REVIEW ARTICLE

Ecological and economical impact of Bats on ecosystem

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ABSTRACT

In an ecosystem diversity of organisms interact with each other and the species are evolving to increase their ability to withstand the rigors of the environment. Major ecosystems of world had threatened by human interference. The report emphasized in particular on beneficial role of bats in the environment as bats contribute in the maintenance of ecosystem. Bat species provide ecosystem services through pollination, seed dispersal and insect control, most importantly in tropical forests. The frugivorous bats plays vital role in the maintenance of species-rich tropical forests because of long distance dispersers of tropical seeds. Insectivorous bats, in particular suppress insect population in the environment, in agro ecosystem particularly as primary predators and natural controllers of night flying insects.

Key words: Bats, ecosystem services, seed dispersal, insect control, fertilizer.

INTRODUCTION

Highly modified environments consequently struggle for maintaining the population of native fauna and flora. Environment is constantly changing a perfect organism. Species diversity linked to ecosystem structure and function in which organism and population interact with each other. Many scientists believe that species diversity is essential for the proper functioning of communities. In community, the mix species of flora and fauna grows together in an area. Species in the community are evolving to increase their ability to withstand the rigors of the environment. When the sources of a disturbances i.e. storms, floods, pests, fires and human induced changes are removed from a ecosystem then the system is expected to return to its previous state.

Main reason of the extinction of species of flora and fauna are that certain individual in a population survive and reproduce, while other dies without leaving offspring. Another reason is that, not enough of some environmental resources i.e. food, water, minerals, disease-resistant ability etc. to go around. The availability of resources in the environment is limited and at that rate individual organism can reproduce and survive. Today, this diversity of life is facing serious

threats. The extinction crisis is enormously seen in tropical forests i.e. 60 percent of plant species are threatened with extinction. Plant species and subspecies are in danger of extinction in their wild habitats.

The loss of species and genetic diversity and degradation of habitats of flora and fauna are the serious questions of ecosystem. Natural ecosystem throughout the world had become increase threatened by human-generated factor such as urbanization, mining, deforestation, chemical and light pollution. Conservation managers reduce the disorder and create undisturbed environment. These different types of conservative system from government have prevented the balance of ecosystem from exterior disturbances. All these government agencies have introduced the role of greater and valuable mammals i.e. bats. Scientists studied and explaining the role of different feeding habits of bats i.e. insectivorous, frugivorous, nectarivorous, omnivorous and carnivorous towards the ecosystem. In this paper, our special concentration is on the beneficial role of insectivorous, frugivorous, nectarivorous bats and its guano also.

Healthy ecosystem are especially important in providing various ecosystem services such as insect-suppression, pollination, seed dispersal, purification of water and air, stabilization of soils, decomposition of waste, binding of toxic substances, nutrient cycling, soil formation and cultural benefits (i.e. spiritual, educational and recreational) that improve human well being. Ecosystem services depending on the ecosystem and the organisms that they constitute. Ecosystem services are the benefits that human obtain from ecosystem for their well-being. Bats contribute its role in the maintenance of ecosystem stability. Bat species provide important ecosystem services by pollinating flowers, dispersing seeds and consuming insects. Thus, bat species playing central roles in the maintenance and regeneration of forest and other ecosystem. Bats provide value to ecosystem as primary, secondary and tertiary consumers that support and sustain both natural and human dominated ecosystem. Of all the bats around the world, approximately seventy percent are insectivorous, nearly thirty percent eat nectar or fruit, ten species are carnivorous, two species are fish-eaters and only three species the common vampire (Altringham, 1996). They are among nature's most beneficial animal and without them, thousands of flora and fauna affected by their absence and threatening entire ecosystem from rainforests to deserts. But some species of bats have become locally or regionally extinct. In recent time, increase unfavorable activity such as destruction of forest and other terrestrial ecosystems, disturbance to caves, depletion of food resources and increased use of pesticide.

Bats have evolved an incredibly rich diversity of behavioral, roosting and feeding habits. Many species of bats occupy in caves and cave-like structure such as tombs, mines. Other roosts are also in tree-cavities and foliage. Bats provide many ecosystem services i.e. food and guano for fertilizer and through contributions to medicine and culture. Humans derive indirect benefits from bats through arthropod suppression, forest regeneration and maintenance, seed dispersal and pollination of a wide variety of ecologically and economically important plant. Consumptive goods provided by bats such as food and guano are often exchange in market, where the market price indicates an economic value. Information on the ecological and economic value of ecosystem services provided by bats can be used to inform decision regarding where and when to protect or restore bat population and associated habits as well as to improve public perception of bats.

Tropical forests are notably dependent on fruit-eating birds and mammals for dispersal of their seeds. Seed dispersal by animal is advantageous in tropical habitats for at least three important reasons; first, it allows seeds and seedlings to escape from such natural enemies as invertebrate and vertebrate seed- eaters, herbivores and fungal pathogens. Second, it reduces the competition seedlings would experience if they germinated at high densities around the parent plant. Thirdly, widespread dispersal by creatures as mobile birds and mammals allows plant to colonize in new habitats.

Two families of bats i.e. Phyllostomidae (New World bats) and Pteropodidae (Old World bats) contain over 100 species of fruit eaters responsible for dispersing seeds from hundreds of species of tropical trees and shrubs. Many of these bats also pollinate a broad variety of plants, including a large number that are commercially valuable. By virtue of their abundance and highly mobile lifestyle, these animals play an essential role in the seed dispersal ecology of tropical forests.

The bat is a very reliable visitor to fruiting plants and finds nearly all of the ripe fruits. As a result, seeds are separated from fruit-pulp when they pass through the bat's gut and are then excreted in a manner that reduces their vulnerability to destruction by fungus. Certain seed species actually have higher germination rates after they have passed through the guts of bats. Because of abundance numbers of frugivorous bats are dispersing, enormous numbers of seed throughout the forest each night. So that, the frugivorous bats plays an extremely important role in the regeneration of forests in the disturbed habitats. In the absence of fruit-eating bats, reforestation of cleared areas will become much more difficult and a significant number of tropical trees and shrubs will lose as well as most valuable plants may be seriously jeopardized. Frugivorous bats play a vital role in the maintenance of species-rich tropical forests because of their unique lifestyles and most effective long distance dispersers of tropical seeds. This is particularly true of Old World flying foxes (especially species of *Pteropus*), which can carry seeds to many miles i.e. between islands in the Southeast Pacific.

Insectivorous bats, in particular play critical roles in many ecosystems by suppressing insect population in both natural and human-altered landscapes. Bats play key ecological roles as primary predators and are the most important natural controllers of night flying insects (Bat Conservation International, 1989). The loss of insectivorous bats are multiplied the insect-pests at an alarming rate and humans increasingly dependent on pesticides for controlling the numbers of insects. The economic value of pest-suppression services are provided by Brazilian free-tailed bats for the production of cotton in texas. Bat provided pest-control services i.e. reduced the pesticide application and avoid crop from damage by insect-pest.

Guano (faecal matter) is actually an excellent fertilizer. Guano is not only a rich fertilizer for crops and other plants, but it also supports whole ecosystem of organism which may be commercially important for humans. Recent research indicates that the guano contained many different types of bacteria, which may actually efficient for breaking down industrial waste (Documentary, 1992).

So bats are rely important role in agro forestry in the form of insect suppression and regulating the uses of pesticides by farmers. Frugivorous bats are the well-equipment to disperse tree-seeds throughout the man-made and natural ecosystems. Bats are again helpful for carry a large pollen loads at a considerable distances. Guano of bats is again very beneficial for increasing the yield of crops. So that, the different types of feeding habits of bats i.e. insectivorous, frugivorous and nectarivorous are beneficial for pollination, seed dispersal and maintaining the genetic continuity of plant population as well as excretory matter of bats are guano are also important to increasing the productivity of agro forestry. So protect the bat roost populations and improve public perception of bats.

DISCUSSION

Bats are well-equiped to disperse tree seeds far and wide through a forest (Allen, 1996). Fruit and nectar-eating bats play a vital role for the survival and preservation of these rain-forests and maintaining the stability of World climates. More than 100 species of fruit eaters are responsible for dispersing seeds from hundreds of species of tropical trees and shrubs. Without the role of bats to pollinate flowers or disperse seeds, the diversity of rainforest animals and plants would be greatly reduced and threatening the ecological balance. For example, In West Africa, bats carry 90-98% of the seeds of "Pioneer plants". Due to seed dispersion by bats, the trees and shrubs grows rapidly and attract other mammals and birds for seed dispersion of different plants. Such cycle of rainforest regeneration might never take place without bats (BCI, 1989). Furthermore, many of our cultivated crop plant still rely on bats for their survival. Even though most of these plants are now commercially cultivated. Ecologically and economically the large important angiosperms group of plants are pollinated by the frugivorous bats.

Bat pollination occurs in approximately 250 genera. Bat pollination is relatively common in certain angiosperm subfamilies. A small but ecologically and economically important group of plants are classified in 28 orders, 67 families and about 528 species of angiosperms are pollinated by nectar-feeding bats. Nectar bats play an important role in maintaining the genetic continuity of plant populations and thus have considerable conservation value. Flower-visiting bats provide two important benefits to plants. They deposit

large amounts of pollen and a variety of pollen genotypes on plant stigmas as compared with many other pollinators, such as insects.

Bats are much larger and have greater energy requirements because of their endothermic metabolism. Bats use a variety of sensory modes, including vision, olfaction and echolocation to locate flowers. Both groups of plant-visiting bats have senses of smell and use olfaction for long-distance detection of flowers; (Marshall, 1983; von Helversen, 1993). Bats are potentially more reliable visitors and they have the ability to carry large pollen loads at a considerable distance and play important roles as pollinators and seed dispersers in tropical and subtropical habitats throughout the World (von Helversen 2003). These ecosystems services are provided primarily by bats in two families, Pteropodidae in the Old World and Phyllostomidae in the New World. Current information suggests that Pteropodidae evolved in Asia about 56 million years ago, whereas Phyllostomidae evolved in the northern Neotropics about 35 million years ago. Only 15 species in six genera are morphologically specialized nectar-feeders in the Pteropodidae and other members of this family are primarily fruit-eaters such as *Cynopterus*, *Epomophorous* and *Pteropus*. Bats such a *Pteropus giganteus, Syconycteris australis*, *Nyctimene robinsoni*, (Singh and Bhatti, 1993; Birt *et. al*; 1997 and Jackowiak *et. al.,* 2009) contain a diverse array of feeding adaptations, but over one half of its species is plant-visitors. About 38 species in 16 genera are specialized for nectar-feeders, 90 species in 22 genera are primarily frugivorous. Pteropodid bats are known to pollinate flowers of about 168 species in 100 genera and 41 families. Phyllostomid bat pollinate flowers of about 360 species in 159 genera and 44 families. Flying foxes of the genus *Pteropus* (Pteropodidae) are important pollinators and seed dispersers in oceanic-island ecosystem (Cox *et. al;* 1991, 1992 and Rainey *et. al*; 1995). Their role is crucial for maintaining community diversity by the regeneration and genetic flow of dominant forest trees. Six plant families (Sapotaceae, Mrytaceae, Moraceae, Combretaceae, Febaceae and Sapindaceae) were particularly important to flying foxes in Samoa.

Bats, along with many other flower-visiting and fruit-eating animals, provide important mobility for plant gametes. One of the most important ecological services that bats provide for their food plants is long-distance dispersal of pollen and seeds. In most seed dispersal system, the seeds are dispersed close to parent plants with only a few meters away i.e.100 t0 1000s meters. But seeds dispersed by frugivorous bats undoubtedly provide relatively long seed-dispersal distances. For example in Central Panama, the Jamaican fruit bat *Artibeus jamaicensis* carries single fig fruits 100-250m away from fruiting plants. Bat-dispersed palms and figs are very common in most of the tropical forest. Figs are important bat-fruit throughout the tropics. Bat dispersed, soft-fruited species of *Cecropia*, *Piper*, *Solanum* and *Vismig* are critically important pioneer species. Fruit-eating Phyllostomid bats thus play an extremely important role in forest regeneration in the New-World.

Many species of nectar or fruit eating bats annually migrates between a series of landscapes and these movements are driven by seasonal fluctuations in the availability of flower or fruit resources. For example, In Western Mexico, many individual of lesser long-nosed bat, *L. yerbabuenae* spends the fall and winter in tropical dry forest where they mate. Here they feed on the flowers and fruit of dry tropical forest trees and shrubs. In the spring, many female migrate upto 1,000 km north, where they feed on flower and fruit of columnar cacti. In late summer and early fall, females and their offspring move into upland areas of Southern Mexico, where they feed on the flowers of *Paniculate agaves* before migrating south again. Similarly, some frugivorous Phyllostomid and Pteropodid bats undergo altitudinal or latitudinal movement. This is especially true for vertebrate as pollinators and seed dispersers for the reproductive success of their plants.

Many of our cultivated crop plants still rely on bats for their survival, these includes fruit such as banana, avocades, dates, figs, peaches and mango. One early study describing the economic importance of bats, in which identify 289 Old World tropical plant species that rely on the pollination and seed dispersal services of bats for their propagation. These plants, in turn contribute to the production of 448 bat-dependent products in a variety of categories, including timber and other wood products (23%), food, drinks and fresh fruit (19%), medicines (15%), dyes, fiber, animal fodder, fuel wood, ornamental plants and others. However, bat-provided services represents one input within a multi-input production process, so the expansive role plays by bats in the production of goods that contribute to human well-being. Majority crops species i.e. 87 primary crop species depends to some

degree on animal pollination; i.e. bees, birds, bats and other insects. In particular, bats are important pollinator for durian (*Duriozibertinus*), star apple (*Chrysophylum cainito*) and velvet bean (*Mucuna pruriens*). In the New World, two families Agavaceae and Cactaceae and many species of Paniculate Agave have enormous economic and ecological value and rely heavily on Phyllostomid bats for pollination. Other species of Agave are used locally to produce similar alcoholic beverages. Agaves are also important sources of sisal fiber in many tropical localities.

The tropical almond tree, *Terminalia catappa* is an example of a bat-dispersed tree with many human uses. This tree is dispersed by *Cynopterus* bats throughout Asia. Old World fruit-bat *Cynopterus sphinx* is highly mobile and potentially more reliable for visitation, because of their endothermic metabolism can carry large pollen loads to long distance. They also disperse small seeds upto hundreds of kilometer and perform an important role in transporting zoochorous seeds to remote areas in both mainland as well as islands. Almond tree is an example of a bat-dispersed tree with many human uses. In India, it is important in coastal communities where it provides shades, fuel-wood and edible nuts. The timber derived from almond trees makes a decorative general-purpose hardwood and making furniture. Tannin id extracted from the bark, leaves, roots and the fruit-shell. The large leaves are also used as wrapping material and have many medicinal uses including anti indigestion and anti dysentery. Young leaves are used to cure headaches and colic. A black dye is obtained from the bark, fruit and foliage. Its leaves and bark have a wide range of other medicinal uses. In the Philippines, a wine is made by fermentation of mature fruits.

In India, the Mahwa tree (*Madhuca indica*), also called the Honey tree, Sugar tree or Indian butter tree is pollinated by *Pteropus giganteus*, *Rousettus leschenaulti* and *Cyanopterus sphinx*. The timber of this tree is used for making wagon wheels in India. Mahwa is incorporated into soaps, candles, cosmetics (e.g. Lipstick, lotions) and medically used in the treatment of Leprosy. Extracts from the fruits are also thought to prevent wrinkles and restore skin flexibility. Seedcakes made from *M. Indica* are used as food for cattle and goats and are helpful to increase their milk production. Sun-dried fruits are directly consumed by humans and the oil extracted from flowers and seeds known locally as mahwa. Due to both effective processes i.e. seed disperse and pollination, new plant again are regenerate, grow and become mature. Attract hungry bats towards mature plant and repeat the continued cycle of reforestation process. In the absence of fruit-eating and nectarivorous bats, reforestation of cleared areas will become much more difficult. Most valuable plants may be seriously jeopardized and tropical important trees and shrubs will loss.

Protection of migratory pathways and critical feeding areas of migrants must be major conservation goals of government. Some of the nectar and fruit-eaters bats play especially important roles in the pollination and dispersal biology of trees, vines and shrubs in oceanic islands where reduced biodiversity and unbalanced faunas are available. Means the greatest conservation of islands faunas are takes place by bat species. Regional economy is affected, when the service of animal-pollinator is being completely lost and the productivity of pollinator-dependent crop declining. Once again, a greater economical value of pollination services is provided by bats. Only increased efforts are needed to educate government agencies, industries, international corporations and the general public about the ecological and economical value of plant-visiting bats and other native flowering and fruit-eating trees.

Insectivorous bats are generalist predators, feeding on a wide diversity of taxonomic group. They are opportunistically consuming appropriately sized prey according to its availability within a preferred habitat. Most insectivorous bats eat large quantities of Lepidopterans (moths), Coleopterans (beetles), Dipterans (flies), Homopterans (cicadas leaf hopper) and Hemipterans (true bugs). Some species also eat unusual prey items such as scorpions and spiders. Various species of prominent agricultural insect pest have been found in the diets of bats. These insect include June beetles, Click beetles, leaf hoppers, plant hoppers, the spotted cucumber beetle and the green stinkbug. In the Midwestern United States, annually consumes approximately 600,000 cucumber beetle, 194,000 June beetles, 158,000 leafhopper and 335,000 stinkbugs. Average-sized bat colony could prevent the production of 33,000,000 cucumber beetle larvae.

The loss of insectivorous bats are multiplied the insect-pest at an alarming rate. All these insect-pest are very harmful for crop and they damage or destroy

agricultural cultivated crop region such as June beetles, Leafhopper and Plant hopper, Stinkbugs, Cut worms, Gypsy moths, Spotted cucumber beetles etc.

1) June beetles: Adults are herbivorous and have the potential to defoliate trees in large numbers. Their larvae, White grubworms attack the roots of grasses and various crops such as Corn, Wheat, Oats, Barley, Sugarbeets, Soyabeans and Potatoes.
2) Leaf hoppers and Plant hoppers: These true bugs are vector of plant pathogens such as Rice dwarf, Maize mosaic viruses and bacteria. Leafhopper and plant hopper are the serious agricultural pests of Potatoes, Grapes, Almonds, Citrus and Row crops.
3) Stinkbugs: Serious pests of various crops including Apples, Pecans, Soya beans, Cotton, Field corn, Peaches and vegetables. Stinkbugs pierce plant tissues.
4) Cut worms: Destructive garden pests, causing fatal damage to nearly any type of vegetable, fruit or flower.
5) Gypsy moths: Serious pests of several hundred species of trees, bushes and shrubs.
6) Spotted cucumber beetles: Serious pests of Corn, Spinach and various Cucurbit vines.

Insectivorous bats is the natural predators, which provided the benefits to the agro forestry by the consumption of millions crop-insects. So, the economic value of the pest-suppression service is provided by insectivorous bats. The percentage of the application of synthetic pesticides become minimized from farmers and safer the human health risks from harmful toxicity. Thus, the benefits provided to the agro forestry by the consumption of millions insects by bats and shows high activity levels in several agricultural forestry. So, Pimentel *et. al;* (1997) concluded that 50% reduction in pesticides use and provided that biological, cultural and environmental pest control technologies in replacement of pesticides. Pesticides application rate reduced due to high bat predation rate and bats provide a direct contribution of regulating service on pest-control for the great agricultural production. Due to the biodiversity of insectivorous bats from forest to open space land e.g. Coffee plantation and agricultural field, they perform their greater role to control the insect-pest numbers in agricultural areas. They are also maintaining their population and provide an important ecosystem service to the farmers (Estrada and Coates- Estrada 2002). The ecological and economic impact of insectivorous bats on ecosystem is that abundant quantity of insects eaten by insectivorous bats.This bat save the thousand of rupees of farmers, which are specially utilized for the applications of pesticides needed to control of a variety of crop-insect.

Highly adapted insectivorous bats such as *Miniopterus scheribersi fuliginosus* and *Pipistrellus savii* (Park and Lee 2009), *Rhinopoma kinneari* and *Scotophilus heathi* (Agarwal and Gupta 1982), *Pipistrellus pipistrellus* (Pastor *et. al;* 2004) and *Myotis macrodactylus* (Hwang and Lee 2007) studied by different zoologist. They were specially noticed that all of these insectivorous bats are very important for agricultural as well as coffee plantation.

Of, the approximately 900 insectivorous bat species, the Brazilian free-tailed bat, *Tadarida brasiliensis*, provides one of the most impressive examples of continental-scale natural pest suppression in the World. Brazilian-free tails are known to consume a wide variety of prey items (including 12 orders and 35 families). Numerous studies indicate that moths (Lepidoptera) are their primary food source and other agricultural pests such as corn earworm or cotton bollworm moth and tobacco budworm moth (Cleveland 2006). Thus, the benefits conferred to agriculture by consumption of these moths by bats may not be limited to their local foraging areas but may extend to agricultural landscapes hundreds of kilometers away.

In agricultural systems, many insectivorous bats are specially habitat, e.g. Organic farms in the United Kingdom, Shade cacao plantation in Brazil, Olive orchards in Greece, Midwestern agricultural land, cereal crops in England, Arboreal crops in Mexico, agricultural riparian areas and still relatively common in rural-areas of South-eastern Australia. The lesser Long-eared bat (*Nyctophilus geoffroyi*) and Gould's Wattled bat (*Chalinolobus gouldii*) were highly selective in the location of their roosts in the landscape, in roost-site selection in roosting behavior and responded differently to different level of roost availability. Gould's Wattled bats mainly lives on trees for roosting while long-eared bats used a broader range of roost sites such as under bark, (Lumsden *et, aL*; 2002). These and other agro ecosystem, where high bat activity has been documented and providing the natural pest control service (Lumsden, 2005). The insectivorous bats use high-volume echolocation calls to locate and capture prey. Since, insectivorous bats

are maintaining insect population in agro ecosystem and supports to the biodiversity conservation.

A single bat can eat thousands of insect each night (ranging from 1,000 to 3, 000). Bats can eat up to half their body weight in insects in a night. One colony of 20 millions Mexican free-tailed bats in Central Texas consumes nearly a half million pounds of insect each night (BCI, 1989). Northern Long-eared bat (*Myotis Septentrionalis*) suppresses mosquito population through direct predation. A little brown bat, one of the North Americas most abundant species is capable for capturing 600 mosquitoes in just an hour. Although bats are commonly credited for their role in mosquito control. A colony of 150 large brown bats can eat approximately 38,000 cucumber beetle in a single summer, which are potentially destroy Corn spinach and Vine plants. So, heavy lost face by U.S. farmers annually and their productivity of crops are become very less (Environment, 1994).

Indian Horse-shoe Nose bat, *Hipposideros speoris* is aerial insectivorous belong to family Rhinolophidae of sub-order microchiroptera. Successively migration of insectivorous bats, *Hipposideros speoris* towards the open land space and increased the cultivation rate of yield. Migratory process as well as their greater adaptation towards the open space gives super beneficial profit to the farmers i.e. protect the crop from harmful insect-pest and increased the cultivation rate of crop yield (Benton 2003).

Many of our cultivated crop plants still rely on bats for their survival i.e. only essential source for their disease resistant development is insectivorous bats. Due to efficient role of insectivorous bats new more productive plants will be produced in the future. Insectivorous bats regulate the insect numbers and provided humankind needed services like food, fuel, fibre and medicine.. Insectivorous bats consumed serious crop-pest and save the billions of dollars of farmers and foresters per annually. During wet season, total arthropod densities increased by 84% per coffee plant. In wet season also increased the reproductive activity of bats and so heavy energy demands of bats at the wet season. Hence, they feed on the most damaging insect-pests and increased the agricultural productivity of crop and coffee plantation. Efficient role of natural predator in agricultural practices, the uses of synthetic pesticides become minimize and safer the human health from harmful toxic present in synthetic pesticides.

Today, these valuable mammals often go unnoticed because they are small, largely silent and minimum their roost sites. Roost sites are a key habitat requirement for bats and may be a limiting resource in highly modified environment. Land-holders and land-managers are frequently unaware of the diversity of bats on their properties, their beneficial nature and the habitat requirements for their continued survival. Insectivorous bats are the natural pest controller, so highlighting on the importance of trees in the rural landscapes as foraging habitat for bats, protect the bat populations and improve public perception of bats. Due to the loss of insectivorous bats, the insect-pest enormously multiplied because of the unchecked control by their natural predator. So, farmers are totally dependent on pesticides for controlling crop-pest, which already suffered our environment and personal health. In United state, 850 million pounds of pesticides applied on crop, which not only contaminated the ground water but it's runoff is further damaging Wildlife habitat.

It is very essential to providing the habitat protection, conservation and monitoring of roosts as well as providing all the essential information to local localities. Insectivorous bats contributed their role in the maintenance of ecosystem stability in both natural and agricultural system and provided ecological and economical benefits to the ecosystem.

Guano use as fertilizers on agricultural crops due to high concentration of nitrogen and phosphorous and which may be primary limiting nutrients of most plant life. Although the benefit of nitrogen to plant are well known. Various sheets and mounds of guano had long been mined from caves and under places where the bats roost. Bats regularly or occasionally roost in caves and provide the primary organic input to cave ecosystem i.e. cave-dwelling salamander, fish population and invertebrate's communities are highly dependent upon the nutrients from bat guano. Bat guano contains insect fragments, arthropods, fish, mice, fruit, nectar, hair, pollen and other valuable nutrients (Fenton 1983).

Insectivorous bats consume energy rich prey with rapid digestion during flight, so the guano is sprinkled over the landscapes throughout the night. Thus, bats

contribute to nutrient redistribution from nutrient-rich resource (e.g. Lake and rivers) to nutrient-poor regions (e.g. arid or upland landscapes). Nectarivorous, frugivorous and carnivorous bats may similarly contribute to nutrient cycling through guano redistribution. So some developing countries harvested the guano for the process of natural fertilizer specially use for increasing the nourishment of soil as well as increasing the yield of crops.

Bats are very vulnerable and most beneficial creatures among natures. Bats are playing the critical economic and ecological roles in ecosystems. Evidence shows that bats perform a leading role in the complex web of life. They are essential allies among in delicate nature system of checks and balances. Without them, entire system of life may die with them. This loss would not only be felt other animal species but by humans as well. Destruction of hibernacula, maternity sites and foraging areas may loss out several hundreds or thousands species at one time. In recent years, bats have increasingly subjected to a variety of disturbances i.e. industrial chemical, water pollution, air pollution, light pollution, habitat alteration, deforestation and other human activities increasing the growing risk of extinction. In particular, alteration of natural habitats by agricultural monoculture, human disturbances to caves and mines and decreasing survival rate of some aerial and aquatic insect-species. All these factors decrease the ability of bats to successfully feed, reproduce and hibernate.

In North America, many of the largest bat populations now live in mines. They have come to utilize these roosts because their original homes in caves or tree hollows have be destroyed. In the past few years, thousands of old mines have been closed for human safety but largest populations of endangered species have been lost due to these closing (BCI, 1994-95). Deforestation of areas near roost entrances has also affected the bat population. If forests are unavailable, predators may take advantage of the unprotected bats. Forests are also used by some young bats for resting places because they are very slow and clumsy fliers during their first week of flight. Bats around the world are in severe decline. In the United States, nearly 40% of the 43 bat species are endangered. In the U.S. gray bats were among the most abundant animals, but now they are on the endangered species list. Also in Southeast Asia, Dawn bats, the primary pollinators of the millions of crop but they have been declining rapidly from loss of cave roosts. Unwarranted human fear, misinformation and persecution of bats at their roosts have declined their population nearly everywhere in the world and many species become endangered. Many of the bat species are necessary in large numbers to maintain the balance of nature. Instead, at such low population levels, that they are almost ecologically irrelevant. Immediate protection action may save them from extinction. Although some bat species have already become extinct, but from the effective and initiatives steps of management, there is a hope for the recovery of remaining populations.

Many of the managements are initiative in protective measure for roosting sites. So after the protection of roost sites and foraging habitats, the periodic monitoring of these areas is necessary to identify potentially damaging activities. In the United Kingdom, all bat species and roosts are protected by the Wildlife and Countryside Act (Jones, 1995), because basic biological foraging information is lacking for most of the species. So little attention has focus on the protection of bat habitats. Warning signs have been posted in some caves to alert people that either maternity colony is present in the caves. Although the sign are attempt to keep people out. Bat Conservation International (BCI), the World's leading bat conservation organization has sponsored various research projects worldwide. These have been critical in illustrating the ecological and economical importance of bats. Although scientific understanding is a important goal of BCI. A primary goal of BCI has been to educate people at all levels about the importance and benefits of bats and the need to protect them. BCI's educational program are specially providing accurate information and conducting the citizens training programs. It also provides the availability of workable solution for problem and the instruction of educators and Wildlife managers. All of these techniques such as educational and research activities play on influential role in changing people's negative attitudes about bat and efficiently counter declining rate of bat populations. BCI's efforts in education, research and partnerships with governments and private groups have been very instrumental and successful in achieving such goals.

REFERENCES

Agarwal KA and Gupta BB (1982) The structure and histology of the tongue in 2 Indian bats, *Rhinopoma*

kinneari (Rhinopomatidae) and *Scotophilus heathi* (Vespertilionidae). Folia. Morphol. (Prague). 30(1): 26-41.

Allen WH (1996) The varied bats of Barro Colorada Island. Bioscience, October, 46: 639-642.

Altringham JD (1996) Bats Biology and Behaviour. Oxf. Uni. Press, New York.

Bat Conservation International (1989) Bats: Gentle friends, Essential Allies, BCI, Austin, Texas.

Bat Conservation International. Annual Report (1994-1995) BCI. Austin, Texas.

Benton TG, Vickery JA and Wilson JD (2003) Farmland biodiversity: is habitat heterogeneity the key: Trends in Ecology and Evolution. 18: 182-188.

Birt P, Hall LS and Smith GC (1997) Ecomorphology of the tongues of Australian megachiroptera (Chiroptera: Pteropodidae). Austr. J. Zool. 45(4): 369-384.

Cleveland CJ, Betke M, Federico P, Frank JD and Hallam TG (2006) Economic value of the pest control service provided by Brazilian free-tailed bats in South Central Texas. Frontiers in Ecology Evolution 18: 182-188.

Cox PA, Elmqvist T, Pierson ED and Rainey WE (1992) Flying foxes as pollinators and seed dispersers in Pacific island ecosystem. In "Pacific island flying foxes". Proceed of International Conservation Conference, (Wilson, D.E. and Graham, G.L. Edis). USFWS. Biological.Report. 90: (23). United States Fish and Wildlife Service, Washigton, D.C; USA. Pp: 18-23.

Documentary (1992) Viewed on Discovery channel 3 March (1997).

Environment (1994) Batty Friends, 36(8): 24

Estrada A and Coates-Estrada R (2002) Bats in continuous forest, forest fragments and in an agricultural mosaic habitat-island at LOS. Tuxtlas. Mexico. Bio. Cons. 103: 237-245.

Fenton BM (1983) Just Bats. University of Toronto Press, Toronto, Canada.

Hwang H and Lee J (2007) Morphological study on the dorsal lingual papillae of Myotis macrodactylus. Korean. J. Electron, Microscopy 37: 147-156.

Jackowiak H, Trzcielinska- Lorych J and Godynicki S (2009) The microstructure of lingual papillae in the Egyptian fruit bat (Rousettus aegyptiacus) as observed by light microscopy and scanning electron microscopy. Arch. Histol. Cyto. 72: 13-21.

Jones G, Duverge PL and Ransome RD (1995) Conservation biology of an endangered species: Field studies of greater horseshoe bats. In: Eco, Evo. And Behaviour of Bats

Lumsden LF, Bennett AF and Silins JE (2002) Location of roosts of the lesser long-eared bat Nyctophilus geoffroyi and Gould's wattled bat, Chalinolobus gouldii in a fragmented landscapes in South-eastern Australia. Journal of Zoology, London, 257: 207-218.

Lumsden LF and Bennett AF (2005) Scattered trees in rural landscapes: foraging habit for insectivorous bats in South-eastern Australia. Bio. Cons. 122(2): 205-222.

Marshall AG (1983) Bats, flowers and fruit: evolutionary relationships in the Old World. Bio. Jour. Linnean. Society. 20:115-135.

Rainey WE, Pierson ED, Elmqvist T and Cox PA (1995) The role of flying (Pterodididae) in oceanic island ecosystems of the Pacific. Zoological Symposium. 67: 47-62.

Ramteke AV, Zade SB and Patil KG (2012a) Insect-pest Suppression and Ecosystem Services of Insectivorous Bat, *Taphozous longimanus* (Emballonuridae). Proceedings of national Congress- Stepping up with Bio-scientific Technologies- INNERVATE 2012 PP: 193-197.

Ramteke AV, Zade SB and Patil KG (2012b) Crucial role of lingual papillae of Fruit Bat, *Cynopterus sphinx* in seed dispersal and pollination. J. Science Information, Special Issue 3: 81-84.

Ramteke AV, Zade SB and Patil KG (2012c) Wide range of fungiform papillae in two Megachiropteran Bats: *Rousettus leschenaulti* and *Cyanopterus sphinx*. Journal of Biological and Physical Sciences, Vol. No.- II (IV), ISSN No. 2319-636X.

Ramteke AV, Zade SB and Patil KG (2012d): Small Rhinolophid Bat *Hipposideros speoris* in agroforestry system. Bionano, Frontier, ISSN No. 0974-0678. Vol: 5(2-1).

Singh RV and Bhatti, US (1993) Functional morphology of the Bucco-pharynx and oesophagus of *Pteropus giganteus giganteus*. Bat. Res. News. 34:1.

Von Helversen O (1993) Adaptations of flowers to the pollination by glossophaginae bats. Pp. 41-59 in Animal-plant interactions in tropical environments (W. Barthlott, ed.). Museum Koening, Bonn, Germany.

Von Helversen O and Winter Y (2003) Glossophaginae bats and their flowers: costs and benefits for plants and pollinators. In: Kunz, T.H. Fenton M.B. eds. Bat ecology. Chicago: University of Chicago Press, 346-397.