

Vertebrate crop depredation and its management around Sariska National Park in the Aravalli's of India

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Abstract

One cannot deny the importance of food acquisition for wild animals and the recent focus on a previously neglected issue: vertebrate pests damaging crops of marginal farmers. Wild animals rely on finding and consuming enough food to survive and reproduce. They need a variety of nutrients for different purposes, and their feeding patterns change based on factors like age, sex, and habitat. Recently, there is a shift in attitude of farmers towards vertebrate pests like These are animals with backbones (like blue bull, wild boars, rhesus monkey, small mammals and birds). Specific concern for marginal farmers, who are likely small-scale or resource-limited. The damage caused by vertebrate pests can significantly impact on their crops and livelihoods. This is high time to focus on the problem of vertebrate pests affecting the crops of marginal farmers, an issue that deserves more attention for ensuring their agricultural success.

- **Wildlife Sanctuaries & National Parks:** While crop damage by vertebrates is common near protected areas, the problem extends beyond that.
- **Urban and Rural Areas:** Vertebrate pests are also causing damage to crops, vegetables, and orchards in and around villages, towns, and cities.
- **Man-Animal Conflict:** This conflict arises due to several human activities that disturb the natural habitat of these animals.
- **Habitat Loss:** Forest conversion, monoculture plantations, overgrazing, and deforestation all reduce the natural food and space available to wild animals.
- **Development and Encroachment:** Infrastructure projects like roads and dams, along with encroachment into animal habitats, further push them towards cultivated fields.
- **Pesticides:** Pesticides is the emerging threat for the vertebrate pest and human well-being which cannot be neglected. Pesticides used in the fields are transferred to the vertebrate pests and impose a problem for their survival as pesticides are reported to be capable of removing whole species from the planet.

These factors essentially force wild animals to seek food sources in human landscape, leading to increased damage to crops. This creates a complex situation where both farmers and wildlife are negatively affected and Man-Animal Conflict comes into picture which is neither good for the man nor for faunal diversity of Sariska National Park.

Keywords: Sariska National Park, Wildlife Sanctuaries & National Parks, Man-Animal Conflict, Habitat Loss, vertebrate pests, crop depredation

Introduction

In general, survival and reproduction of wild animals depend on their ability to locate and harvest sufficient food to meet their nutritional needs. Timings and selection of food plants are synchronized to meet the requirements of proteins, carbohydrates, fats, vitamins, water, minerals, trace elements, etc. All animals have the same general need to acquire energy. The specific patterns of resource utilization may however vary according to species, age-sex classes, group, population and habitat. All the species interact with a variety of food distributed in their home range, which is within their reach. Until recently, there has been little attention given to vertebrate pests that damage crops, particularly of marginal farmers. Crop raid by different vertebrates' mammals and birds, like Elephant (*Elephas maximus*), Gaur (*Ros gaurus*), Blue bull (*Boselaphus tragocamelus*), Barking deer (*Munliacua muntak*), Black buck (*Antilope cervicapra*), Chinkara (*Gazella bennetti*), Wild boar (*Sus scrofa*), Hanuman langur (*Semnopithecus entellus*), Rhesus Macaque- (*Macaca mulatta*), Porcupine (*Hystix indica*) and birds like peacock, parakeet, partridges, sparrows has been widely reported from all over the country (Prater, 1971; Lakra et. al., 1979; Toor, 1982; Schultz, 1986; Sukumar, 1990; Bohra et.al. 1992, Balasubramanian et. al. 1993; Chhangani, 1994; Chhangani and Mohnot, 1997; Chhangani, 2000; Chhangani *et. al.*, 2002). In India crop damage by vertebrates is very common along the immediate periphery of wildlife sanctuaries and national parks. But there are several areas, where they live in and around human habitations on the out skirts of village, towns and cities and do considerable damage to crops, vegetable fields and orchards. This man-animal conflict is mainly due to conversation of forests into large-scale monoculture plantation, shifting cultivation, overgrazing, forest cutting, unwanted developmental activities like roads, dams and encroachment in the home range of animals, which reduces the availability of natural food and space for wild animals and force them to cultivated fields.

Diversity of cultivated plants exposed to different vertebrate pests, their population, crop raids and crop loss, make wildlife and people coexist peacefully with a healthy relationship etc are the aims of this paper and to (1) list the total species of crops, vegetables, fruits and flowers consumed by different vertebrates (2) status and type of the vertebrate species depredating crops (3) estimation of economic loss and threats to livelihood of farmers living in and around Sariska National Park, in the Aravalli Hills (4) Different management strategies employed by the people (5) management strategies and recommendation to control the vertebrates pest in the Sariska National Park.

Material & Methods

Study Site: Sariska Tiger Reserve is a tiger reserve in Alwar district, Rajasthan, India. It stretches over an area of 881 km² (340 sq mi) comprising scrub-thorn arid forests, dry deciduous forests, grasslands, and rocky hills. This area was a hunting preserve of the Alwar state and was declared a wildlife sanctuary in 1958. It was given the status of a tiger reserve making it a part of India's Project Tiger in 1978. The wildlife sanctuary was declared a national park in 1982, with a total area of about 273.8 km² (105.7 sq mi).

Altitude varies from 900 to 3200 feet metric system above a level. Sariska is characterized by distinct winter, summer and monsoon. During summer, temperature fluctuates between 30 – 35°C, and reach may 48°C during May and June. Mean winter temperature is 5°C, and may go down to 2°C during December – January. The average annual rainfall is about 825 mm; minimum 423 mm and maximum 950 mm. The forest is broadly dry deciduous or woodland type dominated by dhawa (*Anogeissus pendula*), 'gorya dhawa' (*Anogeissus latifolia*), salar (*Boswellia serrata*), gol (*Lannea coromandelica*), kherni (*Wrightia tinctoria*), kumbat (*Acacia senegal*), khair (*Acacia catechu*), ber (*Zizyphus mauritiana*), dhonk (*Butea monosperma*). The undergrowth mainly consists of jharber (*Zizyphus nummularia*), adusa (*Adhatoda zeylanica*), gangan (*Grewia tenex*), franger (*Grewia flavescens*), kanter (*Capparis sepiaria*), lantana (*Lantana indicus*). Some climbers and grasses are also found.

The main fauna of Sariska includes Tigers (*Panthera tigris*), leopard (*Panthera pardus*), hyaena (*Hyaena hyaena*), Indian Wolf (*Canis lupus*), Jackal (*Canis aureus*), Sloth bear (*Melwivus ursinus*), Hanuman langur (*Semnopithecus entellus*), Rhesus Macaque (*Macaca mulatta*), Porcupine (*Hystix indica*), Fourhorned antelope (*Tetracerus quadricornis*), Chinkara (*Gazella g. bennetti*), Porcupine (*Hystrix indica indica*), Sambar (*Cervus unicolor*), Spotted deer (*Axis axis*), (Bluebull (*Boselaphus tragocamelus*), Toddy cat (*Paradoxurus hermaphroditus*), Jungle cat (*Felis chaus*), Fox (*Vulpes bengalensis*), Crocodile (*Crocodylus palustris*) and Rock python (*Python molurus*).

Data was collected as and when encountered during travelling and regular field visits recorded from December 2016 to December 2018 in and around Sariska National Park. A well-planned questionnaire was prepared for generating information on type of crops, crop raid behaviour, seasonality food preference, crop protection strategies, economic loss estimation and such other issues concerning livelihood and wildlife conservation. Besides this scane sampling and ad-libitum sampling methods (Altamann, 1974) were also used to collect additional information by direct observations. For population estimation of wild animals census data of state

forest department were used. Photography and videography were also done to confirm the presence of vertebrate pests in the study area.

Results

Different vertebrate pests

There are about 47 cultivated plant species were observed cultivated in and around Sariska National Park, Alwar study area, of which 13 are crops, 22 vegetables and 12 horticulture species observed depredated by 25 species of vertebrates. Which includes 14 mammalian and 11 birds species of which langurs, wild boar, blue bull, sloth bear and porcupines are main crop raider of the area (Table 1).

Table 1: List of vertebrates observed during crops depredation in and around Sariska National Park

S. No.	Name	Zoological name	Frequency
1	Hanuman langur	<i>Semnopithecus entellus</i>	High
2	Rhesus Macaque	<i>Macaca mulatta</i>	High
3	Wild boar	<i>Sus scrofa</i>	Very high
4	Blue bull	<i>Boselaphus tragocamelus</i>	Very high
5	Sloth bear	<i>Melursus ursinus</i>	Moderate
6	Hare	<i>Lepus nigricollis</i>	Moderate
7	Porcupine	<i>Hystrix indica</i>	Moderate
8	Flying fox	<i>Pteropus giganteus</i>	Moderate
9	Squirrel	<i>Funambulus pennanti</i>	Low
10	House shrew	<i>Suncus murinus</i>	High
11	House rat	<i>Rattus rattus</i>	High
12	Bush rat	<i>Golunda ellioti</i>	Moderate
13	Mole rat	<i>Bandicota bengalensis</i>	Very low
14	Indian gerbille	<i>Tatera indica</i>	High
15	Field rat	<i>Millardia meltada</i>	High
16	Grey frankolin	<i>Frankolinus pondicerianus</i>	Moderate
17	Grey jungle fowl	<i>Gallus sonneratii</i>	Low
18	Peacock	<i>Pavo cristatus</i>	High
19	Rose ringed parakeet	<i>Psittacula krameri</i>	Moderate
20	Alexandrine parakeet	<i>Psittacula eupatria</i>	Very low
21	Blossom headed parakeet	<i>Psittacula cyanocephala</i>	Moderate
22	House crow	<i>Corvus splendens</i>	Moderate
23	Brahmini starling	<i>Sturnus pagodarum</i>	Very low
24	Rosy sterling	<i>Sturnus roseus</i>	Low
25	Red vented bulbul	<i>Pycnonotus cafer</i>	Low
25	House sparrow	<i>Passer domesticus</i>	High
26	Baya weaver	<i>Ploceus philippinus</i>	High

27	Indian siverbill	<i>Lonchura malabarica</i>	Low
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1. Hanuman langur:

Langurs are highly adaptive animals and feeding upon variety of food items, which includes, natural, cultivated and artificial food. Langurs eat about 121 types of foot items, which include natural and cultivated plant parts and artificial food provided by the people. Cultivated food in the form of fruits, seeds, grains, vegetables, flowers, and parts of garden bushes are commonly eaten. Langurs in and around Sariska National Parkeats 13 crops, 21 types of vegetables and 12 types of flowers and fruits grown in the fields, gardens and orchards around (Plate 1 and Table 2). Langur consumed maximum number of natural food plants in the month of June, which is about 80.75%.



Plate1: crops depredation by wild animals in and around Sariska National Park

Table 2: Frequency of crop depredation by different cultivated plants by vertebrate pests in and around Sariska National Park

Local Name	Botanical Name	Hanuman langur	Rhesus Macaque	Wild boar	Blue bull	Sloth bear
Crops						
1. Momphali	<i>Arachis hypogaea</i>	2	1	1	5	4
2. Sarson	<i>Brassica campestris</i>	5	0	0	0	0
3. Til	<i>Brassica juncea</i>	4	5	5	4	5
4. Chana	<i>Cicer arietinum</i>	3	3	5	4	4
5. Ganwar	Cyamopsis tetragonoloba	5	5	5	4	5
6. Kapas	<i>Gossypium herbaceum</i>	5	5	0	5	0
7. Rizka	<i>Medicago sativa</i>	2	5	4	1	4
8. Moong	<i>Phaseolus radiatus</i>	3	4	4	4	4
9. Ganna	<i>Saccharum officinarum</i>	5	0	4	3	1
10. Jawar	<i>Sorghum bicolor</i>	5	5	5	5	5
11. Genhu	<i>Triticum eastivum</i>	3	2	5	5	0
12. Moth	<i>Vigna aconitifolia</i>	3	4	5	3	3
13. Makka	<i>Zea mays</i>	1	2	2	1	2
Vegetables						
1. Bhindi	<i>Abelmoschus esculentus</i>	5	0	0	0	0
2. Kanda	<i>Allium cepa</i>	4	4	3	4	0
3. Chandalia	<i>Amaranthus hybridus</i>	5	0	5	5	0
4. Ful gobi	<i>Brassica oleracea L. Var. botrytis</i>	5	5	5	5	5
5. Band gobi	<i>Brassica oleracea L. Var. Capitata</i>	4	5	5	5	5
6. Mirchi	<i>Capasicum annuum</i>	5	0	5	0	0
7. Matira	<i>Citrullus lanatus</i>	4	0	5	5	0
8. Dhania	<i>Coriandrum sativum</i>	4	0	5	1	5
9. Kachar	<i>Cucumis melo var. culta</i>	5	0	5	5	5
10. Kakri	Cucumis sativus	5	5	4	5	5
11. Kaddu	<i>Cucurbita moschata</i>	0	0	5	0	5
12. Gajar	<i>Daucus carota</i>	3	2	1	5	4
13. Sakarkand	<i>Ipomoea batatas</i>	3	1	1	5	0
14. Tumbi / All	<i>Lagenaria siceraria</i>	5	0	5	0	5
15. Tori	<i>Luffa cylindrica</i>	5	0	5	0	0
16. Tamatar	<i>Lycopersicon lycopersicum</i>	3	5	4	5	5
17. Pudina	<i>Mentha spicata</i>	5	5	5	5	0
18. Karala	<i>Momordica charantia</i>	5	0	5	0	0
19. Muli	<i>Raphanus sativus</i>	5	4	5	4	0
20. Palak	<i>Rumex vesicarium</i>	5	5	5	5	0
21. Baingan	<i>Solanum melongena</i>	3	0	5	5	0
22. Methi	<i>Trigonella foenum-graecum</i>	5	0	5	5	0
Flowers and fruits						
1. Papita	<i>Carica papaya</i>	5	5	0	5	0
2. Nimbu	<i>Citrus medica</i>	5	0	0	5	5
3. Mango	<i>Mangifera indica</i>	2	5	0	0	5

4. Shahtut	<i>Maruc australis</i>	5	2	0	5	4
5. Kaila	<i>Musa paradisiacal</i>	2	0	0	5	0
6. Tulsi	<i>Ocimum canum</i>	5	0	0	0	0
7. Amrood	<i>Picidium guajava</i>	3	5	5	4	5
8. Anar	<i>Punica granatum</i>	3	0	5	4	5
9. Jamun	<i>Syzygium cumini</i>	2	2	0	0	5
10. Hajara	<i>Tagetes erecta</i>	3	3	5	5	5
11. Hajara	<i>Tagetes patula</i>	2	3	5	5	5
12. Grafted bare	<i>Ziziphus maritian</i>	1	1	5	1	2

Frequency / intensity of crop depredation by vertebrates: 1- very high, 2-high, 3-moderate, 4-low, 5-very low, 0-nil.

2. *Rhesus macaque*:

The rhesus macaque is a most widely distributed macaque found in north and central India. However, its distribution in north India is discontinuous (Krishanan, 1972). From geological standpoint Rajasthan is a very interesting state. The Aravalis diagonally bisect the state into western arid and eastern semi-arid regions. The Thar desert is situated on the western side of Aravallis. This mountain range is the eastern limit of *M. mulatta* and are not found in the Thar desert.

Rhesus macaque is medium sized, with a rather short tail that is uniformly well haired. Crown hairs grow back from the brows, without a part, whorl or cap. The face is light pink, flesh coloured or reddish. The rhesus macaque is diurnal and it feels at home in trees as well as on the ground but less arboreal than several other macaque species. It attacks cultivated fields, orchards and gardens. Both young and old are good swimmers. They are largely vegetarian. Its diet includes leaves, flowers, fruits, berries and seeds of many species of plants, grass and grains, and algae from ponds. It also eats insects and spiders. It is not known to eat small birds, lizards, or similar small animals but in the Sundarbans, it eats crabs. It frequently eats earth (like termite mounds) in small quantities.

2. *Wild boar*:

Wild boar recorded feeding on about 37 species of cultivated plants in and around Sariska National Park study area (Table 2), which includes 11 species of crops, 21 vegetables and 5 species of flowers and fruits. Amongst the crops the Makka (*Zea mays*), Genhu (*Triticum eastivum*), Gunna (*Saccharum officinarum*) and Mungphali (*Arachis hypogaea*), where as in the vegetables Gajar (*Daucas carota*), Shakarkend (*Ipomaea balatas*) and Kanda (*Allium cepa*) are

damaged most by wild boar. Wild boars were observed eating roots, stem, young and mature leaves, flowers, fruits and occasionally whole plants. The frequency of a plant species eaten depends on the degree of success with which the wild boars could invade the fields. In this study all farms were equally vulnerable to crop raids by wild boars. Generally, the farms located immediately after the sanctuary's boundary wall and the farms with poor crop protection strategies are at risk most and receive frequent losses.

3. Blue bull:

Blue bull is well-known voracious herbivores, which is primarily grazer as well as browser. At Sariska National Park blue bull observed feeding on 32 cultivated plants species including crops, vegetables and fruit trees (Table 2). Like Ganwar, Genhu, Chana, Moong, Rizka, Makka, Moth, Ganna, Kakri, Tamatar, Band gobi, Ful gobi, Matira, Amrood, Anar, Papita and Hajara all are equally and frequently vulnerable to blue bull. Amongst horticulture, the Grafted Beer and Amrud is the most common victim because of their large-sized leaves and fruits. They also like local fruits grown in the agriculture fields like Papita, Banana and Anar. Without exception every one in the village reported that Bluebull brings most damage to their standing crops as they raid crops quite frequently. Makka, Richka, Dhaniya and Gehun is the most preferred crops as they frequently raid wheat fields and eat before grain rips. Raira is the least damaged crop amongst the vegetable and fruit trees. It was also found that they do not leave any opportunity to invade cabbage and tomato fields.

4. Sloth bear:

Sloth bears manage to get cultivated plant food from ground as well as from trees above the ground. Some 28 cultivated plants species were observed consumed regularly or occasionally by sloth bear in different seasons in and around the sanctuary. Amongst crops the makka, ganna and moths are most preferred and grafted ber and shahtouts are preferred horticulture plants, damaged by sloth bear (Table 2). Sloth bear is an opportunistic feeder. It eats whatever if laid hand on in different season in the cultivated fields. Usually, they raid the crops in the nights.

5. Others:

With the above large vertebrates there are many small mammals and birds depredating crops regularly. All most all the cultivated crops and fruits are depredating by these medium and small vertebrates (Table 2). This includes hare, porcupine, flying fox, squirrel, shrew, gerbils,

house rat, bush rat, mole rat and field rat. Besides mammalian pests there are large number of birds, which frequently invade the crop fields and orchards like peacocks, partridges, grey jungle fowl, parakeets, crows, bulbuls and sparrows. Amongst the crops Ganhu, Chana, Makka, Gwar, Moong, Moth and amongst the flowers and fruits Anar, Bare, Hajara depredated most by the bird.

Vertebrate pest populations: Large herbivours and omnivours have a fairly good population and distribution in the Sariska National Park. They can spot in the sanctuary very easily during early morning, in evenings and even in the day times (like langurs). Total 7 large mammalian herbivore and omnivore species observed regularly in and around Sariska National Park like Hanuman langur (*Semnopithecus entellus*), wild boar (*Sus scrofa*), blue bull (*Boselaphus tragocamelus*), sloth bear (*Melursus ursinus*), sambar (*Cervus unicolor*), chinkara (*Gazella bennetti*) and chowsingha (*Tetracerus quadricornis*). Of which the Hanuman langur (*Semnopithecus entellus*), wild boar (*Sus scrofa*), blue bull (*Boselaphus tragocamelus*) and sloth bear (*Melursus ursinus*) are the main pests of crops and their populations shows a increasing trend in the census from 1986 to 2000. Whereas the population of sambar (*Cervus unicolor*), chinkara (*Gazella bennetti*) and chowsingha (*Tetracerus quadricornis*) is showing a decline or static with marginal increase in the population (Table 3).

The population of sambar shows marginal growth because they sometime visits farms and orchards. Similarly, chinkara population is also note exposed to crop fields visits because of very limited agricultural and horticultural activity in their home range so they shows slight decline in their population. Chowsingha has never seen in any crop field during this 6 year long term study proves that, they are not depraved or visited crops fields in and around Sariska National Park. As a result with so much of food competition by grazing pressure very little natural food is available to them which is may not be sufficient to increase their population and shows a drastic decline of 184 animals from 259 in 1986-87 carcasses to 75 census of 1999-2000.

Crop protection strategies and loss

To protect crop fields and orchards from different vertebrate pests' farmers use many methods. On the basis of questionnaires and visual observations the methods for crop protection are calculated in percentage, which is shown in Text fig. 4. These methods include patrolling the fields, keeping dogs, fencing with thorny twigs, barbed wire fencing, displaying colour cloths, shot gun, potash bomb etc. The most commonly used crop protection strategy in guarding their fields by constant day night vigilance during crop reasons. This method is used by 71% of the

farmers in the study area. Few farmers (about 20%) using trained dogs for crop protection and to chase the wild animals away. While the remaining 9% of farmers use other methods including dangerous methods like single shotgun, potash bomb and high voltage electric current in which wild animals are usually killed or seriously injured. Along with above methods all the farmers commonly use thorny twigs and branches of *Prosopis juliflora*, *Acacia nilotica*, *Ziziphus nummularia*, *Z. mauritiana* and some time naturally grown *Euphorbia caducifolia*. Despite all these measures of crop protection the vertebrates' pests do manage to invade the crops.

The annual economic loss to farmers calculated in the study is about Rs. 1,25,500 to 1,35,000 from all the 25 farms every year. In addition to this the cost of crop protection for each farm ranged between Rs. 10,000 to 15,000 per year to each farm, which comes between Rs. 2,50,000 to 3,75,000 annually for all the 25 farms. Therefore, the monitoring cost to a farmer comes more than the cost of crop damage.

Discussion

Since the primary occupation of the villagers in and around Sariska National Park is agriculture and horticulture and the increasing population of vertebrates' pest increases the man-wildlife conflict many times in the recent past. Wildlife conservation and crop damage by vertebrate pests is obviously a management priority.

The commonly used method for the crop protection in and around Sariska National Park is guarding the cultivated field. For successful guarding it is required that people should have been in the fields during the seasons when the crops were most vulnerable, through out the day and night. Obviously, this was not possible because people had many other works to do. It was also found that many times 4-5 farmers hire a person or persons (depend on farmers groups) to guard their crop fields, and share the cost of guarding fields. This practice is the most common amongst all crop protection strategies. It was also noticed in the last 6 years, that attitude of peoples towards the conservation of area and wildlife has changed considerably. Earlier there were few demands for gun licenses, but now this demand has increases considerably which is mainly to protect their agricultural and horticultural fields from wildlife attacks. In majority of cases, we found farmers depend on their crop/horticulture/produce for survival. Such attitude of peoples is not restricted to the study area only but in many other areas as well. This man-wildlife conflict issue related to people's attitude towards falling conservation interest of people in India, Africa and United States (Sukumar, 1985; Infield, 1988; Balasubramanian et.al, 1993; Conover and Decker, 1991; Chauhan and Sawarkar, 1989).

In most of the parts of the Sariska National Park, the heavy damage to the cultivated fields is in the area with high population of particular mammalian pest. Similarly, the over abundant population of mammals create the same problem in another studies Chauhan and Sarvarkr, 1989. A very little information is available on bird damage and its management (Swaminathan and Verma, 2000). This is for the first time the crop loss by birds is also documented in this study along with the list of birds' pests. There seems to be no permanent method to protect the cultivated fields from rodents and birds, except by their natural potential predators. Some horticulture plant species like Papita, Anar, Amrood can be protected from the birds by method suggested by Swaminathan and Verma (2000).

There is an urgent need for better management of human-wildlife conflict and for this, if necessary, a vertebrate pest species can be controlled by culling, as suggested in other studies (Dasmann, 1979; Long and Wood, 1976; Chauhan and Sarvarkar, 1989).

Conversion of forestland into cultivated fields, monoculture plantation, exotic species, unwanted developmental activities like road and dam. For which clearing of forest area forced wild animals to move towards cultivation fields. In absence of natural food, the wild animals are looking for food in the cultivated fields, which was their original habitat. This shrinking of natural habitat by man has created a civil war between wildlife and humans. The better management of this problem is responsibility of government by protecting natural habitats and restricting unwanted developments.

Habitat Contamination by the Pesticides

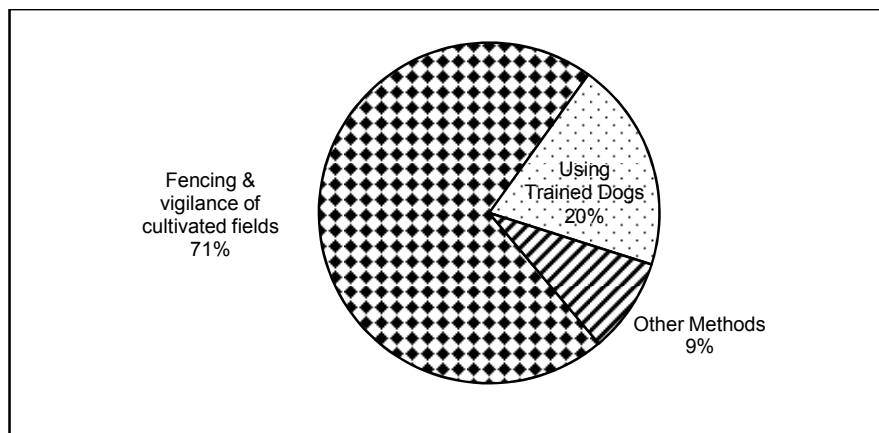
Another potential threat which has been quite neglected by the wildlife researchers till date is pesticide contamination through the consumption of the pesticide contaminated food and water by vertebrate pests. This aspect needs to be highlighted here is the pesticide contamination of the environment leading to the decline in the population of the animals especially by organochlorine pesticides (OCPs). Since many animals live in water and on shores and thrive on fishes and other aquatic animals therefore, they get exposed to OCPs because of bioconcentration and biomagnification of these xenobiotics. Here an example of bald eagle from USA needs to be considered. The bald eagle is the North American species with a historic range from Alaska and Canada to northern Mexico, is the national bird of the USA which has been an endangered species for many years. The reasons being the Habitat destruction and degradation, illegal shooting, and the contamination of its food source, because of DDT contamination, there is a decline in the eagle population, The banning of DDT by the Federal government of USA and related pesticides,

habitat protection done by the Endangered Species Act, and conservation actions taken by the general American public have helped bald eagles to survive. Nevertheless DDT and its residues contaminated nearby water areas, where aquatic plants and fish absorbed it and biomagnified it. Bald eagles, in turn, were poisoned with DDT as and when they consumed the contaminated fish. As a consequence, their eggs had shells so thin that they usually broke during incubation or otherwise failed to hatch at all. DDT contamination and its residues also affected other species such as peregrine falcons and brown pelicans. Many Other pesticides having the same structure as DDT are suspected to have caused increased death, in addition to the harmful effects on reproduction. By 1963, with only 417 nesting pairs of bald eagles existing, the species was facing the danger of extinction. At the time, a controversial step of banning the use of DDT and some related pesticides in the United States was taken by the federal government of the USA. That was in 1972, and it was the first step on the road to recovery for the bald eagle (U.S. Fish & Wildlife Service Migratory Bird Program, February 2021). This shows how dangerous DDT contamination is how disastrous it can be for the avian fauna. More scary studies have indicated that we have largely over looked the darker side of these chemicals as OCPs are reported to be carcinogenic (Mathur et al, 2002 & Ingber et al 2013) mutagenic (Ingber et al 2013&Yaduvanshi et al 2012) teratogenic (Yaduvanshi et al 2012 & ATSDR. Atlanta, GA.1994) immunosuppressive (Repetto. R & Baliga. S.S, 1997 & Corsinia et al, 2003) create endocrine dysfunction such as hypothyroidism or high estrogenic activity (Dewailly et al, 2000 & Rathore et al, 2002) disturb reproductive processes (Pant et al ,2007 & Tiemann.U. 2008) growth depressants (Colborn et al, 1993&Mercier. M, 1981) induces several psychogenic and neurogenic abnormalities in adult stages (Mactutus & Tilson, 1986 & Van Wendel de Jood et al,2001) and are associated with abortions, premature deliveries, still births and infants with low birth weights (Saxena et al, 1981; Saxena et al, 1980; Tyagi et al 2015; Chen. Q et al 2014 & Sharma & Bhatnagar, 1996). OCPs have been in use in India nearly for a half century now. Even after having clear cut evidence suggesting that these chemicals have the ability to eliminate entire species from the planet, the annual consumption of pesticides in India is about 85,000 tons of which OCPs comprise the bulk (India Environment Portal Knowledge for change, 30/10/1998.). Therefore, today OCPs are perhaps the most ubiquitous of the potentially harmful chemicals encountered in the environment and are still widely detected in humans despite the considerable decline in environmental concentrations (Dewan et al. 2003). This kind of environmental Contamination with organochlorine pesticides (OCPs) has also been reported by Sharma and her coworkers in 1996, from Jaipur City. She reported contamination of human samples like mothers' blood, cord blood,

placenta and mothers' milk with OCPs. Presence of pesticides with OCPs shows that how these xenobiotics have contaminated our Mother Nature and now faunal diversity is facing danger of existence and Smooth-coated Otters is not staying away from this potential danger. It can be concluded that the magnitude of pollution is quantitatively enough to contaminate the food and environment and reaching out to all faunal diversity. It can be concluded that the magnitude of pollution is quantitatively enough to contaminate the food and environment and the pesticides reach the human body through various sources mainly by absorption from the gastrointestinal tract through contaminated food chain, are circulated in blood, stored milk and secreted during lactation resulting in sufficient neonatal intake. The battle against the harmful insects would be much less costly and more efficient, and the problem of contamination of the environment by toxic materials would be vastly reduced, if insect activities are controlled by natural means. The use of pest-specific predators; parasites or pathogens; sterilization of insects with the help of radiations; trapping insects using insect attractants like pheromones; use of juvenile hormones or hormone inhibitors may therefore be suggested as alternate ways of pest control (Sharma, 1996; Sharma & Bhatnagar, 1996 & 2017, Sharma, 2018).

Management strategies & Recommendations

The crop raiding activity by different wild animals pose a significant threat to agriculture and horticulture products and thus farmers' livelihood along the immediate periphery of Sariska National Park are at high risks. To reduce the animosity towards wild animals and prevention of agriculture horticulture loss by variety of vertebrate pests is obviously a management priority. Following are the recommendations for controlling crop damage and wildlife management strategy.



Text figure 4: Different crop protection strategies used by farmers in and around Sariska National Park

1. **Habitat protection**: Government and people must respect the wildlife habitats during developmental activities like agriculture, horticulture, construction of roads and dams within or on the periphery of the wildlife sanctuaries and national parks. Such activities cause the destruction of forest with serious impact on wildlife, which force them to feed in the cultivated fields. There is an urgent need to understand the impacts of such activities and to stop these interventions in the most critical wildlife habitats. For this a social, political and legal monitoring is needed to stop such human activity which causing lost of biological diversity of Sariska National Park.
2. **Fencing**: Fencing with local material like *Prosopis juliflora* branches or *euphorbia caducifolia* as bio-barriers, which are successful against blue bull, wild boar and sloth bear. If the farms boundary has no tree on its periphery, then this method is useful to keep the langurs outside the farms, otherwise they can come in to farm through the trees. This is the cheapest and most effective method to protect the crops and such boundaries can be made more effective without much cost. Stonewall is more effective but for the farmers who can afford the cost. Electric fencing, which gives a non-lethal electric shock, is effective against all vertebrates but costly for a marginal farmer.
3. **Guarding**: Vigilance during the crop season is the cheapest way of crop protection with the help of stick, noise, shout, etc. This is the most successful strategies for controlling the crop and horticulture damage by different vertebrates particularly for langurs, blue bull, wild boar, sloth bear, but it is not so effective against small mammals like rodents, flying fox and birds.
4. **Trained Dog**: Use of trained dogs can scare the many major crop raiders like langurs, wild boar, blue bulls and other small mammals to keep them out of field and occasionally can grab young one. Barking of the trained dog definitely deter the vertebrates' pests and also warns the farmer to act upon the vertebrate's pest.
5. **Protection through covering**: Covering made of paper; polyethylene, nylon and gunny bags can reduce the damage of costly horticulture products from birds and rodents. These are the best protection methods and can be used of different size depend on the size of fruits. This method can very beneficial and effective to fruits like Papita, Anar and Kaila against squirrel, parakeets and flying foxes.

6. **Revival of natural cycle**: By stopping destruction of nesting trees of raptors, owls and conserving snakes the population of small vertebrates' pests like rodents and birds can be controlled naturally. For example, by protecting a nest of spotted owl we can protect a pair of owl, which needs on an average 4 mouse in a day, by this pair can eat 1460 mouse in a year. Similarly, if we save a nest of Eurasian eagle owl pair, which needs on an average 10 mouse in a day, this pair can reduce pest species up to 3650 in a year. Such natural controls are eco-friendly and very effective, needs no money.
7. **Biological control**: Sterilization of male animals particularly langurs and blue bull is effective because socially they live in harem system in which one adult male and several adult females lives in a group. This method definitely controls the population of vertebrate pests lives in social groups.
8. **Translocation**: Translocation is considered as the best wildlife conservation and management tool. Through this the problem creating vertebrates can trapped and translocated to their original habitat from cultivated area or they can be rehabilitated to such other habitats where their population is declining.
9. **Culling**: Although it is hard to suggest in a country like India where many wild animal species are an integral part of religion, cultural and environmental heritage. Selective reduction of excessive wildlife pest populations would normally be logical, long range and globally used wildlife management procedure and it is a long-range solution. As in the case of a man-eater carnivorous like tiger or panther is in practice. Although hunting is prohibited and legally banned but realizing the severity of the crops and horticulture damage in the area like Sariska National Park where the marginal and poor farmers are cultivating food grains for their survival. Therefore the culling of selective and identified animals with local acceptance of community and by the trained wildlife experts of forests department or professional hunters hired by forest department is possible. Because the overall objective of hunting is to keep the vertebrate's pest's numbers within a sizable population, so the crop loss can be controlled for the survival of poor farmers.

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