys have taken the technique forward more decisively. Imagine the possibility of a dodo being recreated if such like materials were available for this species.

Alternate site for lion

For lion there is need to utilize the alternate site already identified where natural and/or captive bred populations could be released. Otherwise, in case of Asian lion, at present India is *carrying-all-its-eggs-in-one-basket*. There is a feeling in Gujarat that having another sanctuary for Asian lion would reduce the importance of Gujarat. If true, this is very sad for reasons more than one. This only shows how ignorant and narrow minded some of our politicians can be. Alternate site has been already identified in Madhya Pradesh based on a very elaborate professional analysis⁴. This project is being taken up on a priority basis. Palpur Kuno is located in Northern Madhya Pradesh in Vindhyan Hill ranges, and the project for re-introduction of lion is now taking shape. The sanctuary is about 3455 km² which will be increased to 3700 km² by 2015.

With the above in mind and as a first step, the ecosystem people living in Palpur Kuno are being shifted 25 km away to a new village²². The new site was chosen by the people themselves. The package for 5000 families from 19 villages includes 2 ha of ploughable agricultural land given free to each adult together with Rs 36,000 for construction of a house on the site. The government will construct wells and install hand pumps for each family. A lift irrigation scheme has also been launched on Kunwari River together with primary health centres for people and schools for children. The ecosystem people are happy at such a prospect because the new site is far better than the one they are occupying at present. The transfer is expected to be completed by end 1997 (ref. 22).

Soon after this phase is completed, work on the enhancement of prey-base will begin. This would involve considerable eco-restoration including release of herbivorous prey species which include spotted deer, cheetal, chinkara, nilgai and wild boar. These herbivores would be introduced and time given for them to settle

and multiply. A pre-release 20 ha centre of prospective prey base has been established so as to ensure prey in sufficient numbers. Thereafter, the Asian lion will be translocated in 2000–2001 after being tranquilized and flown to the new home where they are expected to settle permanently²².

This sanctuary is also home to tigers and it is felt that when lions are introduced, the two mega felines will not clash with each other.

The project will cost nearly Rs 64 crores and would be a fitting use of a dacoit-infested area for a lion sanctuary of international importances where human intervention will help to rehabilitate India's most charismatic species.

This is a unique experiment and a group of conservation biologists, wildlifers, social scientists and other professionals should monitor it for the next 50 years and produce periodic reports.

Demand and consumption of tiger parts

There has been a significant increase in the use of tiger parts during the last decade or so. Primarily this demand emanates from China for the Traditional Chinese Medicine (TCM) and secondarily in South-East Asia. Fifteen tiger parts have been identified in TCM by Mills and Jackson²³. Apart from bones, which are in maximum demand, other parts include hair, whiskers, testis, penis, brain, eyeballs, blood, bile, etc. The demand is not confined to China and South East and South Asia, but all over the world where Chinese are expatriates. Thus TCMs are regularly imported by England and other European countries, North America and Australia and also in Middle East, particularly Saudi Arabia (Figure 1).

In China there are also 116 factories producing medicinal liquor based on tiger organs²⁴. Most of the suppliers of tiger parts and processed derivatives are from China, Hongkong, Indonesia, Singapore and Thailand. However, although India has the largest number of tigers in the world, this country is not a supplier of tiger parts in the formal sense, but there is commercial poaching followed by illicit export primarily via Nepal and some even via Singapore. The major importers of tiger-based medicines are South Korea, Japan, Taiwan, USA and Singapore. According to Mills and Jackson²³, between 1970 and 1993, these countries imported atleast 10,881 kg of tiger bones, 12,139 kg of tiger or bear bones, and 27 million tiger derivatives in 'various units of measure'. These authors have concluded that 'the only certainty is that wild tiger populations cannot sustain even limited commercial trade of their parts. Given fragmented habitats and small isolated populations, many of the remaining wild tiger populations will require rigorous protection and management just to survive the continuing loss of habitat and the deleterious

effects of genetic isolation'. These animals cannot survive the pressures of poaching to supply to the international market with tiger bones and their derivatives.

To stop poaching, there are two courses open. One is to curb the production and sale of tiger products internationally. The world community of conservationists has failed to do this for reasons more than one; primarily, because it touches the Chinese sensibility. It is a fit case for discussion in appropriate international fora. These fora may discuss the use of tiger-based medicine and may recommend banning these at least outside China. India on account of its conservation ethic ingrained in the people at large has been a willing partner in saving tiger and all other biota. The international agencies have to swing into action and impress upon importing and manufacturing countries about stopping the use of such medicines (Figure 1). It is also clear that once tiger is decimated, the next target will be lion, followed by leopard (even bear) and all other felines from Asia and Africa.

Most people have very serious reservations about the world community of conservationists not taking any worthwhile action in this direction. Regrettably they are more interested in pushing India against the wall and not even requesting Chinese to stop import of tiger parts. Therefore, a practical view of the situation has to be taken. Perhaps conservation organizations need to help China to raise tiger bones and organs locally by establishing Tiger Farms so as to save tigers in South East Asia and India. Chinese *Materia Medica* is a 'compendium of traditional Chinese medicinal cures, and lists a wide range of curative applications for feline body parts'. Even cat bones and cranium are prescribed²⁴. Tiger farms would decrease substantially, if not eliminate altogether, the demand for tiger bones in SE Asia and India. To be realistic it would be asking too much from Chinese to abandon the tiger bone-based medicines, lotions, potions and soups which they have been using from time immemorial. If something tangible is not done, tiger bones will continue to be smuggled across the borders and tigers will continue to be decimated in South East Asia and India because there is a market for these items in China (Figure 1).

According to *Tiger News*²⁴, the WWF (International) has also been encouraging Chinese traders to introduce substitute bones in place of tiger-bones including those of domestic cats into retail pharmacy outlets ... negotiations with pharmacists and middle men from the main black-market trading areas around Shanghai and Canton, are the latest in a series of WWF (International) moves designed to alleviate pressure on wild tiger populations by persuading consumers to switch from illicit potions containing real tiger-bone to over-the-counter remedies containing body parts of both wild and domestic cats.

The suggestion of 'tiger farms' may sound rather bizarre but ethically there is no difference between raising tigers in farms, and raising sheep, cattle, goat, rabbit, poultry, fish, prawns and other domesticated animals, and even raising wild species like kangaroo and ostrich for purposes of meat. The last two have now been added to the Western menu. Tiger bones could as well be added to the list *only in the case of China*. Tiger farms in China will go a long way to relieve pressure on SE Asian and Indian tigers.

Conclusions

Tiger and Asian lion are making news all over the world. All is not lost; the good news is that both are fast breeders. There is need to follow a pragmatic genetic-evolutionary pathway for their conservation. Otherwise these animals will enter into an extinction vortex. Conservation is no longer merely a game of increase in numbers but of conserving genetic variability after making credible estimation of the same using modern tools. Many wildlife experts are still not ready for such approaches. The heart of the matter is that in general, the smaller a population, the greater is the vulnerability to variation in environment. This will in turn lead to further reduction in population size and drive a particular population into extinction. Genetic problems associated with small populations are well known, and minimum viable population size is a reality. Associated with this are problems due to loss of genetic variability and heterozygosity leading to inbreeding depression and genetic drift. The question arises, what should be the size of a viable tiger or lion population so as to maintain genetic variability in time and space. The answer is that there are no reliable well-researched data on the subject. Therefore, conservation has to be based on science of conservation biology. Alongside there is needed improvement in on-the-ground protection and ensuring abundant and varied prey-base. It may also involve eco-restoration and proper management of ecosystem people. Together all these will ensure the future of tiger and lion.

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REVIEW ARTICLE

Evolutionary extremophilic Archaeal domain of life

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The discovery of varied microorganisms under extreme habitations led to the unlocking of the evolutionary secret of the biokingdom including the search for the progenitor of the most primitive form of life on Earth and in other planets. Fuelled by the limitless possible commercial applications of the extremozymes derived from their organisms, the industry anxiously awaits the results related in designing superior enzymes for commercial applications.

THE geological time scale for the evolution of the living world whose history spans almost with the formation of this Earth shows (Table 1) the existence of microorganisms in the era of Archaean. The gap of 1.1 billion years between the creation of the Earth and Archaeal period witnessed severely harsh conditions compared to the present-day ecosystem. However, the stage was almost set for the chemical evolution. It cannot be doubted that suitable portions of inorganic matter occurring amidst favourable surroundings (anoxic, intense UV radiation from the young Sun without ozone layer) may by the influence of Nature's agent of which heat and moisture

are the chief, receive an arrangement of these parts that foreshadows cellular organization and thereafter pass to the simplest organic state and finally manifest the earliest movement of life. Life thriving about 3.5 billion years ago in an ambience of extreme temperature under anoxic conditions had to be surely quite different from the thermolabile life forms of today. The hyperthermophilic primitive life form does not fit into the Eucaryote-Prokaryote dichotomy. In 1965 Zuckerkandl and Pauling suggested that the systematics of life forms should be based on the most fundamental molecular criteria rather than on the classical cytological phenotype criteria¹. The confluence of advances in microbiology, enzymology and molecular biology has allowed the distinctions of different forms of life as interpreted by Carl Woese² which led to the proposal that living beings on this planet should be classified into three domains: (Figure 1).

- Archaea (Greek, primitive; previously archaeobacteria)
- Bacteria (Eubacteria) and
- Eucarya (Eucaryotes).