
Defaunation
and
Conservation
Editors
Suman Pratihar
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Defaunation and Conservation

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The burrowing owl (*Athene cunicularia*) is a small, long-legged owl found throughout open landscapes of North and South America. Burrowing owls can be found in grasslands, rangelands, agricultural areas, deserts, or any other open dry area with low vegetation. Photo by Howard O. Clark, Jr., Imperial County, California, USA.

Editorial

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At least 322 vertebrates have gone extinct since the year 1500; a trend in human-caused extinctions that likely began during the Pleistocene. Many additional vertebrates remain unrecorded for decades and could be extinct. A global review of 452 invertebrates find that these populations have fallen by 45 percent over the last 40 years. The best data are in the Lepidoptera family—moths and butterflies—which shows a drop in abundance of about 35 percent. To date 1.4 million invertebrates have been described, and monitoring covers only 0.03 percent of the world's known invertebrates. The issue of defaunation is so troubling that Rodolfo Dirzo of Stanford University stated that, "We are beginning to see that defaunation is omnipresent and of great intensity…we need to pay attention to its consequences and significance for society at large." The causes behind defaunation are clear and have been for decades: habitat loss including deforestation; overexploitation of species for bushmeat, medicine, or trophies; and invasive species rank as the big three drivers. "Climate disruption" could eclipse all of these as a driver of mass extinction in the near-future.

Defaunation can also result in co-extinctions. For example, many animals are ecologically connected to plant species, which may depend on them for pollination or seed dispersal. But if an animal species is lost—or if its population drops below a certain threshold—plants are likely to vanish as well.

Layia munzii, a dicot, is an annual herb that is native and endemic to California, USA. It is included in the California Native Plant Society (CNPS) Inventory of Rare and Endangered Plants on list 1B.2 (rare, threatened, or endangered in CA and elsewhere). Photo by Howard O. Clark, Jr., Carrizo Plain National Monument, San Luis Obispo County, California, USA.

Declining Pollinators vis-à-vis Pollination Crisis, Crop Yield, and Biodiversity Loss

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Pollination is the transfer of pollen grains from the anthers to the stigma of a conspecific flower. In angiosperms, after the deposition of pollen grains over the receptive stigma, the pollen tube carrying male gametes develops and extends down the style until it reaches the ovary and subsequently fertilizes ovules enabling seed set. As the plant itself is immobile, incoming pollen must be carried by some external agents. Wind, water, and animals are the three pollinating agencies used by the plants to achieve pollination. Pollination is a key mutualism between two kingdoms of organisms, perhaps the most basic type of exchange of sex for food; the plant gains reproductive success and the animal-usually-gains a food reward as it visits the plant (Willmer 2011). In practice only about 1% of all pollen successfully reaches a stigma (Harder 2000). Nevertheless, pollination by animals (biotic pollination) is both more common (Renner 1998) and usually more effective than alternative modes of abiotic pollen movements using wind or water, and animal pollination is usually also associated with more rapid speciation of plants (Dodd et al. 1999, Kay et al. 2006). Around 90% of all flowering plants are animal pollinated (Linder 1998, Renner 1998). Without pollination by animals, most flowering plants would not reproduce sexually, and humans would lose food and other plant products (Buchmann and Nabhan 1996). Among the animals moths, flies, wasps, bees, beetles, butterflies, and other invertebrates are critically important for ensuring the effective pollination of both cultivated and wild plants (Free 1993, Roubik 1995). Pollinators comprise a diverse group of animals dominated by insects, especially bees, but also include some species of flies, wasps, butterflies, moths, beetles, weevils, thrips, ants, midges, bats, birds, primates, marsupials, rodents and reptiles.

Most of our staple food crops such as wheat, rice, sorghum, barley and maize do not require animals for their pollination. However, wild pollinators play a very important role in the production of other crops such as some pulses, sunflower seeds, cardamom, coffee, cashew nuts, oranges, mangoes and apples. In Europe and North America the accounts of crop pollination are well documented (Free 1993, Roubik 1995, Delaplane and Mayer 2000) especially the western honeybee, *Apis mellifera*. However, similar studies in Asian countries are still fragmentary and inconclusive. Asian countries cover a wide variety of climatic zones that leads to production of varieties of crops. Many of these crops are entomophilous and their yields are also increased due to insect pollination (Abrol 2012). Among all the pollinators, bees are the most potent one including the western honey bee, the eastern honey bee (*Apis cerana*, *A. dorsata*, and *A. florea*), some bumble bees, some stingless bees, and a few solitary bees.

Bees alone comprise an estimated 25,000-30,000 species worldwide, all obligate flower visitors (Buchmann and Nabhan 1996, Tepedino 1979, Wcislo and Cane 1996). Relatively few plant-pollinator interactions are absolutely obligate (Basu and Pal 2008). Most are more generalized on the part of both plants and animals, and they also vary through time and space (Feinsinger 1987, Herrera 1988, Roubik 1992, Waser et al. 1996, Karmakar et al. 2010). Beekeeping provides an important source of income for many rural livelihoods. The western honey bee is the most widespread managed pollinator in the world, and globally there are about 81 million hives producing an estimated 1.6 million tons of honey annually. Both wild and managed pollinators have globally significant roles in crop pollination, although their relative contributions differ according to crop and location. Crop yield and/or quality depend on both the abundance and diversity of pollinators. A diverse community of pollinators generally provides more effective and stable crop pollination than any single species. Pollinator diversity contributes to crop pollination even when managed species (e.g., honey bees) are present in high abundance. The contribution of wild pollinators to crop production is undervalued.

Pollinators are a source of multiple benefits to people, beyond food provisioning, contributing directly to medicines, biofuels (e.g., canola and palm oil), fibers (e.g., cotton and linen), construction materials (timber), musical instruments, arts and crafts, recreational activities, and as sources of inspiration for art, music, literature, religion, traditions, technology, and education. Pollinators serve as important spiritual symbols in many cultures. Sacred passages about bees in all the world's major religions highlight their significance to human societies over millennia.

Mutualism between plant and animal pollinators are beneficial for both the partners (Bertin 1989, Bronstein 1994, Thomson and Pellmyr 1992). But the mutualism is neither symmetrical nor cooperative. In reality, from the evolutionary point of view pollination arises from plant-animal relationships that were fully antagonistic (Crepet 1983, Proctor et al. 1996). The purpose of plants and animal pollinators remain discrete. Generally, reproduction on the one hand, and food gathering on the other, leads to conflict of interest rather than cooperation (Howe 1984, Waser and Price 1983, Westerkamp 1996), e.g., nectar robbers (Inouye 1983). The conflict of interest dictates that natural selection will have an effect on plants and pollinators in diverse ways. Pollinators are agents of selection and gene flow from the perspective of plants (Campbell et al. 1997) and are involved in evolutionary events ranging from plant speciation to moulding the floral phenotype. But floral phenotypes are not simply those that are optimal for the animals (Hurlbert et al. 1996). Conversely, plants select for features of the animal phenotype (Smith et al. 1995), but the result is not optimal for the plants. The most basic evolutionary outcome that is common across both plants and pollinators is efficiency of each in exploiting what for each is a valuable or critical resource. One common manifestation is opportunism and flexibility on the part of pollinators toward plants, and vice versa. To devise the best possible strategies for management, conservation, or restoration of pollination systems, it is essential to have several elements in place. We need excellent knowledge of the natural history of plants and pollinators. And we need an appreciation for interaction webs and a "Darwinian perspective" on how natural selection is likely to have shaped behavior, morphology, and other aspects of the phenotype of plants and pollinators.

Fig. 1. 1. *Apis cerana* on *Brassica*; 2. *A. dorsata* on *Tecoma*; 3. *A. cerana* on *Calotropis*; 4. *A. cerana* on *Trianthema*; 5. *A. cerana* on *Tumera*; 6. *A. florea* over *Cucurbita*; 7. *Trigona* on *Bauhinia*; 8. Hive of *A. dorsata*; 9. Hive of *A. florea*; 10. Hives of *A. mellifera*.

The Pollination Crisis

For nearly three decades it has been well established that there is a decline of pollinators worldwide. The problems regarding pollinators decline were explicitly recognized in the UN Sao Paulo declaration (1998-1999), so that pollination disruption is at last being emphasized as a major issue (Kearns et al. 1998). In principle, pollinator loss might lead to plant loss, and vice versa; uncoupling a mutualism by effects on one partner could have knock-on effects at a community level (Bond 1994, 1995).

One potential consequence of declining populations of pollinators is a decline in the rate of pollination. This may lead to a decrease in the reproduction of a large number of flowering plants, including many rare species and a number of crops. Recent estimates suggest that around 87.5% of the world's flowering plant species are animal-pollinated (Ollerton et al. 2011). Reduced pollination

of these plants will lead to lower seed or fruit set, lower plant regeneration rates and knock-on effects to the animals that rely on plants and their products for food. While humans are unlikely to starve due to lack of pollinators because a number of staple crops such as grains are self-fertilising or wind-pollinated, the balanced diets that we currently enjoy and which are important for healthy nutrition will be threatened. Insect pollinators contribute directly to the quality and quantity of a large number of crops including vegetables, fruits, nuts, oils, and stimulant crops like coffee. As a result the service of crop pollination is considered to be very valuable globally. Estimates in 2005 suggest that global pollination was worth £131 billion or 9.5% of global food production (Gallai et al. 2009). In the UK alone, this figure was estimated at £1,057 million during 2007 (Breeze et al. 2011). Ecologically, the decline of pollinators is potentially serious. Plants form the building blocks of all ecosystems and disruption to their pollination and subsequent reproduction is likely to result in similar declines in plant species diversity and unforeseen effects to the animals and birds that rely on them. This would threaten ecosystem function and other ecosystem services that nature provides.

Threats to Pollinators

Habitat destruction

Since pollination involves more or less specific interactions between plants and animals, any change in their habitat may alter the distribution and / or abundance of a particular species which might affect the other associated taxa in a negative way. Some plant species may survive for sometime through asexual mode of reproduction or by selfing while they lose their pollinators, but evolutionarily this a dead end for that species. Thus, habitat destruction will be an intimidation to the existence of species in near future. While obligate mutualisms with dependence on a single pollinator are very rare indeed and certainly there is a risk of overdependence, e.g., key-stone species, especially fig-wasp relationship, and the loss of the wasp species, the only pollinator can have a disproportionately large influence on plant and animal community structures as the fruits are a vital food resource for numerous birds and mammals (Bawa 1990, Mabberley 1991), especially bats, primates and parrots which often act as seed dispersers. Habitat loss and disruption can also affect pollination success by disturbing the balance between legitimate visitors and the rarer cheats, nectar robbers with unpredictable effects (Willmer 2011). Effect of habitat disturbance is most evident in tropics where vertebrate pollinators are dwindling. In Central America long-snout bats (*Leptonycteris*) have declined in numbers (Medellin 2003), and chiropteran vulnerability to forest breakup is well recognized (Meyer et al. 2008).

Habitat Fragmentation

Habitat fragmentation is more common than habitat disappearance. Fragmentation creates smaller populations, with greater risk of inbreeding depression and genetic drift and it amplifies the spatial isolation of these populations

(Willmer 2011). If the isolation of fragmented populations becomes far from the foraging range of pollinators, if the local pollinator population becomes small enough or vice versa so that pollinators avoid small populations then definitely there will be a pollination deficit. Here are some unequivocal evidences of fragmentation which affect the plant success in different habitats, e.g., in Missouri the *Oenothera* flowers which are pollinated by hawk moths suffering from seed sets due to reduced pollination services on the most disturbed fragmented populations (Moody-Weis and Heywood 2001). In calcareous grasslands, *Betonica* plants in isolated fragments were visited less by bumblebees than plants grown in control areas (Goverde et al. 2002). Pollination quality generally declines in fragmented populations of tropical trees. It was estimated that a minimum of 300 fig trees will require ensuring fig-wasp mutualism in a typical forest of 800 acres (McKey 1989).

Agricultural Practices

Several features those are associated with modern agricultural system make farms poor habitat for wild bees and other pollinators. Crop monocultures sacrifice floral diversity, and consequently diversity of pollinating insects, over large areas (Williams 1986). For example, cultivated orchards surrounded by other orchards have significantly fewer bees than orchards surrounded by uncultivated land (Scott-Dupree and Winston 1987), and the number of bumblebees on crops increases with proximity to natural habitats (Williams 1986). Several key pollinator groups, for example, bumblebees, hoverflies, and solitary bees has been unequivocally linked to this change of land use (Carvell et al. 2004).

Pesticides and Herbicides

Pesticides and herbicides pose a major threat to pollinators. Pesticides are mainly used on crop plants where pollinators are most often limited. Pollinators also are harmed by pesticide application in grasslands (Tepedino 1979), forests, (Kevan 1986), urban areas, and even tourist resorts. The use of pesticides in agriculture is well documented as causing pollinator declines (Kevan 1975a, b, Johansen et al. 1983, Kearns and Inouye 1997, Spira 2001), especially where spraying time coincides with flowering time.

Herbicides are not always toxic to flower visitors, but can have special effects by eliminating key host plants for lepidopterans and key forage plants for bees. They may thereby have major impacts on wild pollinator populations. Herbicide spraying and mechanical weed control in alfalfa fields can reduce nectar sources for wild bees.

Introduction of Non-native Animals including Pollinators

Introduction of mammals including rats, feral cats, and rabbits are threat to pollination systems and communities. Cats reduce numbers of birds, lizards, and small mammals and this can lead to increases in insect populations. A predatory tree snake which was introduced on the Guam Island created severe diminution in bird pollination for local *Bruguiera* and *Erythrina* trees (Mortensen et al. 2008).

The introduction of non-native pollinators has the potential to harm native pollination systems. The introduction of bumblebees into areas sometimes has negative results (Dafni 1998, Otterstatter and Thomson 2008). Non-native *Bombus terrestris* were brought to Japan to pollinate greenhouse tomatoes but soon escaped and become naturalized. By far the most noteworthy introduction of non-native pollinators includes honeybees, which has been introduced in most parts of the world and can be characterized by hypercompetitive having substantial impact. Honeybees in some cases might benefit wildflowers by excluding native pollinators from crops (Williams et al. 1986), but they are often poor pollinators of crops and native flowers compared with native insects (Batra 1995, Kwak 1987, Parker et al. 1987, Richards 1993, Torchio 1990, Westerkamp 1996). Moreover, honeybee colonies require ample amounts of nectar and pollen, and worker bees fly for a long distance to gather floral resources (Roubik 1996). Hence, honeybees may compete with native pollinators for resources, leading to reduced pollinator diversity. Honeybees also are likely to affect the reproduction of native plants, perhaps even facilitating the spread of weedy non-native plants (Allen and Wilson 1992, Barthell 1994, Butz Huryn and Moller 1995).

Climate Change

The general predicted effects of climate change (rise in temperature, changing precipitation) on biodiversity are well documented (Hedhly et al. 2009). The impact of climate change over pollinators is evidenced mainly on the distribution of butterflies (Hickling et al. 2006). Bowers (2007) estimated an advance of 20-41 days in Sonoran desert shrubs, with the flowering curve shifted to peak in March rather than May.

Diseases

Currently honeybees are suffering from various diseases caused by several biotic factors globally. For example, tracheal mites, *Varroa* mites and *Nosema* mites are important agents affecting natural bee pollinators especially honeybees. Now there are accounts of sudden colony collapse disorder (CCD), which is under intensive investigation (Anderson and East 2008), and responsible for loss of around one-third of US hives in 2006-2007.

Discussion

There is ample information to suggest the existence of pollinator declines that have affected, and are affecting, agricultural productivity, loss of biodiversity, and threatening rural livelihoods and sustainable ecosystems. In view of the various scientific reports, The International Pollinator Initiative (IPI) was established in 2000 to coordinate worldwide activities regarding assessment of pollination services and pollinator declines. It is very difficult to evaluate the current state of plant-pollinator interactions. Pollination declines cannot be inferred from the dearth of pollinators even if this can be effectively documented (Thomson 2001b). Current scientific data are usually inadequate and one of the

missions of the IPI has been to establish standard methodologies for documenting pollinator occurrence and abundance, as they vary across time and across environments and for assessing pollination services (Willmer 2011).

There is an urgent need to protect natural habitats and use of reserves in terms of high floral diversity and not just conserving a particular species (Thompson 1997). It is also necessary to understand the requirement of individual endangered pollinator species, and bee biologists in particular have been putting effort into evaluating the minimum needs of solitary bees, in terms of the least numbers of their preferred host plants that are needed to supply their pollen budgets (Muller et al. 2006, Larsson and Franzen 2007).

A recent United Nations report, based on the global assessment of pollinators by an international team of more than 75 scientists from different parts of the world, including India warns that the wild pollinators are declining, and their loss will jeopardize our food supply. The large scientific panel was brought together by the Intergovernmental Platform on Biodiversity and Ecosystems Services (IPBES). Created in 2012 by more than 100 governments, the IPBES seeks to provide scientific information about biodiversity and ecosystem services to policymakers of the member countries. According to the IPBES report, The International Union for Conservation of Nature (IUCN) Red List assessments indicate that 16.5 per cent of vertebrate pollinators are threatened with global extinction (increasing to 30 percent for island species). There are no global Red List assessments specifically for insect pollinators. However, regional and national assessments indicate high levels of threat for some bees and butterflies. From the report it is also evident that the pollinator declines are well-documented in North America and Europe but have not yet been well-researched in other parts of the world.

In India, the important pollinators of food crops are various species of honeybee, *Apis*, such as *A. dorsata*, *A. cerana*, *A. florea* and *A. laboriosa*. The European honeybee, *A. mellifera*, also pollinates many crops and fruits such as apples, sesame, and niger. Many of these pollinators are declining. Researchers from different parts of India have reported a decline in the number of honeybee colonies in India.

The IPBES report makes a number of recommendations to restore the integrity of pollinators: improvements in the science of pollination, better land management, strong regulations underlying pesticide use, and restoration and protection of habitats for wild pollinators. Above all, there is an urgent need for monitoring wild pollinators, and for strengthening the governance of natural assets.

The Ministry of Environment, Forests and Climate Change has recently launched a program to establish a network of Indian Long Term Ecological Observatories (I-LTEO) to monitor the country's ecosystems. The I-LTEO network offers significant opportunities to monitor wild pollinators.

As pollinators survive wild and managed urban or peri-urban green areas such as parks, sport fields, and gardens, increasing the abundance of nectar and pollen-providing flowering plants increases local pollinator diversity and abundance. Therefore, to control the loss of pollinator diversity, the key point regarding them is that, not only the science that requires attention but also the policies taken by the governments for managing landscapes be them are natural, agricultural, or urban equally important. The IPBES assessment also proposes

the government agencies that they must rethink conventional sectoral approaches and narrow disciplinary perspectives. There are many factors involved in the complex environmental challenges threatening human security today. Only a well-coordinated approach including scientists, government representatives and the common man can successfully address them.

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Present Wave of Defaunation in Pakistan

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Introduction

Presently Pakistan is in the grip of the 6th wave of the "Anthropocene Defaunation," which started 1000 years ago, triggered by human interference in natural phenomenon, destroying century's old well-rooted ecosystem. Present interference is now aided by new inventions to milk natural resources as dry as possible, speeding up defaunation at an unparalleled rate and magnitude as previous recorded in earth's history (Barnosky 2012).

Back in 3000 BC the Indus Valley had been a hustling and bustling subtropical broad-leaf ecosystem with rich megafauna, in addition to the domesticated animals (cow, buffalo, horse, donkey, etc.), there were prides of tigers, cheetahs, herds of wild buffalo, wild pigs, bears, porcupines, crocodiles, rhinoceros, antelopes and elephants, roaming about on the landscape (Khan 2006). Now the landscape in the Indus Valley is reduced to an arid grassland, with the loss of lush vegetation and all components of the megafauna, even the domestic animals are at the mercy of favorable changes in climate (Khan 1990).

The Demise of Indus Civilization

This highly developed Indus civilization rapidly declined, and by 1500 BC it was practically wiped out. The diagnosed apparent cause had been repeated flooding rivers, destroying towns and villages, incurring heavy losses to property and life; triggered by ecological disasters following unabated felling and destruction of natural resources (Khan 2006).

The wetter climate, dense jungles, filling the riverine strips of the Indus River system, shallow ground water, gallery forests of tamarish, acasia, delbergia, shisham etc., flanked by dense grasses and marshlands conceded to the explosion in human population: changing balance, destroying megafauna (Fig. 2) and flora.

Present Changes in the Valley

Rising temperatures in Pakistan and India, are causing current wave of defaunation, encompassing all taxonomic groups from lowest to the largest (Cardillo 2008), worrying equally the scientific community, the general public, and biodiversity scientists (Dirzo 2014).

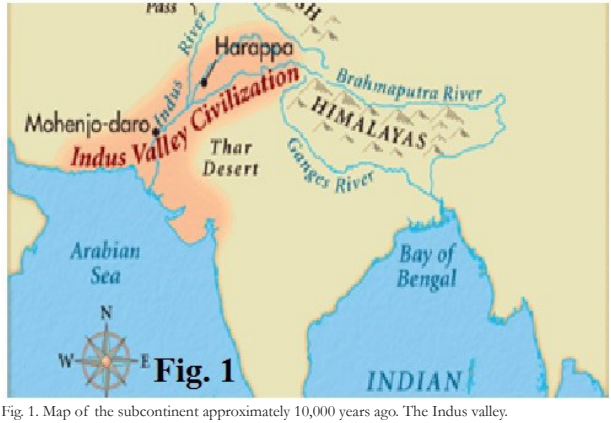

Fig. 1. Map of the subcontinent approximately 10,000 years ago. The Indus valley.

Fig. 2. A stellate dugout from Indus valley with engravings of the megafauna.

The Dilemma

Defaunation starts at cryptic levels, becomes apparent after that it has gathered momentum, and gets out of control. The resistant species do not allow to quantify its magnitude and damage, scientists need intensive multiple surveys, still with greater risk of error.

Differential Patterns of Defaunation

Defaunation factors may differ from place to place, depending on location and local bio-ecological conditions. Moreover, certain lineages are particularly susceptible, while other are relatively least affected i.e., 41% amphibians, while birds (17%), mammals and reptiles experience intermediate threat level. Current

global Defaunation threatens 1,437 mammals and 4,263 bird species per 10,000 km^2 (Barnosky 2012; Brook et. al. 2008).

Factors Speeding Defaunation-Anthropogenic Pressures

Plants and animals co-exist in a peaceful harmony, enjoying available natural resources, until outside forces interfere to destabilize the equilibrium:

Exploitation: The equilibrium in an ecosystem, follows the rule "live and let live." Khan (1990) reported human activities affecting amphibian populations in the Indus Valley. One of the most prominent drivers of defaunation is direct harvesting, whether for food, medicine, or animal parts or pet trade. Estimates of harvest rates are high, 5 million tons of bush meat is harvested annually across tropical rainforests, includes large and medium sized species.

A. Exploitation: None of the amphibian species, in Pakistan, is included in the dietary of the local population. However, amphibians are used in colleges and universities, throughout Pakistan for demonstration of vertebrate anatomy (*Hoplobatrachus tigerinus* is used in Indus Valley institutions, while *Chrysopaa sternosignata* and *Euphlyctis cyanophlyctis* in Balochistan). The number of these species has been found to have been considerably reduced, and have become quite rare around college campuses (Khan 1990).

Each year, hundreds of millions of plants and animals are gathered from the wild and sold as food, pets, ornamental plants, leather, tourist curios, and medicine. If within legal bounds, it should not harm wild populations. However it becomes worrisome when it becomes illegal and threatens the very survival of many endangered species. Overexploitation is the second-largest direct threat to many species after habitat loss, WWF in Pakistan addresses illegal and unsustainable wildlife trade as a priority issue.

According to a recent report, Pakistani illegal trade in different species of frogs, geckos, lizards, snakes, and freshwater turtles is illegally meeting continuously increasing demands in the world pet trade markets. In 2015 alone, consignments with estimated worth of Rs143 million were confiscated. Besides this, there is also a growing trend of keeping large wild animals as pets, become a reflection of one's financial status and power, in which lions and tigers are particularly popular. Unfortunately some are being associated with political parties in Pakistan.

B. Destruction of habitat: Scientists pressurized by the growing demands develop more efficient chemical fertilizers and potent pest controls to boost agriculture produce. The wash-down of these chemicals are absorbed in soil, changes soil chemistry, and encouraging growth of invasive weeds. Moreover, pest control sprays kill resident populations of amphibians and reptiles who prey upon the pests acting as natural exterminators (Dodd 1977; Barclay 1980; Khan 1990).

C. Use of pesticides: The mechanized ploughing banished amphibians and reptiles from fields, they were naturally controlling the pests; consequently there is a rise in pests and decline in production.

The advent of new pesticides have not solved the problem, rather it has furthered deterioration. To boost yield of cash crops, improved long-acting

pesticides are being used to control crop pests. The effects of pesticides on field animals, toads, frogs, and reptiles (skinks, *Mabuya dissimilis* and *Eurylepis taeniolatus*), are well illustrated by number of dead animals which lay dead. Scattered around recently sprayed fields (Khan 1990).

At several sites frogs, tadpoles, and fishes have been found killed in nearby ponds and puddles receiving runoff water from sprayed fields; birds die by eating sprayed insects and caterpillars (Khan 1990).

D. Fumigation of granaries: Throughout grain-producing areas in the Indus Valley, large granaries are built to store grain, attracting insect pests and rats, which are followed by their predators: amphibians, lizards, and snakes. Periodically granaries are fumigated killing both pests and their predators.

E. Industrialization: Large water catchment area "grasslands" in the suburbs of cities and towns across Pakistan (Lahore, Gujranwala, Sheikhupura, Wazirabad, and Failsailabad), which had been feeding and breeding grounds of local species of amphibians and turtles; local flora attracted different arthropods, providing food to the resident amphibians and reptiles, had been replaced by large industrial buildings, with extermination of local flora and fauna (Khan 2006).

F. Mechanization of agriculture: Usually resident amphibians retreat in holes and crevices in tilled fields, close to their feeding and breeding sites. The ox-driven ploughing method gave sufficient time to the disturbed animals to escape from being injured or crushed.

Though mechanization has boosted agriculture produce many folds and saved time, the deep ploughing unearths animals from their burrows, does give the have no time to escape, and are trampled and crushed under heavy machinery.

G. Fragmentation of habitat: Extensive network of roads and link roads constructed across industrial areas, have fragmented surrounding grasslands. Day/night traffic, kills by crushing different types of wildlife as they move across the roads. Moreover, fragmentation of natural habitat had disturbed harmony and reduction in animal number.

H. Nutrient cycling decomposition: Because of use of extensive spray on crops by pesticides, diversity and functional invertebrate communities, have dramatically impacted in reduction of decomposition rate of nutrient recycling. Mostly there is decline in populations of mobile species that move nutrients long distances, affecting agriculture produce.

I. Pollination: 75% decline in insect pollinator diversity is strongly linked to the decline in produce. Decline in pollinators has reduced seed production and reduction in bird population, affecting honey production. The ramification of roads in the grasslands not only partition the habitat, it has obstructed natural water flow, thus increased pollution in habitats.

J. Water quality: Defaunation has affected water quality and dynamics of freshwater systems. The global decline in amphibian populations is also due to increased algae and detritus biomass in habitats, reduced nitrogen uptake, affecting whole-stream respiration. Large animals, including ungulates, hippos and crocodiles prevent the formation of anoxic zones through agitation effecting water movements through trampling.

K. Human health: Defaunation affects human health in many ways: Reduction in ecosystem goods and services, pharmaceutical compounds, livestock

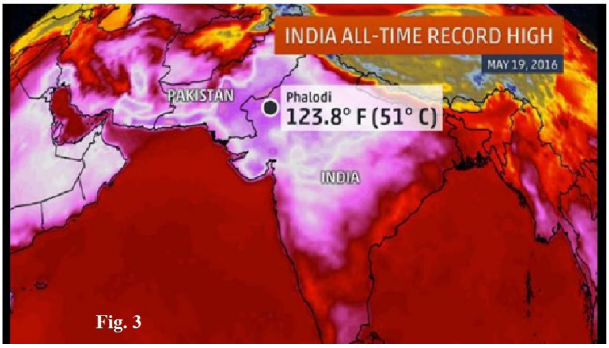

Fig. 3. Subcontinent showing recent temperature increase.

species, biocontrol agents, food resources and disease regulation. Birds 23-36%, mammals and amphibians used for food or medicine are threatened with extinction. In many parts of the world wild animals are the only food source and are critical part of the diet, particularly of the poor. Vertebrate used for food have declined at least 15% since 1970.

L. **Habitat destruction:** During last two decades, these sites have mostly been acquired to set up multipurpose industrial complexes. Draining, digging and levelling construction activities by using heavy machinery, has destroyed local fauna and flora by trampling and drying ponds and puddles.

M. **Urbanization:** similarly almost universally in the suburbs of villages and towns, there had been ponds and puddles formed by the excavation of earth for building purposes, where amphibian and turtle species breed during the summer. These sites have now been filled to destroy breeding grounds of mosquitos, destroying local species of frogs and turtles.

Concluding Remarks

Khan (2006) enumerates wide range of instances of unlawful exploitation of herps going throughout Pakistan: like plundering sea turtles *Lepidochelys olivacea*, *Chelonia mydas*, and *Dermochelys coriacea* and their nests along coastal beaches, when they annually visit sea coast along Pakistan. The poaching activities of local nomadic snake charmer tribes: "sanyasies", "gagras" and "Tapri-was" actively engaged in destruction and depletion of reptilian populations in the wild, to sell in market (Minton and Minton 1964; Khan 1993). They endlessly hunt for several wild reptiles including: *Varanus bengalensis*, *V. griseus*, *Sara hardwickii*, *S. asmussi*, *Trapelus agilis*, *Python molurus*, *Ptyas mucosus*, *Spalerosophis diadema*, etc., lured by high price their skins and body parts fetch (Konieczny 1969b; Vohora and Khan 1979; Khan 1993, 2000).

Local venomous snakes: *Bungarus caeruleus*, *Naja naja*, *N. oxiana*, *Echis carinatus*, and *Daboia russelii* are caught at random from wild, and are supplied in the hundreds to the Health Institutions for venom extraction, to produce antivenin, without consideration of damage done to natural population and ecosystem.

The snakes are kept congested in filthy small pens, are never fed. Those succumbing to adverse conditions are thrown away or burned.

Lizards especially snakes are killed on sight by the general public, as reptiles are regarded as venomous and harmful, following common philosophy "**kill it before it kills you!**"

Due to pressures from all sides, the resident reptiles in Pakistan are fast depleting in number and species, as demonstrated by record of killed/alive reptiles received by the author (Khan 2006) in Herpetological Laboratory Pakistan, from 1964 to 1998 (Table 12.1), note decrease in receipts from 243 in 1964 to 44 in 1998.

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An Application of Corridor Theory on a Physical Landscape using the San Joaquin kit fox (*Vulpes macrotis mutica*) as the Model Species

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Introduction

Corridors have become an increasing important tool in conservation biology, with considerable potential benefit for target populations. However, in the few decades since the corridor concept began to appear frequently in the conservation biology literature, there has been much debate over the value of corridors, how they should be implemented, and how they should be defined. In recent years, increasing clarity on the topic has emerged. Herein I review and synthesize the key scientific literature on corridors to develop important guidelines in how to evaluate potential corridors for the federally endangered and state-threatened San Joaquin kit fox (*Vulpes macrotis mutica*; Fig. 1) along the western edge of the San Joaquin Valley, California, USA. Corridor implementation for the San Joaquin kit fox may concurrently benefit many of the other special status plant and animal species within the San Joaquin Valley of California. The western edge of the San Joaquin Valley is a suitable landscape to evaluate because historically, this region was an uninterrupted linkage corridor for the kit fox, allowing the species to move between three southern core populations (Carrizo Plain National Monument, San Luis Obispo County, grasslands in western Kern County, and Ciervo-Panoche Natural Area, Fresno County) and satellite populations occurring in several foothill valleys northward to Contra Costa County (Merriam 1902, Grinnell et al. 1937). Agricultural development and the associated construction of water delivery systems in the 1960s (large reservoirs, forebays, and a state aqueduct and major canal system) have led to significant fragmentation and habitat loss within the landscape, disallowing genetic flow between southern and northern populations. As a result, native species of the San Joaquin Valley have experienced a drastic population reduction to a point where they required state and federal listing and Endangered Species Act protection (Gibbons 1992, Wilcove et al. 1993, Abbitt and Scott 2001, Harding et al. 2001). In order to recover these species, corridor implementation and habitat conservation efforts are required. The guidelines herein are: (1) a corridor must have a very specifically defined function with respect to the population biology of the target species; (2) a corridor must be explicitly designated as either a habitat corridor or a conduit corridor, and designed accordingly; (3) a corridor must be

Fig. 1. San Joaquin kit fox (*Vulpes macrotis mutica*); a federally endangered and state-threatened species in the San Joaquin Valley, California, USA. Photo by Howard O. Clark, Jr., Carrizo Plain National Monument, San Luis Obispo County, California, USA.

designed and evaluated according to site-specific and species-specific attributes to ensure functionality, rather than through the use of blanket general concepts; and (4) the quality of the habitat within a corridor is a crucial component in corridor evaluation and design.

Defining Corridor Function

Several different disciplines have used the term corridor in the context of habitat conservation (Rosenberg et al. 1997), but clarification of functional versus structural definitions of corridors was needed (Hess and Fischer 2001). A functional approach to corridor design evaluates a corridor in the context of both how it facilitates animal movement and how movement plays in the larger population biology of the species. Functional definitions of corridors are used by the metapopulation, island biogeography, and game management literature, and are rooted in the scientific rigor of these disciplines. Structural definitions of corridors arose in the field of landscape ecology, and focus on the physical existence of a linear strip of habitat within the "matrix-patch-corridor" paradigm of landscape structure, with no explicit consideration of the function of that strip of habitat within the population biology of the species. The functional definition of a corridor is strongly grounded in the science of population biology, and therefore the one that should be use by conservation biologists in corridor planning. However, structural definitions of corridors have been appearing in the conservation biology literature, which have led to confusion over how to evaluate and design corridors (Rosenberg et al. 1997, Hess and Fischer 2001). Hess and Fischer (2001) assert that the "proper design and management of a corridor depends critically on a clear and explicit statement of its functions," and "if corridors are not designed to perform well-defined functions, the outcome may be disappointing, or even deleterious." This strongly functional

approach to corridor design and evaluation is used both in our review and our recommendation of conservation measures addressing potential kit fox corridors along the western edge of the San Joaquin Valley, California, USA.

Habitat versus Conduit Corridors

There are multiple distinct functions that a corridor can perform, and clarifying which of these general functions a corridor serves is a crucial step in its design (Hess and Fischer 2001). Distinguishing whether a corridor is to serve as a habitat corridor or a conduit corridor is particularly fundamental for defining a corridor's function (Lindenmayer and Nix 1993, Hess and Fischer 2001). The difference between habitat and conduit corridors is defined as follows (Rosenberg et al. 1995, as described in Hess and Fischer 2001): "[A] corridor that provides for movement between habitat patches, but not necessarily reproduction, is performing a conduit function. If a corridor provides resources needed for survivorship, reproduction, and movement, it is performing a habitat function." If the scale of an animal's movement is small relative to the width and length of a corridor, it may take several generations for a species to move through the corridor; such species are called "corridor dwellers," and the habitat within such a corridor would have to perform a "habitat" function and provide resources for reproduction (Beier and Loe 1992). Alternatively, if the length of a corridor is realistically traversable for an animal engaging in natal dispersal, seasonal migration, daily foraging, exploration, or finding a mate, then that species would qualify as a "passage species" with respect to that corridor. In such a situation, the corridor would only have to perform a "conduit" function.

Habitat corridors and conduit corridors have differing requirements of the habitat contained therein, which means they have different requirements for corridor design (Hess and Fischer 2001). The most salient difference is that habitat corridors must contain habitat of sufficient quality and quantity to allow for reproduction. Alternatively, conduit corridors need only provide habitat through which the animals are willing and able to move, with sufficiently high survival rates. It has been demonstrated empirically with eastern chipmunks (*Tamias striatus*) that corridors used by resident chipmunks (i.e., habitat corridors) were of different quality than those used by transient chipmunks (i.e., conduit corridors; Bennett et al. 1994). Ibex (*Capra ibex nubiana*) migrating between core populations in the Negev desert, Israel, selected habitat less steep than that used within their core population areas, presumably because negotiating less steep habitat allowed them to move through the corridors more rapidly (Shkedy and Saltz 2000). A study on corridor use by butterflies stated that for vagile species that can disperse readily "corridors need not support animal populations to function effectively as movement conduits" (Haddad 1999).

In addition to differing habitat quality requirements, conduit versus habitat corridors will also generally have different dimensional requirements. For habitat corridors, the width of the corridor should be approximately the width of the home range of the target species, so as to provide sufficient area with the corridor for a home range (Harrison 1992). However, this approach is only appropriate for habitat corridors, and is not the proper approach to take for conduit corridors because of their different function (Lindenmayer and Nix 1993). Overall, the habitat quality and width requirements of a habitat corridor versus

a conduit corridor for a given species can differ considerably, and therefore the determination of which of these functions is desired for a corridor must be clear before corridor design and evaluation can effectively occur. Furthermore, the differing corridor requirements suggest that it may still be possible to establish a conduit corridor in an area where the habitat quality is too low or the amount of habitat available is too small to provide the reproductive resources required for a habitat corridor.

Species-specific and Site-specific Design Criteria

Corridor use is highly dependent upon the behavioral ecology of the target species, including its social structure, its use of environmental cues, and the degree to which it is a specialist or generalist (Lindenmayer and Nix 1993, Bennett et al. 1994, Haddad 1999). The nature of the habitat within the corridor will interact with these behavioral traits to largely determine the willingness of a given species to use a corridor. Furthermore, designating a precise function for a corridor is something that inherently must be performed on a species- and site-specific basis (Hess and Fischer 2001). The importance of these aspects of corridor function has become increasingly apparent through time, leading to designing and evaluating corridors on a species- and site-specific basis (Lindenmayer and Nix 1993, Haddad 1999) which relies less on general rules of corridor planning that are not tailored to the target species and site.

The attempt by Harrison (1992) to designate minimum corridor width based upon the home range size of the target species is one of these general rules that, while having some underlying conceptual legitimacy, is not sufficient to predict the utility of a corridor because it does not take into account site- and species-specific variables (Lindenmayer and Nix 1993). In a study of corridor use by seven arboreal mammal species in Australia, the home range size of the target species did not predict the relationship between corridor width and corridor use, because animals both heavily used corridors much smaller than their home range width and did not use corridors that were much larger (Lindenmayer and Nix 1993). The study attributed the lack of compliance with Harrison's predictions upon idiosyncratic aspects of the behavior of the target species, and subtle aspects of the nature of the habitat within the corridors. The authors concluded that the Harrison home range width approach is not a sufficient criterion for the designation of corridor width, and recommend that corridor dimensions be designed with the consideration of the behavioral ecology of the target species and other site- and species-specific factors, and with a clearly defined function in mind (Lindenmayer and Nix 1993). Another study of corridor use, in this case by butterflies, reiterated the importance of behavior and other species- and site-specific characteristics (Haddad 1999). Haddad (1999) indicated that while increased corridor width did have a positive effect on migration rates between patches, the incremental benefit of additional corridor width plateaued fairly rapidly, and the positive relationship between width and migration rates was largely the result of the behavior of a given butterfly species. These studies indicate that corridor width and corridor design in general need to be done on species- and site-specific basis.

Corridor Quality

In the majority of the original metapopulation studies that showed the benefit of linking subpopulations for the abundance and persistence of the entire population, the quality of the habitat within the links was not explicitly considered (Henein and Merriam 1990). Likewise, the quality of the habitat within a corridor is not always considered to the degree to which it is warranted (Noss 1987, Henein and Merriam 1990, Hess and Fischer 2001). For the purpose of this discussion, corridor quality is defined by the survival rate for the animals passing through that corridor. High quality corridors have high survival rates for the animals that use them, and low quality corridors have low survival rates for the animals that enter them. This is the same definition of corridor quality used by Henein and Merriam (1990) in their investigation of the influence of corridor quality on the dynamics of metapopulations. Their model results indicate that while metapopulations with exclusively high-quality corridors between patches have a larger population size at equilibrium than do those with one or more low quality corridors, the size of the metapopulation declines as the number of low quality corridors increases. Furthermore, the connection of a patch to a metapopulation by a low quality corridor has a negative effect on overall metapopulation size, although it can increase the population size and persistence time in the formerly isolated patch. These results indicate that while a good quality corridor will likely benefit the persistence of a species, a low quality corridor may actually be detrimental to species abundance and persistence. This is consistent with concerns that corridors can have costs as well as benefits, and that these costs are often not fully considered in corridor implementation (Simberloff and Cox 1987). Overall, the scientific literature elucidates the importance of explicitly considering corridor quality in the design and evaluation of corridors.

Application of kit fox corridors along the western edge of the San Joaquin Valley

Conservation measures detailed herein provide a contribution to a regional corridor strategy for the San Joaquin kit fox through the western edge of the San Joaquin Valley. The following analysis applies the four guidelines for corridor design and evaluation described above to the potential corridor options for the kit fox.

1) Defining corridor function

The desired function of the western edge corridor can be designated with varying specificity with respect to the population biology of the San Joaquin kit fox. On the most basic level, the function of the corridor is to facilitate the movement of San Joaquin kit fox along the western edge of the San Joaquin Valley, especially through a "pinch point" in western Merced County, CA. An ambitious, and possibly unobtainable, goal for corridor function would be to enable dispersal from the kit fox core populations south of Merced County at a sufficiently high rate to allow for the recovery and persistence of the "northern range" satellite population in Alameda, Contra Costa, and San Joaquin counties (Clark et al. 2007,Orloff et al. 1986, Sproul and Flett 1993). A more achiev-

able corridor function would be for corridor implementation to increase kit fox dispersal through western Merced County above current rates, and in doing so, fully offset any potential decline in kit fox dispersal that may result from proposed and future fragmentation and habitat loss in western Merced County. The first seeks to recover the northern range population from its current isolated status so that it may in theory persist indefinitely, whereas the second of the proposed functions for the corridor seeks mainly to prevent further isolation of the northern range population and provide opportunities for kit fox to successfully disperse. It is clear that the first function requires a more dramatic increase in the rate of dispersal with corridor implementation than does the second. The following considers what rates of dispersal from corridor implementation are likely necessary to meet these two alternative functions.

What rates of dispersal through western Merced County are necessary to allow the northern range satellite population to persist? The northern range kit fox population is most likely a sink population, and as a likely sink population it is by definition dependent upon immigration from a core population in order to persist (Clark et al. 2007, Pulliam 1988, Smith et al. 2006). Furthermore, the northern range population appears to have declined since the various water projects and transportation facilities that impede kit fox dispersal through western Merced County were built. It cannot be stated with certainty that the decline in dispersal rates through western Merced County was responsible for the decline in the northern range population, because other factors such as increased development and increased predator densities within the northern range are likely factors as well. However, it can be stated with fair certainty that the northern range satellite population will not be able to recover and persist without considerable immigration from the large southern core populations.

In estimating the requisite rate of dispersal necessary to maintain the northern range population there are two general considerations: the influx of individuals to maintain genetic diversity and the influx of individuals to keep population numbers high enough to prevent local extinction (Noss 1987, Otten and Cypher 1998, Hess and Fischer 2001, Schwartz et al. 2005). These genetic and demographic concerns are separate mechanisms, and as such are evaluated separately. The one-per-generation rule has been described as an approximate guideline for the number of individuals migrating into a population that are necessary for the maintenance of genetic diversity (Mills and Allendorf 1996). However, this rule may need to be revised to be five or even ten individuals per generation, because most immigrants into a population will be natal dispersants or other individuals that are expected to have lower survival rates and reproductive fitness, and hence are not as likely to contribute genetically to the population. San Joaquin kit foxes have an average life span of approximately two to three years (McGrew 1979), so the application of these rules suggests that there needs to be between one kit fox every other year to five kit foxes per year successfully traversing corridors in western Merced County from south to north if the objective is for these immigrants to allow for the maintenance of the genetic diversity of the northern range satellite population.

The rate of immigrants necessary to prevent the local extinction of the northern range population from demographic mechanisms via metapopulation processes is difficult to predict, because the site-specific nature of this question means that no general guidelines have been developed. Technically, the required

rate of immigration to sustain a sink population is equal to the difference between the reproductive rate and the mortality rate. Small populations, even if they are not sinks, are also subject to extinction from demographic and environmental stochasticity and require sufficient immigrants to "rescue" the population in order for it to persist (Brown and Kodric-Brown 1977). It has been established that the northern range population is very small and likely a sink (Clark et al. 2007, Smith et al. 2006), but there are no precise measurements of the mortality and reproduction rates within this population, so necessary rates of immigration must be approximated. The apparent decline in the northern range population over the last several decades implies that the required rate of immigration needed to maintain the population is relatively high, and that the current rate of immigration is far from adequate. The rates of immigration required to maintain a satellite sink population are likely to be higher than those required to maintain genetic diversity (Beier 1993, Schwartz et al. 2005), particularly for a relatively short-lived, low-density species with high interannual population variability such a kit fox (White and Garrott 1997, Dennis and Otten 2000, White et al. 2000). The rate of successful dispersal through western Merced County necessary to prevent local extinction of the northern range population from demographic factors is expected to be at the very least equal to the high end of the estimate required for genetic diversity of five animals per year, and is quite likely much higher.

What degree of corridor implementation is necessary to increase current rates of kit fox dispersal through western Merced County, and in doing so offset impacts on current kit fox dispersal rates from proposed and future fragmentation and habitat loss? All evidence indicates that the current rates of kit fox dispersal through western Merced County as a whole are extremely low. A camera detection survey of the canal and dam face crossings in the region detected no use of the crossings by kit fox, but did detect use by red fox (*V. vulpes*), gray fox (*Urocyon cinereoargenteus*), coyote (*Canis latrans*), badger (*Taxidea taxus*), raccoon (*Procyon lotor*), and other mesocarnivore wildlife species (C. Johnson, unpublished results). A subsequent study of the use of crossing structures by kit fox in western Merced County also showed no conclusive evidence of use by kit fox (D. Newman, unpublished results). The lack of kit fox use of the crossings was attributed to the general absence of the species in the area. There have also been very few recent records of kit fox in the western Merced County corridor "pinch point," suggesting that very few kit fox may be attempting to cross this area. The northern range populations both just north of western Merced County and in Alameda and Contra Costa counties have been in decline in recent years and were demonstrated to be at undetectably low densities (Smith et al. 2006). Assuming that these populations are dependent upon dispersal through western Merced County for their persistence, this suggests that the current dispersal rates are quite low, especially as compared to dispersal rates in the past. The degraded condition of corridor habitat in western Merced County further suggests that current kit fox dispersal rates are low, although generally very low kit fox densities in the region may be a major factor causing the low rate of kit fox dispersal as well. Given that current kit fox dispersal rates through western Merced County are low, even a small increase in dispersal rates from corridor implementation could be a substantial improvement over current conditions.

Precisely defining the desired function of a corridor must be performed before the corridor is designed and implemented to ensure that it will ultimately be effective in promoting the conservation of the target species (Lindenmayer and Nix 1993, Hess and Fischer 2001). This desired function must of course be feasible if it is to serve its role in guiding the design process and being the criteria by which the success of the corridor is evaluated (Hess and Fischer 2001). It is also crucial that the function of the corridor be explicitly defined with respect to the population biology of the target species (Lindenmayer and Nix 1993, Rosenberg et al. 1997, Hess and Fischer 2001). Here I elucidate the various options that could be designated as the desired function of the western Merced County kit fox corridor.

The desired function for the western Merced County kit fox corridor that may have the maximum conservation benefit for the species would be providing sufficient connectivity for the recovery and persistence of the small northern range population in Alameda, Contra Costa, and San Joaquin counties. This requires a fairly high minimum immigration rate, estimated to be at least five animals per year successfully moving north through the corridor into the northern range. Because this is apparently much higher than current kit fox migration rates through the region, this function would require substantial improvements to the corridor above its current condition. Merely protecting land in western Merced County from future fragmentation and habitat loss would be insufficient to achieve this function, because this would not significantly increase dispersal rates above current levels. It is not clear that an immigration rate of at least five animals per year is possible. While sufficient immigration to support the recovery of the northern range population may be desirable, it is not a viable designated function for corridors in western Merced County if it cannot be reasonably achieved. An infeasible goal for a corridor cannot rightly serve as a standard by which to judge the corridor's success, and is not a useful guiding principle for the corridor's design (Hess and Fischer 2001).

A more modest desired function for the western Merced County kit fox corridor may need to be designated. Alternative goals for corridor function would need to be both reasonably feasible, and explicitly stated with respect to the population biology of the San Joaquin kit fox (Lindenmayer and Nix 1993, Rosenberg et al. 1997, Hess and Fischer 2001). One defensible function for the kit fox corridor may be to protect and enhance corridors sufficiently to facilitate kit fox dispersal to prevent further isolation of the northern range population. Given that the rate of dispersal through western Merced County is currently low, and that some relatively simple options for enhancing corridor function are available, this designated function should be readily achievable.

It is reasonable to ask whether there is an intermediary goal for the kit fox corridor between the two options described above that would serve as a viable goal for corridor function. Enhancing the corridor to allow kit fox dispersal at a rate that exceeds what is necessary to prevent further isolation of the northern range population, but is not sufficient to allow for the recovery and persistence of the northern range population, does not have a clear function with respect to the population biology of the species. It is reasonable to recognize uncertainties by enhancing corridors in the region to a degree that may exceed requirements to prevent further isolation of the northern range. However, investing substantial resources into corridor enhancements to provide intermediary rates

of kit fox dispersal that will nonetheless be insufficient to allow for the recovery of the northern range population is a poorly defined function with respect to the population biology of the San Joaquin kit fox, and hence cannot serve as a guideline for the design of the corridor or the evaluation of the corridor's effectiveness (Hess and Fischer 2001). The goal of preventing further isolation of the northern range population and providing opportunities for kit foxes to successfully disperse is the most biologically viable conservation function for kit fox corridors in western Merced County.

2) Habitat or Conduit Corridor?

A critical component of defining the function of the kit fox corridor is to determine whether it is to be a habitat corridor or a conduit corridor. Habitat corridors and conduit corridors have different design requirements (Hess and Fischer 2001), so clearly defining this function will influence how the corridor will be designed. The defining characteristic of a habitat corridor is that it be incorporated into the regular home range and successfully used by the target species for reproduction (Rosenberg et al. 1995, Hess and Fischer 2001). This generally entails requirements for high habitat quality and large corridor width. Alternatively, the purpose of a conduit corridor is to provide a means by which animals can move between two larger habitat patches (Falcy and Estades 2007). Conduit corridors must not be longer than the distance the target species is capable of moving in a short, discrete dispersal period, although the requirements for habitat quality and corridor width are generally less stringent than those of a habitat corridor. Whether the kit fox corridors are to have a habitat function or a conduit function thereby depends upon the answers to the following questions (Hess and Fischer 2001): Are the potential corridors of sufficient habitat quality and size to support successful kit fox reproduction therein? Are the potential corridors short enough that kit fox may reasonably traverse them during natal dispersal or other discrete movements?

There are two options for kit fox movement corridors through western Merced County that could provide opportunity for movement between the northern satellite population and the larger populations to the south. The first is a corridor along the western-most edge of Merced County running adjacent to a highly developed water delivery infrastructure, hereafter called the "western corridor." The second option is a corridor bypassing the water delivery infrastructure a few km east of the western corridor option, and predominately transverses through an agricultural matrix, hereafter called the "agricultural corridor."

• The Western Corridor

The western corridor option runs in the vicinity of a reservoir and forebay system, connecting the annual grassland habitat to the north and south of these bodies of water. The vegetation within this corridor is predominantly California annual grassland, although there are portions of shrubland and ruderal vegetation, small riparian areas with cottonwood trees (*Populus fremontii*), cattails (*Typha* sp.), and other associated plant species. The topography within this corridor is predominately flat. Most of the dam face is covered in angular boulders, a potentially impassable substrate for kit fox. However, just below this rocky slope

is a strip of annual grassland that traverses the front of the dam. Extending this strip of annual grassland approximately 9 m higher up the dam face around the top of the spillway would make the spillway more easily passable by kit fox and would create a path of contiguous grassland habitat along the length of the entire corridor. The proposed grassland extension along the dam face above the boulders can be created by adding a limited amount of soil to fill in gaps between the rocks, which will facilitate kit fox movement through the area.

• Agricultural Corridor

The agricultural corridor runs through a matrix of rural residential and agricultural lands east of the water delivery infrastructure. It begins in the grazed annual grasslands in the core kit fox habitat to the south of western Merced County and quickly enters a matrix of orchards and row crops fragmented by roads, solar farms, aqueducts, and canals. The majority of habitat within this corridor is currently comprised of agricultural land with a severe lack of escape structures and refugia for kit foxes. Small dairies and feedlots, and some rangeland are interspersed within the row crops or orchards. Many private residences and county roads occur in this potential corridor, along with other land uses such as gravel mining and landfill. An aqueduct and two major canal systems run through the agricultural corridor, providing opportunities for movement parallel to the waterways and impeding travel perpendicular to their paths.

It is highly unlikely that any of the potential kit fox corridors contain habitat of sufficiently high quality that kit foxes would place a natal den within them, much less be able to successfully raise pups. The western corridor begins within the open annual grassland to the south and while this habitat is potentially high enough quality for a kit fox natal den to be established, the western corridor requires movement through narrow habitat strips or through marginal habitat, so at least portions of the corridor must be considered a conduit corridor rather than a habitat corridor. The agricultural corridor could hypothetically be made wide enough to be a habitat corridor if sufficient land is acquired. However, it is unlikely that the habitat within the agricultural corridor would ever be of sufficient quality to support the establishment of a successful natal den system, and the quality would likely never be equitable with the southern core habitat where successful reproduction occurs. A large fraction of the proposed land acquisitions within the agricultural corridor would likely be conservation easements on farmed areas. While kit fox have been shown to occasionally disperse through agricultural habitats, they cannot establish natal dens therein because the regular soil turning precludes the establishment of natal den systems (Warrick et al. 2007). The grazed areas within this corridor are not currently known to support active natal dens, and it is unlikely that they would establish new ones given the patchiness of the grassland habitat and the number of roads, residences, and other anthropogenic structures and activities that would be contained within even the fully-protected version of the agricultural corridor. For these reasons, I conclude that any of the potential San Joaquin kit fox corridors through western Merced County could not realistically function as a habitat corridor because the available habitat for the corridor is either too narrow or of too low quality to allow for successful reproduction (Hess and Fischer 2001).

In order to qualify as a conduit corridor, the potential corridor must be short enough to be realistically traversed by a kit fox during a single, discrete dispersal period. The longest recorded kit fox dispersal distances in recent years are from the Naval Petroleum Reserves to Bakersfield (Kern County; 64 km), and the Carrizo Plain National Monument to Camp Roberts, San Luis Obispo County (96 km; Schwartz et al. 2005). The recorded maximal movement distances by kit fox in one night are between 9.4 km for pup dispersal and 13.5 km for adults (Zoellick et al. 2002; Clark 2003). A study that directly measured dispersal distance of kit foxes at the Naval Petroleum Reserves, Kern County, showed a mean dispersal distance of 7.8 ± 1.1 km (range 1.8-32.3 km, n = 48; Koopman et al. 2000). The lengths of the potential corridors in western Merced County range between approximately 3 km for the western corridor to approximately 20 km for the agricultural corridor. Both corridors are all within measured maximum dispersal distances for the San Joaquin kit fox. However, when mean dispersal distances for kit fox are considered, it appears that the western corridor is less than half the mean dispersal distance, but the agricultural corridor is more than twice the mean dispersal distance. This suggests that the western corridor is considerably more likely to be successfully used as conduit corridor by kit fox than the agricultural corridor because of its shorter length. This is especially true when considering that the foxes are not dispersing from the beginning of the corridor, and in fact they may be moving several km before they actually enter the corridor.

3) Species- and Site-specific Corridor Evaluation

An important aspect of evaluating a corridor on a species- and site-specific basis is considering how the particular behavioral tendencies of the species will interact with the specific characteristics of the habitat within the corridor to predict corridor use and efficacy. In the case of western Merced County, both corridors require kit foxes to cross multiple anthropogenic structures, including the dam face, canals, and roads of varying sizes. The general trend is that more crossings are required moving from the western to the agricultural potential corridors: the western corridor requires four crossings, and the agricultural corridor requires crossing each of the three major canals twice, one crossing of a wasteway, two crossings of an interstate highway, two crossings of state highways, and numerous crossings of county roads and solar farms. Estimating the probability that a kit fox is willing and able to cross these various structures is an important factor in assessing the effectiveness of the various corridor options. Unfortunately, data on the likelihood of kit fox crossing bridges across canals, or using culverts under roads, in western Merced County is not available. However, kit foxes have been observed using aqueduct overshoots and culverts near Lost Hills, Kern County (Clark 2001).

Presumably, various crossing requirements within the corridors will impose a filtering effect on kit fox movement, as they are almost certainly less willing to move over anthropogenic structures than open habitat. The filtering effect could be due to either the kit fox displaying a behavioral reluctance to move through or over the structures, or not being able to locate the proper crossing structure. Crossing structures are also points in a corridor with increased mortality risks. Regardless of the mechanism by which crossing an anthropogenic

structure decreases the likelihood of kit fox passage, it is reasonable to expect that the greater the number of such crossings required, the less likely a kit fox is to be able to successfully traverse the entire length of a given corridor. It is difficult to compare the relative filtering effects of crossing canals to crossing roads on kit fox movement. An estimate of the relative degree to which this is a factor in the two potential corridors described herein would be the relative ratio of the number of major crossings in the corridors. The number of major crossings in the agricultural corridor is at least five times greater than those of the western corridor, which would imply that there is at least a five times greater risk to kit foxes from these factors in the agricultural corridor. It is also possible that multiple successive structure crossings could have a disproportionately negative effect on kit fox dispersal rates, as a dispersing kit fox encountering a large number of successive structure crossings may simply decide to turn around and not continue to disperse into habitat that appears increasingly unsuitable.

Species- and site-specific factors must also be considered in determining the width of the corridor. When considering the corridors as conduits, estimating an acceptable corridor width should be based upon estimates of how wide the corridor will need to be for a kit fox to be willing to enter it and protect the kit fox sufficiently from any edge effect. The width of the home range is not a proper criterion for corridor width in this case, because these are not habitat corridors in which animals are establishing home ranges. The designation of a corridor width is most relevant to the agricultural corridor, where the desired width will determine the amount of private land requiring acquisition. The other corridor is a mix of public and private land, and its width is generally constrained by the reservoir, forebay, and other fixed water features. Kit foxes in the southern San Joaquin Valley have been shown with telemetry studies to regularly use a corridor 120-m wide (Clark et al. 2005). This corridor includes an aqueduct with two strips of buffer land 60 m wide on either side, and is surrounded by intensive agriculture. Extrapolating from this situation to western Merced County, a corridor width of 60 to 120 m would be sufficient for a kit fox to be willing to enter and travel within for moderate distances.

4) Corridor Quality

The definition of corridor quality used here is related to the survival rate of animals passing through the corridor. A high quality corridor has a high survival rate for the animals passing through, generally comparable to the survival rate within the core population areas, whereas a low quality corridor has a low survival rate (Henein and Merriam 1990). Corridor quality is of particular concern in western Merced County because all the potential corridors have characteristics that are expected to result in higher mortality rates as compared to the habitat north and south of the corridors.

Low quality corridors are not only less effective at allowing for animal dispersal, they can also be deleterious to the metapopulation as a whole because they may cause a demographic drain on the populations they connect (Noss 1987, Henein and Merriam 1990). If a low quality corridor were implemented in western Merced County, it could potentially have a negative effect on the size of the entire metapopulation. In particular, it would be a demographic drain on the kit fox populations just south of Merced County, which are part of the greater

Ciervo-Panoche core population. Protecting the Ciervo-Panoche core population is a high priority goal for kit fox preservation (Haight et al. 2002, 2004), and there is evidence that it is already the smallest of the three core populations and may be in decline (Smith et al. 2006). It is crucial to ensure that any corridor implemented in western Merced County keep the mortality rates within that corridor as low as possible to prevent these negative impacts from occurring.

Predation pressure, low prey base, canal crossings, road crossings, and corridor length would all contribute to lower kit fox survival rates in the corridors. Predation pressure could be due to greater predator densities, and it is expected that the densities of red foxes, coyotes, and dogs would be greater near canals and developed areas, and possibly near agricultural fields (Clark et al. 2005). Crossing points at canals and roads are also potential mortality increasing factors, because while crossing at these "pinch points" kit foxes are more vulnerable to predators (Hess and Fischer 2001). Kit fox mortality at road crossings increases with the speed and heaviness of the traffic and the width of the road, especially roads over two lanes wide (Bjurlin and Cypher 2003). Finally, the longer a corridor is, the longer the amount of time a dispersing animal will have to spend in it, and the greater the mortality risk involved. Because all of these mortality-inducing factors are greatest in the agricultural corridor, this should be considered the lowest quality corridor. The western corridor has fewer roads or canals to cross, is further from developed areas, and is much shorter. It is thereby expected that the mortality risk for kit foxes would be the least in the western corridor option.

Recommendations for Corridor Design and Implementation

General Guidelines

It is imperative that any corridors implemented not have an excessively high mortality rate (i.e., be of low quality). A low quality corridor could potentially reduce the size of the entire kit fox metapopulation and cause a demographic drain on the Ciervo-Panoche core population. A high survivability approach would require that any designated corridor be of high quality, with the lowest mortality rate for kit fox that is reasonably attainable. Because one high quality corridor is much more beneficial to the overall metapopulation than many low quality corridors, it is also recommended that the general strategy be to focus resources into producing one high quality corridor, rather than spreading resources across multiple corridors and failing to produce even a single high quality corridor.

Precisely defining the desired function of a corridor with respect to the population biology of the target species is a crucial step in the corridor design process. The function defined for a corridor needs to be feasible in order for it to serve a meaningful role in corridor design and evaluation. There are two possible functions that could be designated for the western Merced County kit fox corridor strategy. The more ambitious is for the fully implemented corridor to permit sufficient dispersal through western Merced County and allow the recovery and persistence of the northern range kit fox population. The dispersal rate required for this function has been estimated to be a minimum of five kit foxes per year, and may be much higher. The alternative function is for the

fully implemented western Merced County kit fox corridor to prevent further isolation of the northern range population and provide opportunities for kit fox to successfully disperse, increasing dispersal rates over existing levels. It is likely that, even with full corridor implementation, a dispersal rate through western Merced County of approximately five animals per year will not be attainable. Therefore, the goal of preventing further isolation of the northern range population and providing practical opportunities for kit foxes to successfully disperse is recommended as the defined function of any kit fox corridor in western Merced County.

Any kit fox corridor implemented in western Merced County would function as a conduit corridor. The choice and design of a corridor in western Merced County should therefore be based upon the principles of conduit corridor design and function. The primary function of a conduit corridor is to allow animals to move between core habitat areas during discrete dispersal events, as rapidly and safely as possible. The behavioral tendencies of the target species are important to consider in conduit corridor design. The length, width, and number of structure crossings are all factors in the western Merced County corridors that must be considered with respect to conduit corridor design. Ideally conduit corridors are shorter than the target species can be reasonably expected to move during a discrete dispersal event. The width of a conduit corridor is based upon the behavioral and mortality factors relevant to the target species. The corridor must be wide enough for the dispersing animal to be able to locate and be willing to enter. When the major mortality factors are edge effects (Ewers and Didham 2006, 2007), corridor width can also decrease mortality rates for dispersing animal; however, in the case of the western Merced County corridors the major mortality factors are contained within the corridors, so width is not expected to lower mortality rates as much as it may in other situations. There is also a point of diminishing return with width in conduit corridors, where a wider corridor may take longer for an animal to traverse as it wanders to and fro within the corridor (Haddad 1999). In a conduit corridor, having to cross roads, canals, and other anthropogenic structures reduces the likelihood and speed with which an animal may travel through the corridor; therefore, these factors are major detractors from a conduit corridor and should be minimized.

Corridor Recommendations

These guidelines for the design and evaluation of corridors indicate that the best option for the western Merced County kit fox corridor is to focus resources on implementing the western corridor. The western corridor is the shortest and has the fewest roads, canals, and other anthropogenic structures to cross. These characteristics indicate that the corridor would have the lowest mortality rate of both corridor options, and hence of the highest quality. Lower mortality rates within a corridor not only make the corridor more effective, they are also crucial to ensuring that the corridor does not have a negative effect on the entire metapopulation by causing a demographic drain on core populations. This is an especially important consideration in western Merced County, where the core population to the south, the Ciervo-Panoche population, is both a high priority for protection, and may possibly be in decline.

The main drawback of the western corridor is its narrowness at the structure crossing points, specifically the reservoir and forebay. Corridor width is not as important of a factor in conduit corridor design as are habitat quality and mortality rates, so these benefits are considered to outweigh any drawbacks from narrow corridor segments. Building infrastructure to allow kit fox to readily pass through these narrow points in the western corridor should be feasible.

Another benefit of the western corridor is that it could also be fully implemented relatively quickly, because much of the land is already in public ownership and each has only two major structural crossings that would need enhancement to be readily passable by kit foxes. The implementation of the western corridor would provide a tangible increase in the likelihood of a kit fox being able to successfully disperse through western Merced County, thereby fulfilling the defined function of the corridor.

The application of these guidelines also leads to the conclusion that the agricultural corridor is the least scientifically defensible of the kit fox corridor options. The agricultural corridor has the highest potential mortality rate for dispersing kit fox because it is the longest; has the greatest number of roads, canals, and other anthropogenic structures for the kit fox to cross; and likely has elevated predator densities. The greater mortality risks associated with the agricultural corridor not only decrease the efficacy of the corridor, they also could cause the type of demographic drain on the entire metapopulation that has been described for low quality corridors. Ensuring that the corridor implemented does no harm to the species in question is a primary objective, and the agricultural corridor is the least likely of the corridor options to meet this criterion.

Initially, the agricultural corridor appears to offer at least the hypothetical benefit of greater width, through the preservation of large amounts of agricultural land. Corridor width is one factor that can increase corridor efficacy under certain conditions, and is an important factor to consider in corridor design (Noss 1987, Hess and Fischer 2001). However, for the agricultural corridor, the greater width this corridor could hypothetically provide does not outweigh the drawbacks this corridor has with respect to lower quality and higher mortality rates. The greatest benefit of very wide corridors is realized in habitat corridors, where animals incorporate the corridor into their home range and use it for reproduction. The agricultural corridor is a conduit corridor because it would not be of high enough quality to support kit fox reproduction, even with full implementation. Greater width can compensate for greater length in habitat corridors, but not in conduit corridors, because the animals must still traverse the entire corridor within a discrete dispersal event. In addition, the greater width of the agricultural corridor is also to some degree illusionary. There are numerous canals and roads in the agricultural corridor that kit foxes would need to cross, and in some cases there is only one bridge where a kit fox may cross a canal. The corridor at these points is essentially as narrow as the bridge or crossing structure, because that is the path the kit fox must actually take to get through the corridor. Having a wide swath of habitat protected on either side of a bridge will not necessarily greatly increase the odds that a kit fox will actually find and decide to cross a bridge. In this regard, the agricultural corridor is not necessarily any wider than the western corridor. Finally, while in some cases greater corridor width can reduce mortality effects on animals using the corridors, this is largely true only where the main mortality factors come from edge effects (Noss 1987).

The mortality factors in the agricultural corridor for the most part come from factors that are within the corridor, not on the edge, and making the agricultural corridor wider will do little to remedy the mortality factors contained therein (Bjurlin and Cypher 2003).

The agricultural corridor would take the longest, and be the most expensive, of the corridor options to implement. Conservation easements and land acquisitions from numerous private landowners would be required to fully implement this corridor. This would likely take decades to achieve, and there is no guarantee that all of the landowners within the designated corridor would cooperate, greatly lowering the degree of connectivity that the corridor could achieve. The time delay and lack of guaranteed outcome would further reduce the benefit this corridor would provide to the San Joaquin kit fox. The northern range population has been in decline, and is now at undetectably low densities (Smith et al. 2006). The agricultural corridor would not be of much benefit to increasing kit fox dispersal rates until it was nearly fully implemented. By the time the corridor could be implemented, it may be too late for increased dispersal rates to the northern range to have any benefit, because the northern range population may have already gone locally extinct. These limitations suggests that the agricultural corridor may not even be able to fulfill the function of increasing current rates of dispersal through western Merced County to prevent further isolation of the northern range populations.

Conclusion

California is experiencing significant growth (Clark et al. 2004) and in order to conserve wildlife resources, a corridor system is required. Habitat loss and fragmentation of the landscape due to development is causing San Joaquin kit fox populations to continue being isolated from each other, which may lead to the extinction of some of the smaller satellite populations.

Applying corridor philosophy as described in the literature is challenging, especially when the physical landscape that is being considered for corridor implementation is severely degraded and marginally suitable for threatened and endangered wildlife. In regard to the San Joaquin kit fox, the corridor required along the western edge of the San Joaquin Valley needs to be a conduit corridor in order to link habitat patches that are currently occupied by kit foxes. However, the corridor will need to be supplemented with escape dens to help facilitate movement and reduce mortality, because a kit fox may not be able to travel through the entire corridor in one discrete movement. Additionally, the corridor can also serve as a habitat corridor for smaller species, such as the Western burrowing owl (*Athene cunicularia hypugaea*), a California species of special concern.

To ensure kit fox survivability between habitat patches, the corridor should be of high quality, but not necessarily the width of a kit fox home range. Low quality corridors may actually be detrimental to a species' abundance and persistence due to higher mortality rates. Taking into account the kit fox's social structure and other environmental and behavioral factors may encourage the use of corridors by kit foxes.

Connecting habitat patches by implementing corridors, especially through "pinch points" that prevent movement of species and increase mortality levels, is key for the preservation of the metapopulation and will prevent localized

extinction of smaller, isolated populations. Using the guidelines described here regarding (1) defining corridor function, (2) habitat versus conduit corridor, (3) species- and site-specific corridor evaluation, and (4) corridor quality, will help facilitate species conservation on degraded landscapes.

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Loss of Megafauna Species from Pakistan: Causes and Implications

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Introduction

Pakistan (30.3753° N, 69.3451° E) is located in the region referred to as South Asia. Pakistan is bordered by China in the north, Iran and Afghanistan in the east, India in the west while Arabian Sea lies to its south. The country falls in the temperate zone with arid conditions characterized by hot summers and cool or cold winter in most parts of Pakistan (Khan 2006). Pakistan possess a myriad of ecological zones stretching from mangrove and littoral zone occurring at the sea level to permanent snow fields, cold deserts as high as 8500 meters (Roberts 1991, 1992, and 1997). This altitudinal variation along with other physiographic features has resulted in a spectrum of ecosystems which in turn has favored diversity of wildlife species in Pakistan. The coastal wetlands, mangroves, estuarine areas and littoral zones provide refuge to Cetacean species (aquatic mammals), Sea Turtle species, Marsh Crocodile (*Crocodylus palustris*), medium-sized carnivores such as Fishing Cat (*Prionailurus viverrinus*) and Smooth-coated Otter (*Lutrogale perspicillata sindica*). These areas also attract many resident and migratory waterfowl whereas high altitude snow covered peaks and meadows provide refuge to world's rarest carnivore and ungulate species such as Snow Leopard (*Uncia uncia*) and Marcopolo Sheep (*Ovis ammon polii*). The Indus River and its tributaries with associated alluvial plain and several wetland types such as lakes, marshes, and flood plains hold immense importance for aquatic and semi aquatic wildlife species. The rugged arid mountains in the south-western and western parts of the country are significant for a variety of ungulates such as Suleiman Markhor (*Capra falconeri jerdoni*) and Sindh Wild Goat (*Capra aegagrus blythi*) and several reptiles particularly lizard and snake species.

Status of Wildlife in Pakistan

Pakistan is particularly rich in mammalian and avian diversity. The country has reasonable reptile species richness but low amphibian diversity (Table 1). Pakistan does not have high species endemism (Table 1), and none of the world's identified biodiversity hotspots lies wholly in Pakistan. However, some parts of northern mountains of Pakistan are included in Himalayan Biodiversity Hotspots. Further, the country has 55 Important Bird Areas and two Endemic Bird Areas-Western Himalya and Indus Plains. There has been no evaluation of

conservation status of reptiles and amphibians of Pakistan. Sheikh and Molur (2004) prepared a conservation status and Red List of mammals of Pakistan while BirdLife International has given the conservation status of birds of Pakistan.

Extinct Species of Pakistan

The following section treats species extinction from political boundaries of Pakistan, and not from the region or geographic entity. It is a sobering thought that a few majestic large carnivores and ungulates went extinct from the country. The Tiger (*Panther tigris*, Linnaeus, 1758) and Lion (*Panther leo*, Linnaeus, 1758) fell victim to imprudent hunting by the influential rulers who used to kill these creatures for sport causing their eventual extermination in the 19th century. The Asiatic Cheetah (*Acinonyx jubatus*, Schreber, 1776) which ones roamed from south-west Baluchistan to the west of River Indus has now been completely wiped out. Due to the tense security situation along Runn of Kucth, Sindh, no detailed survey has been conducted recently to record the Wild Ass (*Equis hemionus*, Pallas 1775) from its known localities of Pakistan. Hence, it cannot be ascertained if the species has any resident population or visiting individuals. As many as two deer species such as Swamp Deer (*Cervus duvauceli*, Cuvier, 1823) and Red Deer Hangul (*Cervus elaphus*, Linnaeus, 1758) are believed to become extinct from Pakistan due to poaching, unsustainable hunting by the community, habitat degradation and loss, and competition with livestock species. Further, two extra-limital bovid species such as Blue Bull (*Boselaphus tragocamelus*, Pallas 1766) and Himalayn Tahr (*Hemitragus jemlahicus*, Smith, 1826) have no resident populations in Pakistan.

Wildlife Species on the Verge of Extinction

The available published data revealed that 19 wildlife species are facing imminent threat of extinction. The details of critically endangered species of mammals, birds, and reptiles of Pakistan are in provided Table 2. The majority of perilous mammalian species are of carnivore and ungulate mammals. Species of bears, hyaena, leopards and other medium-sized cats are facing varying degree of threats mainly habitat degradation and loss, poaching, ruthless persecution, conflict with local community due to depredation on livestock and decrease in natural prey species while illegal hunting, habitat modification and competition with livestock have threatened survival of ungulates, antelopes, and deers. The fate of several bird species seems in danger as well. The vulture species of Pakistan had suffered from serious populations decline. The current data on populations of White-rumped Vulture (*Gyps bengalensis*) and Indian Vulture (*Gyps indicus*) are meager which still put the species under extinction pressure. Likewise, species richness and abundance of Houbara and Crane has declined. The former is hunted for sport while later is hunted and captured for domestication. Among reptiles, diversity of sea turtles and freshwater turtles has significantly reduced. The literature reports as many as five marine turtle species from the coastal wetlands of Pakistan. However, recent data suggest that only two species occur. Olive Ridley (*Lepidochelys olivacea*) and Green Turtle (*Chelonia*

mydas) visit the coast with the later being more common. The number of visiting Hawksbill Turtle (*Eretmochelys imbricata*) and Leatherback (*Dermochelys coriacea*) has decreased putting them on the brink of extinction from Pakistan. Factors such as development along the coast, habitat modification and loss, depredation and pollution, have serious impacts on marine turtles. Although, none of the fresh-water turtle species are critically endangered, but the two categories-soft shell turtles and hard shell turtles are facing various levels of threats. The soft-shell turtles are hunted and captured in huge numbers to be smuggled out of Pakistan for food while hard-shell turtles are illegally exported as pets.

Table 1. Wildlife Species diversity of Pakistan.

Taxa	Number of Species	Endemic Species	Critically Endan-gered	Endan-gered	Vulner-able	Reference
Mammal	195	4	12	12	20	Sheikh and Molur (2004)
Birds	603	01	5	9	18	BirdLife International (www.birdlife.org, accessed on 10/12/2016)
Reptiles	209	36	2	3	7	Khan (2006)
Amphibians	25	06	—	—	—	Pratihar et al. (2014)

Table 2. Critically endangered mammals, birds and reptiles species of Pakistan.

	Common Name	Scientific Name	Threats	Current Distribution	Estimated Population/ Number
Mammals Order Carnivora					
Family Ursidae	Brown Bear	*Ursus arctos isabellinus* (Horsfield, 1826)	Habitat degradation, persecution, bear baiting, hunting for medicinal use, pelt and fur.	Deosai National Park, Khunjerab National Park, Satpara Game Reserve (Gilgit-Baltistan)	150–200[1]
	Balochistan Black Bear	*Ursus thibetanus gedrosianus* (Blanford, 1877)	Habitat degradation, persecution, bear baiting, hunting for medicinal use, pelt and fur.	Sulaiman Range, Pub Range (Baluchistan)	1000[2,3]
Family Mustelidae	Ratel or Honey Badger	*Mellivora capensis* (Schreber, 1776)	Persecution, habitat fragmentation, reduction of prey species populations	Kirthar National Park, Mahal Kohsitan Wild-life Sanctuary, Surjan, Sumbuk, Othiano, Eri Game Reserve (Sindh), Mekran, Lasbela, Kalat and Chaghai (Baluchistan)	31[4]

Table 2 (Continued). Critically endangered mammals, birds and reptiles species of Pakistan.

	Common Name	Scientific Name	Threats	Current Distribution	Estimated Population/ Number
Family Hyaenidae	Hyaena	*Hyaena hyaena* (Linnaeus, 1758)	Persecution, habitat fragmentation, reduction of prey species populations	Kall, Bhal, Palugram, Daphar Plantation, Jals park, Qaderabad, Sukh-Beas near Chunian and Changa Manga (Punjab), Kirthar National Park (Sindh)	30[4]
Family Felidae	Sand Cat	*Felis margarita* (Loche, 1858)	Persecution, poaching	Nushki, Chaghai (Baluchistan)	Possibly extinct[5]
	Caracal or Red Lynx	*Caracal caracal* (Schreber, 1776)	Persecution, poaching, habitat fragmentation, reduction of prey species populations	Lal Suhanra National Park (Punjab), Kirthar National Park, Runn of Kutch Wildlife Sanctuary (Sindh)	10-15[4]
	Panther or Leopard	*Panthera pardus* (Linnaeus, 1758)	Habitat degradation and fragmentation, persecution, poaching, hunting for pelt and fur, reduction of prey species populations, livestock depredation	Margall Hills, Galiat, Manglot Wildlife Park, Dareen, Toreshore, Zari, Khalifat Range, Penchar, Kirthar Range	Few individuals[6, 7]
	Snow Leopard	*Uncia uncial* (Schreber, 1775)	Habitat degradation and fragmentation, persecution, poaching, hunting for pelt and fur, reduction of prey species populations, livestock depredation	Naltar Wildlife Sanctuary, Chitral Gol National Park, Khunjerab National Park, Bar valley in Gilgit, Skardu, Ghizar, Tooshi game reserve in Chitral, Chitral Gol National Park, Kohistan, Naran, Mahodand and Utrot valleys in Swat and Passu Glacier.	200-400[7]
Order Perissodactyla					
Family Equidae	Indian Wild Ass or Onager	Equus hemionus khur (Pallas, 1775	Habitat loss, poaching, domestication	Nagar parker bordering areas, mud flatlands of Runn of Katch (Sindh)	68[6, 8]

Table 2 (Continued). Critically endangered mammals, birds and reptiles species of Pakistan.

	Common Name	Scientific Name	Threats	Current Distribution	Estimated Population/ Number
Order Artiodactyla					
Family Bovidae	Goitered Gazelle	Gazella subgutturosa (Sykes, 1831)	Poaching, competition with live-stock, habitat degradation and loss.	Jhalwar (Balo-chistan)	
	Mountain Sheep	*Ovis ammon* (Linnaeus, 1758)	Poaching, competition with live-stock, habitat degradation and loss.	Pamir plateau in Pakistan at Khunjerab Pass and Kilik Mintika Passes, Northern ranges of Karakorums, Karchnai nullah in Khunjerab National Park, Sakhtarabad	< 150[9]
Order Rodentia Family Sciuridae					
	Himalayan Marmot	*Marmota himalayana* (Hodgson, 1841)	Livestock grazing	North and North-east of Skardu, North of Shyok River.	<100[8]
Birds					
Family Accipitridae	White-rumped Vulture	*Gyps bengalensis* (Gmelin, 1788)		Widely distrib-uted throughout the provinces of Punjab, Sindh and the broader valleys of Khy-ber Pakhtukhwa (KPK)	11[10]
	Indian Vulture	*Gyps indicus* (Scopoli, 1786)		Southeast region of Pakistan	200-250 pairs[11]
Family Charadriidae	Sociable Lapwing	*Vanellus gregarious* (Pallas, 1771)		Jaffarabad District, semi-natural steppic habitats	<10[12]
Family Gruidae	Siberian Crane	*Leucogeranus leucogeranus* (Pallas, 1773)		Lakki Marwat, Zhob district of Baluchistan, Tanda Dam, Rann of Katch Game Reserve, Chashma Barrage Wildlife Sanctuary, Taunsa Bar-rage Wildlife Sanctuary, Zangi Nawar Wildlife Sanctuary	Possibly extinct 13

Table 2 (Continued). Critically endangered mammals, birds and reptiles species of Pakistan.

	Common Name	Scientific Name	Threats	Current Distribution	Estimated Population/ Number
Family Otididae	Great Indian Bustard	*Ardeotis nigriceps* (Vigors, 1831)		Cholistan Desert, Dry semi-desert regions	300[14]
Reptiles Order Chelonia					
Family Chelonidae	Hawksbill Turtle	*Eretmochelys imbricate* (Linnaeus, 1766)		Ormara on Balochistan coast, Sandy, shoreline, sandy beaches[15]	
Family Dermochelyidae	Leatherback Turtle	*Dermochelys coriacea* (Vandelli, 1761)		Primarily found in the open ocean, though recent satellite tracking research indicates that leatherbacks feed in areas just offshore. Gwadar [16]	

[1]Nawaz (2007), [2]Sheikh (2006), [3]Anon. (2012), [4]Sheikh and Molur (2004), [5]Sliwa et al. (2016), [6]Henschel et al. (2008), [7]Anon. (2016), [8]Shahid (2008), [9]Schaller and Kang (2008), [10]Murn et al. (2008), [11]Gilbert et al. (2004), [12]Chaudhry et al. (2012), [13]Birdlife (2016), [14]Birdlife (2016), [15]Ilyas (2014), [16]Dawn (2015).

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Biodiversity in India: Its Importance and Conservation

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Biodiversity in a crude way is referred to listing of species, their number and status in particular region. However, it is an ephemeral phenomenon and is more related to social and economic development of the region. Four decades ago it was not a serious issue but after the 1972 Stockholm conference it has been focused as a major bio-political issue.

The 1992 United Nation conference on environment and development—the "Earth summit"—put biological diversity on the International agenda by signing the convention on biological diversity (CBD). Entering into force as an international law in December 1993, the CBD has now been ratified by over 169 countries. There are three major thrusts to the CBD: (1) Conservation of biodiversity; (2) the sustainable utilization of biological resources; and (3) the equitable sharing of benefit arising from such utilization.

The Indian region, with a total area of 329 million hectares, is indeed rich in biological diversity (having about 89,599 species of animals) because of its tropical location, varied physical features, and climate. India led the way in ratifying the CBD. But have we followed its provision to protect our biological resources? The answer is no.

In the present paper some important aspects on biodiversity such as scenario, real situation, loss of biodiversity, their conservation and sustainable utilization for the present and future generation, etc., are discussed.

Introduction

Biodiversity refers to the rich variety of life forms on the earth - the different plants, animals, and micro-organisms. It also includes the genes they contain and the ecosystem they form. In fact, it (biodiversity) is a concept laying emphasis on interrelated nature of the living world with its processes.

The term 'biodiversity' was first used in its long version biological "diversity" by Loverjoy (1980) and is most commonly a relatively new compounded word. Biodiversity in a crude way is referred to listing of species, their number and status in a particular region. However, it is an ephemerical phenomenon and is more related to social and economic development of the region. Four decades ago it was not a serious issue, but after the 1972 Stockholm conference, it has been focused on as a major bio-political issue.

The term biodiversity has been used so often, and so loosely, that its meaning has become obscured. On the simplest level, it relates to the dizzying array of life forms, filling every conceivable niche on scales ranging from microbes to blue whales. Variety is not only the spice of life but the essence of life itself.

Levels of Biodiversity

There are three distinct levels of biodiversity, though all of them are components of a much intricate web. They are:

1. Genetic diversity: refers to variation of genes within species, sub-species or a group of species.

2. Species diversity:

(a) Species richness: the total number of species in a defined area;
(b) Species evenness or abundance: the relative abundance of species;
(c) Species dominance: the most abundant species;
(d) Phylogenetic diversity: relationship between different groups of species.

3. Ecosystem diversity: the diversity in habitats or ecosystems.

Species diversity

Ecologists estimate the biological diversity by the species richness.

What is the number of species on the globe?

(i) An estimated 1.7 million species have been described to date but at present it seems to vary from 5 million - 12.5 million (Swingland 2001).
(ii) According to E.O. Wilson (vide Madhyastha 2000), it may be 100 million species living today on the earth.
(iii) According to Peter Raven (vide Madhyastha 2000), there are about 30 million species.

Global biological spectrum may be as follows:

Table 1. Species diversity within the major categories of organisms.

No.	Category	Global scenario (No. of species)	Indian scenario (No. of species)
1	Protozoa	30,800	—
2	Porifera	5,000	—
3	Cnidaria	9,000	—
4	Platyhelminths	12,200	—
5	Nematoda	12,000	—
6	Annelida	12,000	—

Table 1 (Continued). Species diversity within the major categories of organisms.

No.	Category	Global scenario (No. of species)	Indian scenario (No. of species)
7	Mollusca	50,000	5,050
8	Echinodermata	6,100	—
9	Insects	8,000,000	54,000
10	Non-insect Arthropods	1,230,400	—
11	Fishes	32,500	3,285 (45 threatened)
12	Amphibians	4,200	204 (62% endemic)
13	Reptiles	6,300	456 (33% endemic)
14	Birds	9,000	1,228
15	Mammals	4,000	372 (81 threatened)
16	Cattle	178.6 million	—
	Total	89,599 (2% of world land mass). Not constant. This number is variable.	

Table 2. Estimated number of described species and possible undescribed species of micro-organisms.

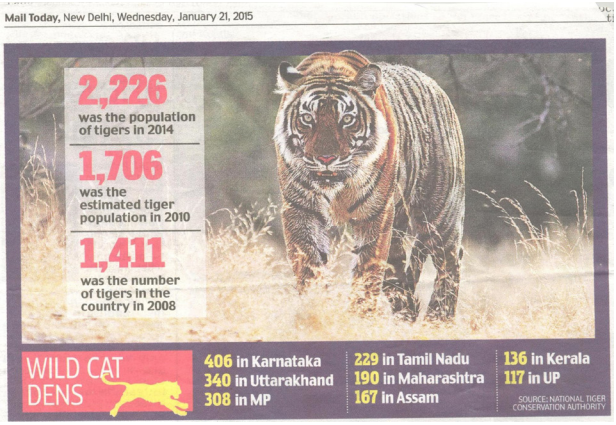
Group	Described species	Estimated species	Presently known	Indian scenario
Algae	40,000	3,500,000	11.0	—
Bacteria	4,000	3,000,000	0.1	—
Fungi	70,000	1,000,000	5.0	23,000
Protozoa	40,000	1,000,000	40.0	—
Viruses	5,000	500,000	1.0	—
Total	1,590,000	9,090,000	57.1	23,000

Source: Global biodiversity status of the Earth's living resources compiled by world conservation monitoring centre and edited by Brain Groonbridge, vide S.S. Singh and S.C. Tiwary (1998). Employment News. Vol. XXII (41) pp. 1-3.

Table 3. Plant biodiversity.

Groups	Global	Indian Scenario
Green Plants	300,000	45,000
Bacteria	—	850
Fungi	—	23,000
Algae	—	1,600
Lichens	—	2,664
Bryophytes	—	1,022
Pterydophytes	—	64
Gymnosperms	—	15,000
Angiosperms	—	53,430

Endangered species (By Jairam Ramesh, Union Minister for forest, April 2010)
Total: 560; Animals 313; Plants: 247
Mammals: 89; Birds: 75; Reptiles: 25; Ampibia: 63; Fish: 39; Mollusks: 2; Invertebrate: 20 = 313



The status of many invertebrate species is not known. Lack of data is perhaps because schedule I of wildlife (Protection) Act 1972 includes only a few of the species of the coconut crab of Andaman and 130 species of butterflies. A number of beetle and butterfly species are also becoming rare, vulnerable, or near extinction either due to excessive exploitation or habitat destruction.

Biodiversity from the equator to the pole

It is very interesting to know if there is any relationship between animal biodiversity and latitude. The swallow fall butterfly occurs all over the world. Table 4 shows the number of sub-species of the butterfly in strips of 100 at various latitudes (Waldron and Ricklefs 1973).

Table 4. Biodiversity of swallow fall butterfly from the equator to the pole.

Latitude	North							South			
	70	60	50	40	30	20	10	10	20	30	40
No. of Species	14	31	74	136	131	167	240	261	161	92	23

The above table indicates that maximum number of sub-species of butterflies were recorded both at 100N and 100S. This hypothesis may be true for other animals also. Whether this is related to the physical variation in land mass or not, is yet to be ascertained.

Table 5. Country-wise distribution of total number of animals species (Up to 10th ranks).

Country	Mammals	Country	Birds	Country	Reptilia	Country	Amphibia
Indonesia	515	Colombia	1921	Mexico	719	Brazil	516
Mexico	449	Peru	1703	Australia	686	Colombia	407
Brazil	428	Indonesia	1519	Indonesia	600	Ecuador	358
Zaira	409	Ecuador	1447	Brazil	467	Mexico	282
China	394	Venezuela	1275	Colombia	383	Indonesia	280

Table 5 (Continued). Country-wise distribution of total number of animals species (Up to 10th ranks).

Country	Mammals	Country	Birds	Country	Reptilia	Country	Amphibia
India	372	Bolivia	1250	India	353	China	265
Peru	361	Malaysia	1200	Ecuador	345	Peru	251
Colombia	359	India	1200	Peru	297	Zaira	216
Uganda	311	China	1195	Malaysia	294	USA	216
Tanzania	310	Brazil	672	Thailand	242	Venezuela	197

Table 6. Endemic species in India.

Groups		No. of Species
Plants	Pteridophyta	200
	Angiosperms	4950
Animals	Parasites	500
Protozoa	Free living	90
	Lepidoptera	9
Mollusca	Land and Freshwater	967
Pisces	Freshwater	64
	Marine	14
	Amphibia	123
	Reptilia	182
	Aves	60
	Mammalia	44

Factors that increase and decrease biological diversity

The factors that tend to increase and/or decrease biological diversity have been shown in the tabular form below:

A. Factors that tend to increase biodiversity	B. Factors that tend to decrease biodiversity
High diversity at one trophic level increase diversity at another level	Environmental stress
An environment highly modified by life	Extreme environments
A physically diverse habitats	A severe limitation on the supply of essential material
Moderate amount of disturbance	Extreme disturbances
A small variation in the environmental condition	Introduction of exotic species
Evolution	Geographic isolation
Middle stage of succession	—

Source: Compiled by N.A. Madhyastha (2000). Human environment and biodiversity. AIBA News link. 3 (3) 1-4.

Biodiversity: Key to food security

It has now have been proved beyond doubt that preservation of biodiversity is at the heart of a successful food security and breeding program. Farmers have been focusing attention only on the plant that is most amendable to their condition. From the 20,000 edible species, only a dozen crops (e.g., barley, maize, millet, rice, sorghum, and wheat) are getting farmer's attention. Animal husbandry also followed a similar path. Among the world's 4,000 mammals and 9,000 birds, almost all meat, milk, eggs, and other animal products today come from just five animals (cattle, pig, goat, sheep, and poultry). It is high time now; we must exploit other and unexplored varieties of crops and animals to feed the humanity. Increased agricultural output is necessary to feed teeming millions but at the same time conserving biodiversity and exploring the unexplored varieties of life forms, is a must.

Growth of Population and Food Requirement (Sharma 2003)

We must explore, unexplored varieties of life form.

S.n.	Items	2001	2021	2041
1.	Projected population (in millions)	1027.02	1287.88	1468.4
2.	Average food req/ capita/day (MT)	0.565	0.708	0.808
3.	Food requirement (MT/yr)	206.16	258.54	394.78
4.	Food production (MT/yr)	211.17	262.38	284.09
5.	Grain/ deficit food grain(Mt)	4.99	3.82	(-10.69)

Biodiversity: key to food security

	Edible species	Farmers attention
Global	20,000	About a dozen crop only (rice, wheat, maize, millet, sorghum)
	Mammals - 4000	Meat, milk, eggs, etc., are just coming only from 5 animals (cattle, pig, goat, sheep and poultry)
	Birds - 9000	

Microbial diversity and its importance

Microbial diversity constitutes an essential part of the biological diversity on the earth. Micro-organisms possess a large size of diversity in forms of number and genetic makeup. They possess a novel pool of genetic resources. Less than 5% of the total number of microbes has been discovered and major of diversity in these organisms are yet to be explored and identified in future.

Micro-organisms are crucial to the functioning of the World's ecosystem and thus to the livelihood of human kind. They are major contributors to the

biogeochemical cycle and perform unique important activities in the circulation of matters. At present the importance of micro-organisms has increased because of their significant contribution in biotechnology, biochemistry molecular biology and in genetic engineering of plants and animals.

Now the microbial resources has immense potential for sustainability through increased food production, alternate technologies, waste re-utilization, bio-remediation and production of useful metabolites, enzymes and hormones. Over 3,000 antibiotics including those of commonly used penicillin, tetracycline, etc., are derived from these microbes. Therefore, the importance and utility of micro-organisms in the Biosphere as well as in the human welfare has been acknowledged with utmost importance.

Microbial biodiversity and its significance:

- Less than 5% of the total number of microbes have been discovered.
- Remaining species are yet to be explored and identified.
- Immense potential for sustainability through increased - food production, waste re-utilization, bioremediation; production of enzymes and metabolites.
- 3000 antibiotics (including Penicillin, Tetracycline, etc.) are derived from these microbes.

Role of remote sensing in biodiversity conservation:

Conservation of biodiversity can only be achieved through protection of biological habitat. Under "Jai Vigyan" project, sponsored by Government of India. The Department of Space has been contributing in the bio-resource assessment of the nation (Roy and Behera, 2000). Remote sensing technology is very useful in locating different types of bio-resources to identify appropriate corridors surrounding natural habitats and protect them from human interventions and other harmful influences that endanger the existence of these habitats.

Biodiversity variation over millions of years and rising biological diversity:

Many people worry that biological diversity is decreasing because of the unwise action of human beings. Before we discuss that, we need to know how biological diversity has varied over geological time. Fig. 1 shows the number of families of marine organisms from 600 million year ago to the present time (Phillips and Chilton 1996). Ordovician and Cretaceous period onward show the fastest increase in the families of marine organisms.

Ecologists worry about the extinction of species and the resulting loss of evolved genetic information. It is well known, however, that few extinctions have occurred at the level of the phylum or above in the hierarchy of classification. This implies that genetic evolution at least up to a certain level has been

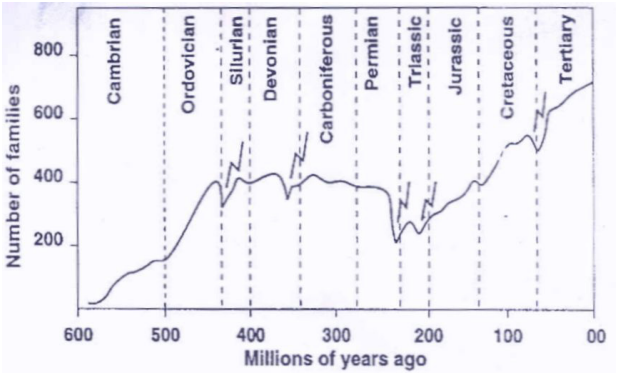


Fig. 1. Increasing biological diversity over millions of years.

preserved through geological time. Many small modifications have been lost through the extinction of species.

Species are going extinct all of the time, while extinction of genera and families are rare. Most biologists agree that, on the average, a species exist for 1-1.0 million years.

Nature has, over almost a billion years, recovered from many calamities, to increasing number of species and families that we see around us. What then, is worrying many people today? Why do many among us lament the loss of diversity and destruction of nature?

Values of biodiversity

It can be studied under 3 headings - Ethnic, Economic, and food values.

Ethnic values: Humans are a part of nature and not apart from nature. Well being of one part of nature is necessary for the well being of all others. All species have an inherent right to exist. The Indian culture evolved amidst forests where our learned Saints and sagas lived.

The Economic value of biodiversity can be classified into two categories - direct (includes food, medicine, genetic resources, dyes, fur and fibers) and indirect values (maintenance of healthy eco systems).

The food (crop plants and animals) value and industrial use of plants (cork, gum, latex, camphor, resin) are well known to everybody.

Loss of biodiversity: Causes and consequences

In the biosphere, where the evolution is in operation, extinction is in operation, extinction of unfit and rarity of less fit in natural selection is an evolutionary necessity. Therefore, extinction is not an abnormal process in the life of a species. Whenever all the niches of an ecosystem are occupied, extinction

occurs as a part of origin of new species. Thus extinction is a must for the survival of the fittest.

However, the present day drastic changes in the environment and habitat due to human population explosion and unmanaged development activities are so unnatural that the species are not getting full liberty of time and space for survival and adaptive radiation, therefore resulting in the loss of biodiversity.

According to some estimates about 27,000 species are being driven towards extinction each year. That means about 75 species are getting wiped out every day globally.

In India about 450 plant species, 81 mammals, many more birds, reptiles, fishes, amphibians, mollusks and other invertebrates are threatened with extinction. Some very soon, some within a decade or so. The world's humid and tropical regions are more vulnerable to species extinction. About 25% of the plant and animal species might be lost by 2025 AD (Lugo, 1988). If genocide is a crime, specicide in equally so.

The pie chart (fig. 2) put forward by Chrias (1994) is self-explanatory and elaborates on the causes of extinction of species. Fig. 3 indicates the proportion of species that will be lost over the next 50 years, assuming the current rate of

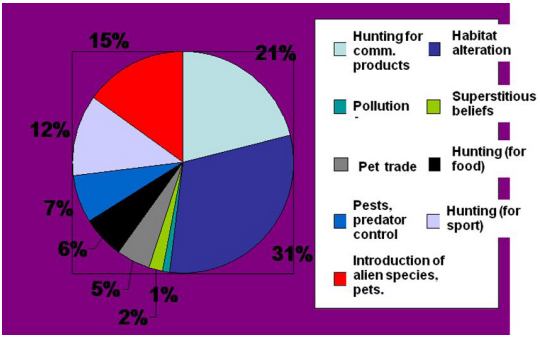


Fig. 2. Causes of extinction of species: a pie chart.

deforestation (WRI, 1992). The calculations are from 1990 (0% in 1990), ignoring earlier losses. The shaded region shows the uncertainty in the prediction.

Researchers trying to chart biodiversity are fighting the clock, with species disappearing at what may be an unprecedented clip - often slipping from our grasp before we have the chance to study them. Many experts believe the sixth major extinction in our planet's history is underway, this one with the distinction of being largely caused by humans. By some accounts, we are losing species 10,000 times faster than new ones are being generated through evolution. The threat comes from many sources including climate change, industrial and agricultural pollution, destructive hunting and fishing practices, deforestation, over exploitation, land development, indiscriminate water abstraction, destruction of feeding and breeding grounds and other activities leading to habitat fragmenta-

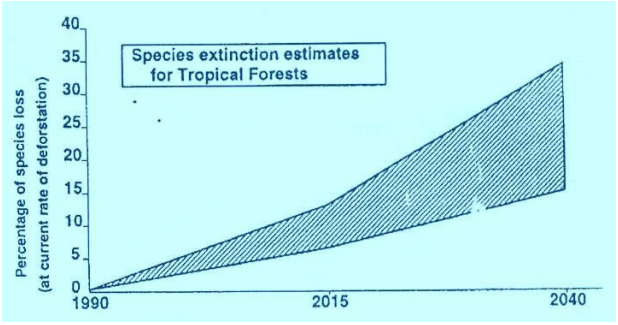


Fig. 3. Estimated species loss due to deforestation, 1990-2040. (After WRI 1992).

tion, and destruction. Regardless of the exact causes, the net effect is the erosion of our natural legacy - a loss that is incalculable and, in many cases, irreversible.

The unit of biodiversity, a species can become extinct for any of the following reasons: (i) Disappearance of fundamental niche (ii) Habitat destruction and depletion of resources (iii) overexploitation (iv) competitive extinction of one tropic level and (v) illegal trade.

Biodiversity conservation strategies:

The important aspect or need in this regard is to teach the people about the real situation of loss of biodiversity, their conservation and sustainable utilization for the present and future generations. Steps needed are:

1. Awareness (physical, social, and aesthetic values).
2. Practical life situation (to link the biodiversity with real life problems).
3. Sustainable (wise) utilization.
4. Conservation (i.e., to educate the masses with the idea that all the living resources have a limit of growth, therefore, for the fullest use, they should be conserved).
5. Formal and non-formal education system (from Primary to University level education).
6. Organization of workshops and camps.
7. Newspapers and electronic media can play an important role in conservation of biodiversity.
8. Celebration of biodiversity conservation day / or week.
9. Important steps to be taken to develop new technologies necessary for conservation and sustainable use of forest biodiversity.
10. Besides above methods, *in situ* (to be done by protecting areas rich in biodiversity such as National parks (about 148 in number), sanctuaries (503 in number) and Biosphere reserves (13 in no) and *ex-situ* (i.e. conservation of biological diversity outside their environment) have been adopted. Maxted

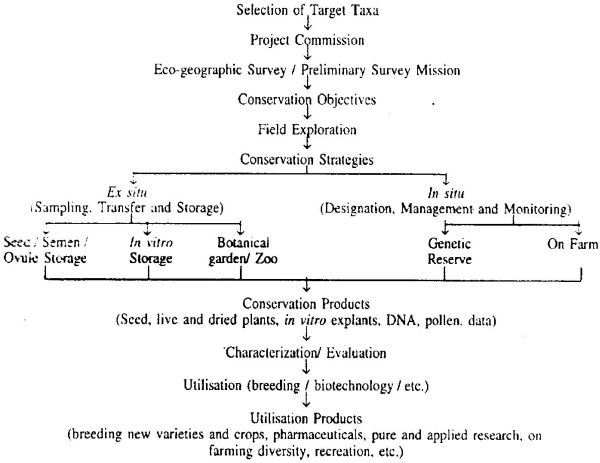


Fig. 4. Model of biodiversity conservation (adapted from Maxted et al. 1997).

et al. (1997) model (as illustrated in fig. 4 and quoted by Vyas et al. 2003) of biodiversity conservation is self-explanatory.

Gene Banks at Global level

Gene banks to preserve endangered and regional plant species have been initiated by University of Dublin, Ireland, the polish Academy of Sciences, and the polytech University in Madrid, Spain, the seed bank at the University of California, The royal Botanic Gardens at Kewi, The international Rice Research Institute at Los Banos (Philippines, The Izmir Centre (Turkey), The Vavilov Institute (Lenigngrad) and The United State's National Seed storage Laboratory (NSSL) located at the University of Colorado in Fort Collins. The efforts are praise worthy aimed at saving the wild and other species.

Effect of Climate Change

Global warming affects many aspects of the environment, including sea level, coastlines, agriculture, fishery, forestry and wildlife. Continued global warming could have a beneficial impact and a harmful impact in many others.

Beneficial: People could begin to farm in regions where it is currently too cold.

Harmful Impact—Global warming could:

(i) Alter the ecology of many part of the earth.

(ii) Change rainfall pattern; heavy precipitation; drought; decrease in water catchment area.

(iii) Melting enough polar ice to raise the sea level (2 cm in last century)

- Over 200 Antarctic glaciers retreated (vide Prabhat Khabar 23.04.2005).
- Himalayan glaciers retreating @ 10-15m/yr (05.04.2005)
- Gangotri glaciers retreating @ 23m/yr (05.04.2005)
- Giant iceberg known as B15A (Near Mc Murdo station on North Antarctica coast) has broken; about 160 sqkm + 70 km. can supply water to US for 120 day. (21.04.2005)
- 3240 sq km iceberg broken near Larson Himkagar of Antarctica – May, 2002

Overall Impact of Global Warming

With the threats of global warming and consequent climate changes looming large across the globe – Water resources, agriculture, fisheries, Wetlands and biodiversity would be primarily impacted – ultimately with reflections on food production.

The reported impact of global warming includes:

Melting of glaciers (about 200)
Rise in sea levels.
Increase in sea surface temperature (Since 1960)
Ocean acidification
Floods, droughts, violent tropical storm, change in monsoon pattern, abnormal and extreme rain falls.
Coastal erosion and inundation (27 countries including India).
Decline in ocean productivity.
Shrinkage of vital base of ocean food web.
Changes in the flow of ocean current.
Disturbances to nursery and breeding ground.
Freshwater stress and scarcity.
Pollution of aquaculture system.
Prevalence of fish diseases.
Shrinkage of cold weather.
Contamination of sea food.
Extinction of species.
Decline in food fish production.

Greenland is the main culprit for climate change as the ice rocks of that area is melting faster as compared to Antarctica which may result in an increase in sea level up to 20 ft. We have to know that what happened during Ice age (about 125,000 yrs ago) when ice rocks were formed there.

Some latest reports regarding biodiversity (vide newspaper 27/02/2012)

(i) Last census - 87 lakh sps (2.2 lakh aquatic) S B Biju or Satbhama Das Biju, Kerala, Village KaddaKal (Dist Kolam) at present at Delhi University, also called FROG MAN is the leading scientist in the field of discovery of new species

in India: so far 81 thousand new species discovered in India: 46 thousand new species of plants: Estimated number of total species is 3.0 Crores.

- Twelve new species of nocturnal frogs discovered in Western Ghat out of which 3 species have not been seen since last 75 years; are as ancient as Dinosaurs
- *Hydrophis donaldi* (sea snake of Australia : New Species)
- Frogs are the best indicator of pollution.
- Equipment: Remotely operated Vehicle (ROVE)

(ii) 20% of the species of the world are on the verge of extinction

(iii) Estimation of temperature rise by year 2100 (3oC or 5oF) will cause rise in sea level by 25 mts

(iv) Increase the severity of tropical storms.

(v) Lead to shifts in plant and animal population.

(vi) Ocean currents and wind patterns could change, making some areas cooler than they are now.

(vii) It will be difficult for many species to survive in the regions they now inhabit; may be forced to migrate; could become extinct.

(viii) Enhance evaporation rate and hence increase the other components of the hydrologic cycle.

(ix) Cloud outburst, volcanic eruptions, tsunamis, etc., will become more frequent.

(x) Outbreaks of many diseases; livelihoods to be affected (hunger); Inundation of many coastal cities.

Scientists of the world feel that:

(i) Whatever resources we have till 2100 AD, that has to be spent to decrease CO_2 (up to 40%): 10.08.2011

(ii) More energy to be produced from atomic power plant

(iii) Renovation in traditional source energy production

(iv) Energy efficient electrical equipment to be used

(v) Lesser use of those equipment which produces more CO_2

(vi) Preaching of Green Islam (Indonesia) and Buddhist views of Environmental conservation will save the biodiversity.

A novel step to conserve Biodiversity

Dr. Harshwanti Bisht (Teacher of Economics at Bhojbasha, near Gomukh, 3792 meter above sea-level) successfully planted 10,000 Bhojpatra (of 1-14 yrs age) with the help of one mountaineer (Ratan Singh) and 3 laborers. As on today, in her nursery about 20,000 plants of – Bhoj, Mangil, Pahari, Pipel, Kutki, Areha, Samal Panza and 12,000 plants of Atis are ready for plantation (September 2013). These are rare medicinal plants. She has developed emotional attachment with nature- environment.

Fund requirement for biodiversity conservation:

The Global biodiversity strategy estimated that effective conservation in developing countries would cost US$30.0 billion per year, with global spending on conservation (all countries) is estimated to be $4.14-6.0 billion/yr. The average annual commitment of aid for biodiversity in the period 1987-1994 was US$445.75 million. The investment varies considerably among donors. Biggest overall donors were Japan, U.S., Finland, and Switzerland were among the top 5 biodiversity funder besides Germany, Netherlands, and Norway. During the recent UNO climate change Summit held at Paris in 2015, the developed Nations have assured to invest adequate fund to save the environment and Earth.

Some Questions and Solutions

India led the way in ratifying the convention on biological diversity. But have we followed its provisions to protect our biological resources?

The answer is no.

Why?

1. The new economic policy has increased exports of national resources and encouraged the opening up of protected areas for industrial exploitation (increased erosion of biodiversity).
2. Less focus has been given on the neglected lower life forms including micro-organisms.
3. Local communities are alienated.
4. The Government sleeps: The government is yet to notify the order regulating the removal of genetic material from India.
5. Imposition of tax on the industry which uses biological resources.
6. Commissioning the preparation of detailed status report on biodiversity in India, covering both wild and agricultural biodiversity and animal biodiversity.

Conclusion

The conservation of biodiversity is of critical importance, not only because the very diversity is under threat of extinction and erosion, but also because it can be of direct and indirect benefit of human kind. In fact, plants and animals hold in them a lot of treasurers like cures for diseases and genes to increase yield of our food crops.

"Without support from all sections of society the goals of the biodiversity conservation can't be realized" - Jeffrey McNeely (1999)

"A threat to any species of plant and animal life is a threat to man himself" - Indira Gandhi

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Defaunation—Disappearance of Species and Declines in Abundance—Need of the Hour

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On One day, I was watching the National Geographic Channel, in which a large scale hunting of Canadian seals was aired. To safeguard themselves from the hunter, the seals were busy in their impromptu races from here and there on the sea. Thereafter, I was watching the famous Oktoberfest of Germany, in which large scale slaughtering of cows and bulls were portrayed to fulfill the enjoyment of the festival on a large scale. The famous Bakrid has also imbibed me a moment and knocked my mind how an animal is sacrificing for mankind. The famous crab hunting by Norwegians and Dutchman at the North Sea keeps me at a bay. Although, these channels aired the very fact and it provides thrilling adventure but non-other the less, it also portrayed the path towards extinction of flora and fauna and thereby mass destruction of the eco-system. The recently held Paris Climate Convention in which the main focal theme were climate as well as norms of greenhouse gas emission where India also ratified the same or the recent statement of UN Secretary General's speech on North-Korea's Nuclear War head testing, all of them are giving the same message that to safeguard the "Blue Planet", the need of the hour is conservation. Hence, conservation of both flora and fauna is the essential pre-requisite if we want to survive on the earth.

While discussing the above, it may inculcate in our mind, that what mind set up inspired me to introduce such facts. Hence, the term 'Defaunation'- the prerequisite for faunal conservation is the need of the hour. In a recent Indian Daily news paper, it was boldly, superfluously written "Meat eating is driving 300 wild mammal species into extinction". Hence, the term defaunation prevails for this time to conserve bio-diversity.

Defaunation is the loss of faunal life within the eco-system. It is different from extinction in that it includes both the disappearance of species and decline in abundance. It was first implied at the symposium held in University of Campinas, Brazil, in the year 1988. Since, then the term augmented with an alarming rate in conservation biology as an international phenomenon. News articles have been surfacing from a journal published in Paris where it was clearly mentioned that wild mammal species in Asia, Africa, and Latin America are being driven to extinction by humanity's voracious appetite for bush meat, according to a world-first assessment released on 19 December 2016. (Courtesy Times of India, 20 October 2016)

The species at risk range from rats to the rhinoceros, and include docile, ant-eating pangolins as well as flesh-ripping big cats. The findings, published in the

journal 'Royal Society Open Science', are evidence of a "global crisis" for warm-blooded land animals, 15 top conservation scientists concluded. Even in the latest publications of National Geographic, the Hornbill of Nagaland and the compactor dragon of Indonesia are on the verge of extinction. The data analysis of a leading Environmental journal says that 'Defaunation is a global phenomenon. Life on Earth is on the verge of Extinction with negative evolution.'

It is prudent to mention that terrestrial mammals are experiencing a massive collapse in their population sizes and geographical ranges around the world. This decline, it said, was part of a larger trend known as a "mass extinction event", only the sixth time in half a billion years that Earth's species are dying out at more than 1,000 times the usual rate. Thus defaunation and mass extinction is proportional phenomena.

According to the Union for the Conservation of Nature's Red List of endangered species, a quarter of 4,556 land mammals assessed are on the road to annihilation. For 301 of these threatened species, "hunting by humans" – mainly for food, but also as purported health and virility boosters, and trophies such as horn or pelts – is the main threat, according to the comprehensive review of scientific literature.

It is also pertinent to note that inbreeding and genetic diversity have a tremendous effect on defaunation. Loss of genetic diversity degrade the ability of a population to fight with environmental consequences and it may leads to individuals within community as homogenous. If it happens, animals are infected with diseases and it also target a specific genome. Inbreeding lowers the ability of reproduction and survival rate. Once survival rates are affected the diversification of animals hampered. The red panda of Darjeeling Himalayas are also facing similar situations. Whereas the giant panda of the Chinese region are flourishing with alarming rate. It may also lead to geographical isolation. The consequences of defaunation can be expected to affect plant communities in the form of seed dispersal. It also affects small bodied seed dispersers (i.e., bats, birds, dung beetles) and predators (i.e., rodents). The loss of species diversity is the reflective of a larger biodiversity destruction. The physical habitat quality is also suffered. It is revealed from a detail analysis in Western Amazon, that bird and bat species which rely on mineral licks for sodium are suffering from large scale affect of defaunated areas. The degradation of such licks have a negative effect on health and reproduction of bat populations. Defaunation has negative consequences with high modular network in which specialized frugivores instead act as the connector hubs (Courtesy Wikipedia).

It is also relevant to note that defaunation in the ocean has occurred later than on land. A sizeable number of marine species have been driven to extinction. Marine defaunation has a wide scale impact on ecosystem structure and function. Chemical contamination especially in the Malacca Strait where large scale oil / chemical containers are passing through play a major role for defaunation. The Mexican Gulf and Gulf of Aden are also experiencing a similar phenomenon. The bio-geochemical cycle and the reproduction and biological cycle have been altered. In India, The Great Ganges are also losing its animal life due to defaunation. The Indo-Gangetic Dolphin which was a daily phenomena in earlier days, in near future it will be a thing of the past.

Two of the most important ecosystem services threatened by marine defaunation are the provision of food and coastal protection. It is relevant to

mention that Japan's Annual Whale hunt has also jeopardized the balance of the Pacific belt ecosystem in a large extent. The world's whaling watchdog moved to curtail Japan's annual hunt, where scientific license was issued, it was warned that purpose of licensing meant for research and not for meat hunting. Hence, it was desired to halt the JARPA-II program. However, Japan further started the program under the new name NEWREP-A (New Scientific Whale Research Program in the Antarctic Ocean). As per the latest whale watch, Japan killed 333 Minke Whales in the Southern Ocean, with many of them pregnant. The Southern Ocean is one of best whale sanctuaries in the world. The main target of Japan's whale hunt based on two species i.e,. Antarctic minke whale (*Balaenoptera bonaerensis*) and Northern or common minke whale (*Balaenoptera acutorostrata*). Hence, the objectives of defaunation has been dwindled in a large scale. Hence, the very purpose of conservation needs at this stage.

According to Conservation of Antarctic Marine Living Resources (CCAMLR) treaty which is mainly entrusted with overseeing conservation and sustainable exploitation of the Antarctic Ocean, also known as the Southern Ocean Consensus, formulated a common draft policy among 24 member countries and the European Union to protect marine life. Thus, the Ross Sea in Antarctica will be the world's largest marine reserve in the world. It will cover more than 1.55 million square kilometers of which 1.12 million square kilometers will be a no fishing zone.

Thus, the conservation of fauna is the only answer to prevent defaunation. Life forms and global change are proportional to each other. If it is reciprocally placed the question to protect defaunation will be unanswered for a long time. Hence, immediate steps must be in place to protect the Blue Planet. Only 15% of world's 35 biodiversity hotspots are left intact. In this context the term Anthropocene is also relevant. It means the age of human induced change. But the different schools say that it may be time for a 'formalization' of the anthropocene as an entity '*equivalent to other formally defined geological epochs*'. Anthropocene may have begun with the detonation of the Trinity atomic device at Alamogordo, New Mexico. The atomic bomb catalyzed the Anthropocene. Later on Hiroshima and Nagasaki also accelerated the radio-nuclides across the globe which leads mortality in large scale. (Courtesy-Quaternary International).

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Remote Sensing and GIS for Wildlife Management

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The conservation of wildlife species is an important issue. GIS and Remote Sensing Technology plays a vital role in the wildlife analysis. Spatial ecology is the study of patterns and processes occurring in a geographic space or landscape that influence characteristics of plant and animal populations such as densities, distributions and movements (Clark et al. 2008). Remote Sensing techniques and use of GIS for mapping the endangered species can be conducted to help in understand the environmental factors (including land, soil, climatic condition) responsible for the extinction of species.

When two or more larger areas of similar wildlife habitat join, it creates a link of wildlife habitat, generally native vegetation known as a Wildlife Corridor. The allowance for the movement of animals and continuation of viable populations make corridors critical for the maintenance of ecological processes. Corridors can enable migration, colonisation and interbreeding of plants and animals by providing landscape connections between larger areas of habitat. Across the landscape a sequence of stepping stones (areas of habitat such as paddock trees, wetlands and roadside vegetation are discontinuous), lineal strips of vegetation and habitat are continuous (e.g., riparian strips, ridge lines), consist corridors which may be parts of a larger habitat area which has been selected for its nature or likely importance to local fauna.

The two main contributors which continue in the decline of biodiversity across the landscape are habitat loss and fragmentation. Across both public and private lands a holistic approach is required to ensure the connectivity between remaining habitats and to protect and manage the natural ecosystems. Fragmented patches or islands are created when native vegetation is cleared and these patches may show an increase in the cut-off from other areas of habitat which may show the result in many plant and animal species becoming isolated, especially for the case when land between the patches is permanently altered for human activities. The on-going viability of ecosystems and the individual populations of species within them is severely affected as these vegetation patches are reduced in size and become increasingly isolated which ultimately leads to a break down in the ecological processes such as migration of species, dispersal, nutrients recycling, plant pollination and other natural functions required

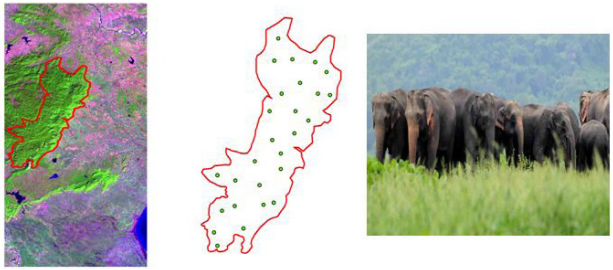

Fig. 1. Habitat site mapping through satellite imagery.

for the health of ecosystem. It can result in severe decline of biodiversity and the local extinction of sensitive species. An extremely important role in the maintenance of biodiversity is played by the corridors, but they can only partly compensate for the overall habitat loss produced by the fragmentation of the natural landscape. Therefore, it is important, for the maintenance of the vegetation remnants and vegetated corridors for enhanced network across all lands both private and public. In this way private landscapes can contribute to wider landscape conservation efforts by enhancing and linking existing reserves and conservation networks.

The evolution of GIS, the Global Positioning System (GPS), and Remote Sensing (RS) technologies has enabled the collection and analysis of field data in ways that were not possible before the arrival of computers (Sonti 2015). An analysis of the complex inter relationship among the various environmental factors existing over a geographical area involves us in the study of wildlife habitat suitability. In order to identify the most suitable and moderately suitable habitats, each model of GIS should be applied. Each model involves a study of life consisting requisite factors of food and cover including forest type, topography, water resource, distance from human activity center and other factors.

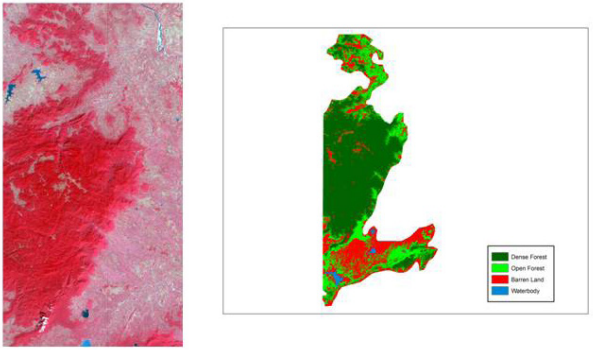

Fig. 2. Land use map through satellite imagery.

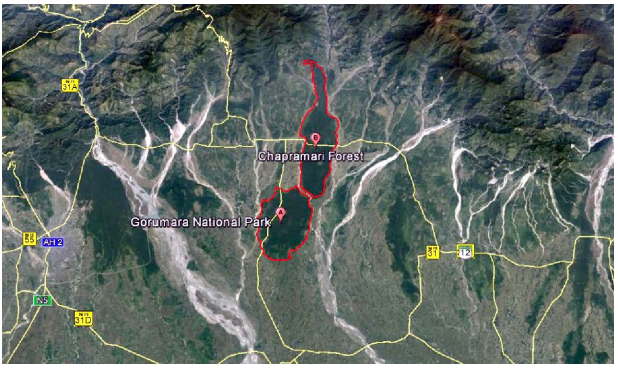

Fig. 3. Google Earth image for identification of location of forest area.

Field investigation with GPS, Landsat imagery, and topographic maps were employed to generate the thematic layers relevant to each model in the GIS Database, using Arc GIS software leading to the generation of habitat suitability maps. These kinds of maps are very useful in obtaining a clear idea about habitat suitability for animal species and wild life corridors.

With its versatility and potential in addressing ecological issues, Geographical Information Systems (GIS) were used in a study of wildlife habitat prediction (Danks and Klein 2002).The Global Positioning System and optional environmental sensors or automated data-retrieval technologies such as Argos satellite uplink, mobile data telephony or GPRS and a range of analytical software tools can be used for wildlife tracking. This process is known as GPS wildlife tracking whereby biologists, scientific researchers or conservation agencies can remotely observe relatively fine-scale movement or migratory patterns in a free-ranging wild animal.

Global positioning system (GPS) devices have improved the availability and accuracy of animal-relocation field studies and greatly enhanced wildlife research (Cagnacci 2010). For this process a GPS-enabled device is needed which will record and store location data at a pre-determined interval or an interrupt by an environmental sensor. These data may be stored pending recovery of the device or relayed to a central data store or internet-connected computer using an embedded cellular (GPRS), radio, or satellite modem for plotting the animal's location against a map in near real-time or, when analysing the track later, using a GIS package or custom software.

Wildlife tracking can place additional constraints on size and weight and may not allow for post-deployment recharging or replacement of batteries or correction of attachment, while GPS tracking devices may also be attached to domestic animals such as pets, pedigree livestock and working dogs, and similar systems are used in fleet management of vehicles. Birds, reptiles and marine mammals are examples of direct attachment where a collar cannot be used.

The GPS unit must be very lightweight in case of birds to avoid interfering with its ability to fly or swim. This device is usually attached by gluing or, for short deployments, taping to the bird as the unit will then naturally fall off when the bird next moults.

The device would be glued to the fur and fall off during the annual moult in deployments on marine mammals such as phocids or otariids. Units used with turtles or marine animals have to resist the corrosive effects of sea water and be waterproof to pressures of up to 200bar.

Collar attachment shows a suitable body type and behaviour being the primary attachment technique. It would normally be used on the animal's neck (assuming the head has a larger circumference than the neck). It can also be used on a limb, perhaps around an ankle. Animals like primates, large cats and some bears are suitable for neck attachment whereas animals such as kiwi, would work well in limb attachment due the foot is much larger than the ankle.

Cases of where collar attachment is not suitable includes, such as animals whose neck diameter may exceed that of the head. Examples of this type of animal may include pigs and Tasmanian devils. Large, long-necked, birds, such as the greylag goose, may also need to be fitted with a harness to prevent removal of the tag by the subject.

In comparison to other methods, implanted transmitters may suffer from a reduced range as the large mass of the animal's body can absorb some transmitted power, which mainly includes rhinoceros tracking, which is done with a hole drilled in animal" s horn for the device implant.

The work of a GPS-based tracking system starts with the involvement of a receiver that picks up signal from several of GPS satellites continually orbiting the Earth. It helps in the calculation of unit's location on the globe by triangulating the position of three or more of these satellites. The more spread out the satellites, the more location will be estimated precisely.

The positional data is stored by the GPS-based device until the data are retrieved by either recapturing the animal wearing the collar or downloading remotely (i.e., wirelessly) the GPS data. A researcher can easily make the programs

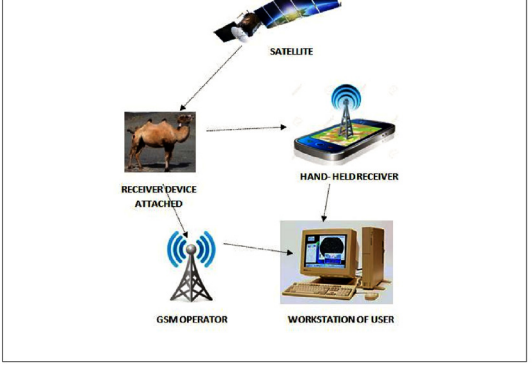

Fig. 4. GPS-based tracking system.

of some GPS base tags to send the positional data back to him or her at intervals in time, specifically, which has varied typically from hourly to daily or weekly depending on battery life constraints. Data can be remotely received either via a portable receiver (typically hand-held), or transmitted to a base e station through a ground-based GSM (Global System for Mobile communications) network, via SMS or data links, or through a satellite-based network. An animal tracking tag stays on the animal for months, so to prolong battery life; it takes the current point location and turns off immediately.

The GPS-based tracking devices shows an ability in currently lacking the battery power for receiving and transmitting these data continuously, when GPS locational data updates every second. The real-time monitoring enables the researcher to program the tag to transmit data immediately when the animal moves in a particular way.

1. Movement and Behavioural analysis, which analyzes the spatial behaviour and movement of animals across a landscape.
2. Positional Analysis which keeps track of location of animals in relation to dynamic features (such as livestock herds) and stationary geographical features (such as roads and fences).

GPS data can help the researchers and managers regularly formation of location and movement patterns of animal being provided for identification of a "normal" range of movement rates as well as long term and current hotspots of target animal activity. In the most effective means, patrols are setup to protect animal against poaching. With the help of design algorithm, RTM enabled tags can be program to recognized and alert managers of in mobility an unusual changes in movement rats collard animals to detected deviation from normal behavioural states.

Wildlife managers are alerted to unnatural variations in movements or immobility and can immediately deploy patrols to investigate the possibility of an injury, illness or a poaching event. Current location data give wildlife managers more time to intervene appropriately and a better chance of saving the animal or catching poachers at the scene of the crime.

Newly developed RTM implant units are now starting to be used to help detect poaching events in rhinos. These units, implanted in animals' horns, monitor rhino behaviour via three-dimensional accelerometers, and abnormal behaviour will trigger instantaneous alarms send out to wildlife rangers.

In relation to dangerous features in the landscape, real time data on the position of tagged animals will allow wildlife managers to respond rapidly and proactively to evolving situations. The author team designed sophisticated software algorithms to analyze incoming movement data, for this study. These virtual boundaries are termed as "geofences". The real-time locational information is especially important for the animals which prone to frequent interactions with people, such as elephants, or where interaction between wildlife and livestock is to potential due to disease transmission between them.

The algorithms will determine the animal's proximity to pre-determined points or areas of interest and will send immediate alerts to managers, normally via SMS or an e-mail, when animals move too close to high-risk features or enter a dangerous area.

For this study many imagery tools are available and some ground truth is needed. Elevation is an important topic as it plays an important role for identification of wild life habitat and its conservation and management. Wildlife is an important part of ecological community as wildlife play an important role in the environment. It should be done depending on available resources. Conservation means preservation, protection and scientific utilization of natural resources so that they may remain suitable for all organisms including humans. Wildlife conservation has become an increasingly important practice due to the negative effects of human activity on wildlife. Wildlife itself is an important character of nature so its conservation is an important obligation for human beings for the sustainability of life on planet earth.

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Insect Community Associated with the Wetland Ecosystem of Terai Region, West Bengal, India: Diversity and Conservation Approach

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Introduction

Wetland, an interface between terrestrial and aquatic ecosystems plays a critical role as an ecosystem service provider and supports a wide variety of flora and fauna. India has a wide variety of wetlands due to varied topography and climatic regimes. This wetland habitat is of great economic importance as it provides livelihood to numerous people living around them and at the same time, considered as resourceful reservoir of biodiversity and often harbor many endangered as well as endemic species. Besides, these are the most productive ecosystems of the world and play vital role in global nutrient cycling and in regulation of ground water replenishment. Due to this amazingly high productivity of wetlands, it has been brought to the attention of researchers throughout the globe. Although, diversity within inland freshwater ecosystems in the Eastern Himalayan region is highly diverse (Allen et al. 2010), there is still lack of baseline information on diversity and distribution of aquatic insects in general and aquatic bugs in particular.

The Terai region of West Bengal, lying in the Himalayan foothills, is endowed with different types of wetlands like ponds, lakes, marshes, swamps, streams, pools, and rivers and is a belt of marshy grasslands, savanna, and forests. The major rivers flowing across this region are Teesta, Torsha, Jaldhaka, and Raidhak. The biological and physical attributes of wetlands in this region vary according to the major landforms like, hills, forests, plain, and plateau. As aquatic insects are the most widely used organisms in freshwater biomonitoring studies, the study of aquatic insect's diversity in varied landforms of Terai region of Bengal and the riparian land usage practices assumes a great significance in this region considering endemism and conservation priority of species, which in turn is also important for monitoring ecosystem health. Earlier studies on aquatic insects of this region were undertaken by several scientists like Distant (1903, 1906, and 1910), Bal and Basu (1994), Nandi et al. (2004) and Basu et al. (2013, 2014, 2015, 2016). However, comprehensive and updated information in the relevant area of study is still lacking from this biodiversity rich hot spot

region of India. Hence, the present study has been undertaken to report the aquatic insect diversity of the area and to get an insight in to the fragile eco-health of this region, which becomes a major concern for the conservation of biodiversity of the region as a whole.

Methods and Materials

A total of fifty wetlands were surveyed in the Terai region based on availability and feasibility. Aquatic insects were collected during the pre-monsoon and post-monsoon season from 2011-2013 by using a rectangle-shaped insect net and a long-handled aquatic net from different wetland ecosystems like rivers, streams, ponds, lakes, forested pool. The specimens collected were preserved in 70% ethyl alcohol in 5ml-10ml Borosil® glass vials based on their size. The insects were identified up to family level using a Leica M205A Stereozoom binocular microscope with the help of standard keys (Dudgeon 1999, Subramanian and Sivaramakrishnan 2007, Fraser 1933, 1934, Morse et al. 1994, Thirumalai 1999, Wiggins 1977, 1996) and photographed using the same. Diversity index (Shannon-Wiener index) of different families was calculated using PAST 1.89 software.

Results and Discussion

The study showed that most of the fast flowing aquatic habitats support a wide variety of macro-invertebrates, especially aquatic insects. This community represents a reasonably balanced distribution of species belonging to different insect orders. However, with the changes in habitats or water quality parameters, the community also responds (Sharma et al. 2004). They are morphologically or physiologically adapted to the aquatic environment and adaptations are relatively old and stable. They are suitable indicators of water quality and sensitivity to ecosystem changes because, 1) they are ubiquitous and affected by the perturbations in different aquatic habitats, 2) the large number of taxa responds to a range of environmental changes, 3) their long life cycle allow them to study on their abundance and age structure, 4) They are taxonomically sound and can be identified up to the family, genus, or species easily with the existing literature, and, 5) they are well-distributed in all types of aquatic habitats ranging from freshwater lotic and lentic ecosystems to marine and their distribution can be categorized in different ways like local, regional, and global.

Aquatic insect community is represented by 31 families in the Terai region of West Bengal during the course of present study. The whole community was categorized under Hemiptera and non-Hemiptera. The non-Hemipteran families like Gyrinidae (Fig. 7), Hydrophilidae (Fig. 8), Dytiscidae of the order Coleoptera; Baetidae (Fig. 4) and Leptophlebiidae (Fig. 3) of the order Ephemeroptera; Calopterygidae, Chlorocyphidae, Protoneuridae (Fig. 11), Euphaeidae, Gomphidae, Libellulidae (Fig. 10), Macromiidae of Odonata; Perlidae of Plecoptera (Fig. 9) and Stenopsychidae of Trichoptera are prevalent in the wetland ecosystems of the study area. Whereas, the aquatic and semi-aquatic Hemiptera is represented by the species like *Ptilomera* (*P.*) *assamensis* Hungerford and Matsuda, *Metrocoris* sp., *Chimarrhometra orientalis* Distant, *Amemboa mahananda*

Basu et al. of the family Gerridae and *Hydrometra greeni* Kirkaldy of the family Hydrometridae. The study showed that the abundance of aquatic Hemiptera was comparatively higher in 26 sites than the non-Hemiptera. In the sites like Bania River of Chilapata forest, Sikhiajhora, Jhora within Chapramari Wildlife Sanctuary, Dhupjhora within Gorumara National Park, Panchanoi River within Mahananda Wildlife Sanctuary, small jhora with in Gorumara National Park, waterfalls near Bunkulung, Jhora within Mongpu coming from Sinchal Lake, Bijanbari bazar and the Hemipteran abundance was much higher as compared to the non-Hemipteran abundance. Whereas, in the sites like Pond 1 of Baradighi, Mal River, stagnant pool within North Khairabari Reserve forest, Rishi River, Murti River near Samsing, the abundance of non-Hemiptera was much higher than the Hemiptera. But, the sites like Bagdogra near Sanyasithan tea garden, Jhora near Manebhanjang and Murti River near Medla camp showed more or less similar abundance of Hemiptera and non-Hemiptera. But, it was clearly visible most of the sites with high Hemiptera abundance were with low non-Hemiptera abundance and vice versa. The abundance of aquatic insects is provided in Table 1.

Table 1. Abundance matrix for Hemiptera and non-Hemiptera in the study area.

Sampling sites	Coleoptera	Diptera	Ephemeroptera	Hemiptera	Odonata	Plecoptera	Trichoptera	Sampling sites	Coleoptera	Diptera	Ephemeroptera	Hemiptera	Odonata	Plecoptera	Trichoptera
S1	0	0	1	42	1	0	0	S26	0	0	4	3	0	0	1
S2	1	0	0	5	1	0	0	S27	6	0	0	4	0	0	0
S3	0	0	0	8	4	0	0	S28	0	0	1	26	4	0	1
S4	0	0	0	10	2	0	0	S29	4	0	15	17	12	1	1
S5	0	0	0	52	1	0	3	S30	14	0	10	24	3	0	1
S6	4	0	0	33	8	0	0	S31	0	0	2	15	8	0	0
S7	0	0	1	13	0	0	0	S32	5	0	0	14	14	0	0
S8	1	0	3	43	0	0	0	S33	5	0	0	24	4	0	0
S9	8	0	4	54	21	0	0	S34	1	0	1	23	1	0	0
S10	0	0	0	3	9	0	0	S35	6	0	0	32	2	0	0
S11	1	10	31	33	1	0	0	S36	4	0	0	16	7	0	0
S12	0	0	0	4	0	0	7	S37	0	0	3	11	0	0	0
S13	0	0	3	13	0	0	0	S38	5	0	0	15	2	2	0
S14	0	2	0	10	6	1	0	S39	3	0	0	6	0	0	0
S15	1	0	0	20	1	0	0	S40	0	0	2	11	0	0	0
S16	7	0	0	13	1	0	0	S41	1	0	0	12	0	0	0
S17	14	2	21	57	1	2	4	S42	0	0	4	9	2	0	0
S18	3	0	7	13	3	0	0	S43	0	0	1	11	4	0	0
S19	1	0	0	108	1	0	0	S44	1	1	1	50	0	0	3
S20	0	0	0	57	2	0	0	S45	0	0	1	5	0	0	0

Table 1 (Continued). Abundance matrix for Hemiptera and non-Hemiptera in the study area.

Sampling sites	Coleoptera	Diptera	Ephemeroptera	Hemiptera	Odonata	Plecoptera	Trichoptera	Sampling sites	Coleoptera	Diptera	Ephemeroptera	Hemiptera	Odonata	Plecoptera	Trichoptera
S21	2	0	0	9	3	0	0	S46	1	0	0	4	1	0	0
S22	3	0	0	21	8	0	0	S47	0	0	0	5	3	0	0
S23	5	0	2	29	1	0	0	S48	8	0	0	11	3	0	0
S24	2	0	0	20	2	0	0	S49	5	0	0	11	0	0	0
S25	7	0	0	11	0	0	0	S50	36	0	12	11	0	0	7
Grand total									**165**	**15**	**130**	**1051**	**147**	**6**	**28**

In the Ghoshpukur dighi of Darjeeling plains, 5 families of Hemiptera were found consisting of 34 individuals and both the Shannon diversity index was highest than the non-Hemiptera group. It is to be noted that among the 50 localities, both Hemiptera and non-Hemiptera showed the similar pattern of diversity in the 10 localities. However, in the 33 localities surveyed, the non-Hemiptera is most diversified as comparing to the diversity of aquatic Hemiptera. In the localities like Bagdogra, Sanyasithan tea garden of Darjeeling district and Jaldhaka River, within Gorumara National Park and in the Raidhak river of Jalpaiguri district, the aquatic Hemiptera and other groups of aquatic insects showed similar kinds of diversity. On the other hand, non-Hemipteran group showed highest diversity (14.12) with the occurrence of 5 families at the stagnant pool beside Rishi River, where from only 2 families of water bugs were reported. The second highest diversity of non-Hemiptera was found in the site 1, along the Rishi river of Darjeeling with the family richness of 12, however, represented by only one family. The non-hemipteran group was also highly diverse in the localities of Jhora within Chapramari Wildlife Sanctuary (5.45), Murti River within Gorumara National Park (4.63) of Jalpaiguri and in the Manjukhola under Phuguri tea estate of Darjeeling than the aquatic Hemiptera. The list of 50 sampling sites along with the diversity of Hemiptera and non-Hemiptera is provided in the Table 2.

Diversity index can be used to detect environmental health. High species diversity indicates a healthy distribution of resources among individuals of many species of a community (Mason 1990, Takhelmayum and Gupta 2011). The present study showed that the Shannon Diversity index (H) were less than 1 in most of the sites and did not show much fluctuations, which in turn indicates a disturbed unhealthy condition of freshwater ecosystems (Turkmen and Kazanci 2010). The presence and abundance of Hemiptera community, which are mostly predators and absence of sensitive groups such as Ephemeroptera, Plecoptera and Trichoptera (EPT) in few sites also an indication of disruption of ecosystems (Rosenberg and Resh 1993).

Table 2. Diversity of Hemiptera and non-Hemiptera in wetlands of Terai region.

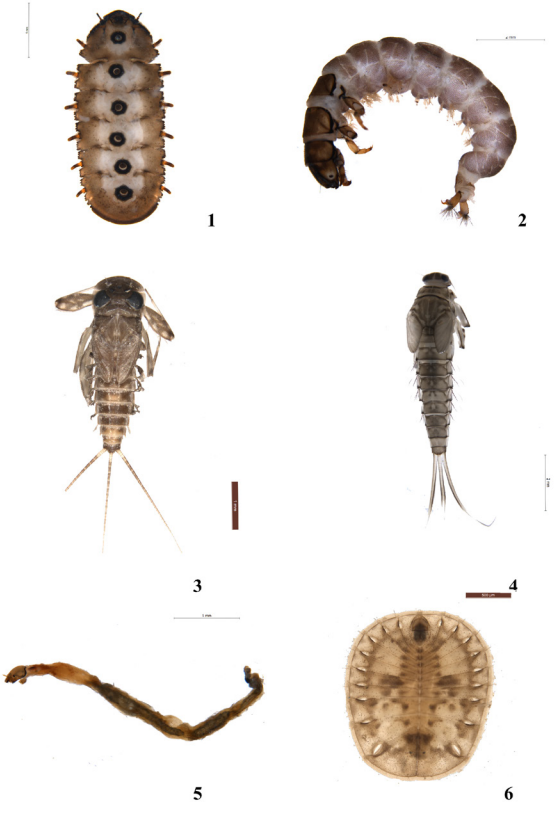
	Hemiptera			Non-Hemiptera		
Sampling sites with locality code	**No. of families**	**DI shannon**	**Evenness_e^H/S**	**No. of families**	**Shannon_H.non-**	**Evenness_e^H/S**
Bania river,Chilapata Forest (S1)	2	0.1914	0.6055	2	0.6931	1
Bhimbar dighi,near Sayedabad Tea Garden (S2)	3	1.055	0.9572	2	0.6931	1
Canal within GavaGanga and Kamala Tea Garden (S3)	3	0.7356	0.6956	1	0	1
Dhobijhora,Mongpu (S4)	1	0	1	1	0	1
Dhupjhora, Murti river,within Gorumara N.P. (S5)	3	0.908	0.8265	2	0.5623	0.8774
Ghoshpukur dighi,Kamala Bagan (S6)	5	1.323	0.7508	3	0.8877	0.8098
Jhora near Mongpu,coming from Sinchal lake (S7)	3	0.9251	0.8407	1	0	1
Jhora within Chapramari W.L.S. (S8)	2	0.6929	0.9997	3	1.04	0.9428
Kalipur wetland,within Gorumara N.P. (S9)	4	0.592	0.4519	9	1.842	0.7008
Pond 1, Baradighi,Malbazar (S10)	2	0.6365	0.9449	2	0.687	0.9938
Mahananda river,within Mahananda W.L.S. (S11)	1	0	1	6	0.971	0.4401
Mal River (S12)	1	0	1	1	0	1
Murti River,infront of Murti Banani Bunglow (S13)	3	0.8981	0.8183	1	0	1
Murti river,Medla camp,Gorumara N.P. (S14)	3	1.055	0.9572	5	1.523	0.9172
Panchanoi river, Mahananda W.L.S. (S15)	2	0.6109	0.921	2	0.6931	1
Pond near Rhino camp, Gorumara N.P. (S16)	2	0.6663	0.9735	3	0.7356	0.6956
Rabijhora,near Teesta River (S17)	3	0.6582	0.6438	9	1.772	0.6536
Rellykhola,Teesta,Teesta bazar (S18)	1	0	1	5	1.479	0.8778

Table 2 (Continued). Diversity of Hemiptera and non-Hemiptera in wetlands of Terai region.

	Hemiptera			Non-Hemiptera		
Sampling sites with locality code	**No. of families**	**DI_shannon**	**Evenness_e^H/S**	**No. of families**	**Shannon_H.non-**	**Evenness_e^H/S**
Sikhiajhora (S19)	7	0.8478	0.3335	2	0.6931	1
Small jhora within Gorumara N.P. (S20)	3	0.7534	0.7081	2	0.6931	1
Teesta Canal,Teesta barraige,Gajaldoba (S21)	3	0.6837	0.6604	3	1.055	0.9572
Wetland within Chapramari N.P. (S22)	4	1.263	0.884	4	1.241	0.8645
Falls near Bunkulung, near Mirik (S23)	3	0.7441	0.7015	3	0.9003	0.8201
Manjukhola, Phuguri tea estate, Near Mirik (S24)	1	0	1	3	1.04	0.9428
Teesta,Chitre bridge (S25)	1	0	1	1	0	1
Neora River, near rail bridge (S26)	1	0	1	3	1.055	0.9572
Stagnant pool, North Khairabari Reserve forest, Madarihat (S27)	1	0	1	1	0	1
Stagnant pool beside Rishi river, Rishikhola,W.B. and Sikkim border (S28)	2	0.4293	0.7681	5	1.561	0.9524
Rishi River, site 1, Rishikhola (S29)	1	0	1	12	2.186	0.7414
Rishi River,Site 2, Rishikhola (S30)	1	0	1	7	1.488	0.6324
Dhupjhora, Gachbari,Murti River (S31)	2	0.673	0.9801	4	0.9404	0.6403
Buri Torsa River, Bish khutia, border between South Khairabari and North Khairabari R.F. (S32)	4	0.8953	0.612	6	1.337	0.6348
Buri torsha Riverside, South Khairabari R.F. (S33)	3	0.5443	0.5745	3	0.9369	0.8507
Poro River, Poro beat, Chilapata forest range (S34)	4	1.001	0.6805	3	1.099	1
Raidhak River,Alipurduar (S35)	5	0.8656	0.4753	3	0.9003	0.8201

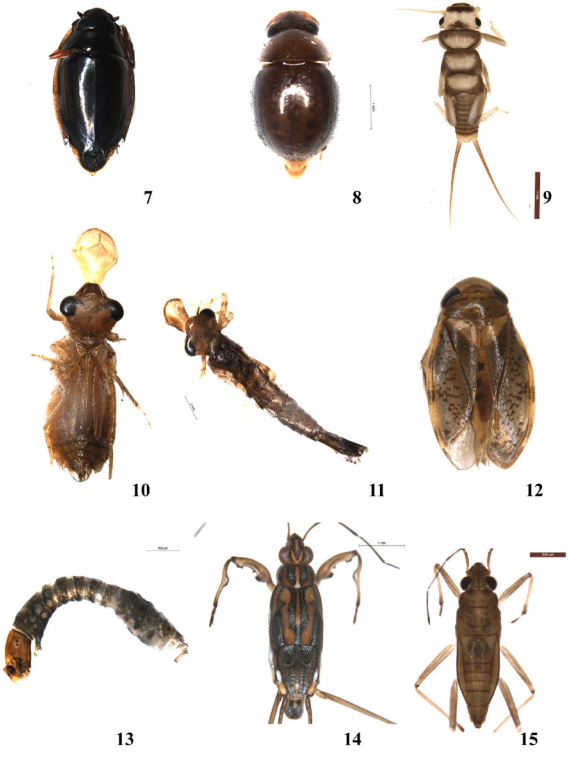
Table 2 (Continued). Diversity of Hemiptera and non-Hemiptera in wetlands of Terai region.

	Hemiptera			Non-Hemiptera		
Sampling sites with locality code	**No. of families**	**DI_shannon**	**Evenness_e^H/S**	**No. of families**	**Shannon_H.non-**	**Evenness_e^H/S**
Srikhola (S36)	2	0.3768	0.7288	3	0.9165	0.8335
Jhora near Manebhanjang (S37)	1	0	1	1	0	1
Dima River, Damanpur forest, Buxa T.R. (S38)	2	0.5799	0.8929	3	0.995	0.9016
Jhora within Chilapata forest, Mendabari beat (S39)	1	0	1	1	0	1
Buxa Jhora,near Buxa fort, B.T.R. range (S40)	1	0	1	1	0	1
ChaitanyaJhora within Buxa Tiger Reserve,Rajabhatkhawa (S41)	1	0	1	1	0	1
Murti River, near Murti rail bridge (S42)	1	0	1	2	0.6365	0.9449
Chel River, Gorubathan (S43)	1	0	1	3	1.055	0.9572
Bijanbari Bazar, Stream (S44)	1	0	1	4	1.242	0.866
Stream, near Pulbazar (S45)	1	0	1	1	0	1
Jaldhaka River,within Gorumara N.P. (S46)	1	0	1	2	0.6931	1
Bagdodgra,Sanyasithan tea garden (S47)	1	0	1	1	0	1
Pond at Mainaguri (S48)	2	0.586	0.8984	4	1.264	0.8846
Gourjanjhora, near Mal (S49)	2	0.4741	0.8033	2	0.673	0.9801
Murti river, Samsing (S50)	1	0	1	4	1.02	0.6934



Legend to Figure:

1. Belphracidae, Diptera
2. Trichoptera
3. Leptophlebidae, Ephemeroptera
4. Baetidae, Ephemeroptera
5. Chironomidae, Diptera
6. Psephenidae, Coleoptera



Legend to Figure:

7. Gyrinidae, Coleoptera
8. Hydrophilidae, Coleoptera
9. Plecoptera
10. Libellulidae, Odonata
11. Protoneuridae, Odonata
12. Micronectidae, Hemiptera
13. Simulidae, Diptera
14. Gerridae, Hemiptera
15. Mesoveliidae, Hemiptera

Conclusion

The two important criteria of biodiversity conservation are 1) monitoring of habitat and 2) identifying priority areas for conservation at various spatial scales. However, diversity indices provide information about the rarity and commonness of species which in turn help to understand the community structure of an ecosystem (Barman and Gupta 2016). The fluctuation in the abundance and distribution of aquatic insects in the wetlands is due to the macroclimatic and microclimatic changes and variation in the availability of resources (Danks 2006, Vineesh 2007). The community structure of aquatic insects may be useful in assessing the water quality because of their high abundance, high birth rates with short generation time, large biomass in freshwater habitats (Roy 1994). The investigation shows that though the Terai region of West Bengal mostly covered with forests, this region is under several threats. Deforestation within the catchment, rapid urbanization, unsustainable tea and agricultural plantation, dam construction and electro-fishing in the rivers has been increased in the recent days in this area. The aquatic insect community responds to the ecosystem pollution by their presence or absence and by changing their abundance. It has also found that although this region encompasses several protected areas, should be given priority to reduce the land use disturbances. It is also suggested that understanding responses of aquatic insects to the habitat degradation will be helpful to young researchers to build up their plan for the practice of scientific based management of water quality.

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Conservation Status and Strategy of Indian Fresh Water Turtles—Facts Beyond Research and Publication

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Our India is full of variety, varieties in her language, customs, food, culture, religion, dance, music, architecture, and also in turtle species. India is fortunate to have a rich diversity of turtles. Five of the seven known species of marine turtles and 30 species of freshwater turtles and tortoises are found here. These include the Northern River Terrapin (*Batagur baska*) and the Red-crowned Roof Turtle (*Batagur kachuga*) – two of the world's 25 most imperilled freshwater turtles and the Indian Narrow-headed Softshell Turtle (*Chitra indica*) – one of the world's 40 most endangered freshwater turtles. The presence of 29 species of tortoises and freshwater turtles and 6 species of marine turtles makes India one of the most diverse chelonian faunas in the world and thus considered to be one of the top five Asian countries in terms of its importance for turtle conservation because 40% of its total chelonian fauna is threatened. It is amazing that turtles which have been survived for more than 200 million years and lived with dinosaurs as well as primitive man, are now becoming threatened by civilized people all over the world. There is long list of predators that eat turtles including tigers, hyaenas, otters, wild boars, crocodiles, monitor lizards, pelicans, crabs and even nilgai. But most versatile and intellectual enemy of turtles are modern people. As a part of mythology, turtles are worshipped in many parts of India. Side by side thousands and thousands of turtles of different species are losing their life in different parts of the country each year because of a variety of human activities.

In India freshwater turtles are severely threatened by habitat loss and degradation, construction of dams, and pollution. Added to this the rampant illegal hunting and smuggling of turtle species from different states of India for both local consumption as well as booming international market in Southeast Asia like Singapore and Hong Kong have decimated populations of Indian turtles. Although the Wild Life (Protection) Act of 1972 lists all species of turtles under Schedules 1-4, making their capture, possession and trade illegal, unfortunately, such long history of exploitation and lack of proper enforcement has resulted in unsustainable use. As a result, several species which were endemic to India have become extinct or are now close to extinction. Conservation efforts started in earnest with Indian scientists attending global groups such as the ICMA that were set up in the 1960s. Efforts by conservationist Robert Bustard and India's own expert herpetologist Romulus Whitaker pushed the movement forward. Shanker says that turtle-saving efforts coincide with the beginnings of the big-

ger conservation movement in the country. Although the future of turtles may be jeopardized, concentrated efforts at conservation, including enforcement of anti-poaching laws and fishing regulations in tandem with community outreach and alternate livelihood programs, are already started in different states by many government and non-government organizations and individuals that comprise the international turtle conservation community which are helping reverse the threats to turtles and tortoises. All of them have been working hard for many years and successes and major steps forward are being generated in favour of turtles by their combined efforts.

The Checklist of Indian Fresh Water Turtles and Tortoises

India's freshwater turtle fauna was not known clearly until a country-wide survey was conducted during late 1980s. Occupancy of different species of freshwater turtles in various Biogeographic zones and in different states of India has been reported. Here is the checklist of Indian fresh water turtle with their IUCN and CITES conservation status.

Name of species	Common name	Distribution	IUCN status	CITES
Batagur baska	Northern River Terrapin	Orissa, West Bengal	Critically Endangered	Appendix I
Batagur dhongoka	Three-striped Roofed Turtle	Assam, Bihar, Madhya Pradesh, Rajasthan, Uttar Pradesh, West Bengal	Endangered	Appendix II
Batagur kachuga	Red-crowned Roofed Turtle	Bihar, Madhya Pradesh, Punjab, Uttar Pradesh, West Bengal	Critically Endangered	Appendix II
Cuora amboinensis	Southeast Asian Box Turtle	Arunachal Pradesh, Assam, Nagaland, Nicobar Islands	Vulnerable	Appendix II
Cuora amboinensis kamaroma	Malayan Box Turtle	Arunachal Pradesh, Assam, Nagaland, Nicobar Islands	Vulnerable	Appendix II
Cuora mouhotii	Keeled Box Turtle	Arunachal Pradesh, Assam, Meghalaya, Mizoram	Endangered	Appendix II
Cuora mouhotii mouhotii	Northern Keeled Box Turtle	Arunachal Pradesh, Assam, Meghalaya, Mizoram	Endangered	Appendix II
Cyclemys gemeli	Assam Leaf Turtle	Arunachal Pradesh, Assam, Meghalaya, Mizoram, West Bengal	Not Evaluated	Not Evaluated
Geoclemys hamiltonii	Spotted Pond Turtle, Black Pond Turtle	Assam, Bihar, Jammu, Meghalaya, Punjab, Rajasthan, Uttar Pradesh, West Bengal	Vulnerable	Appendix I
Hardella thurjii	Crowned River Turtle	Assam, Bihar, Madhya Pradesh, Meghalaya, Punjab, Uttar Pradesh, West Bengal	Vulnerable	?
Melanochelys tricarinata	Tricarinate Hill Turtle, Three-keeled Land Turtle	Arunachal Pradesh, Assam, Bihar, Uttar Pradesh, West Bengal	Vulnerable	Appendix I
Melanochelys trijuga	Indian Black Turtle	Andhra Pradesh, Assam, Bihar, Gujarat, Karnataka, Kerala, Maharashtra, Meghalaya, Mizoram, Tamil Nadu, Uttar Pradesh, West Bengal	Near Threatened	Appendix I
Melanochelys trijuga trijuga	Indian Black Turtle	Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Tamil Nadu,	Near Threatened	Appendix I
Melanochelys trijuga coronata	Cochin Black Turtle	Kerala	Near Threatened	Appendix I
Melanochelys trijuga indopeninsularis	Bengal Black Turtle	Assam, Bihar, Meghalaya, Mizoram, Uttar Pradesh, West Bengal	Vulnerable	Appendix I
Melanochelys trijuga thermalis	Sri Lanka Black Turtle	Tamil nadu	Vulnerable	Appendix I
Morenia petersi	Indian Eyed Turtle	Assam, Bihar, Uttarakhand, Uttar Pradesh, West Bengal	Vulnerable	Appendix I

Name of species	Common name	Distribution	IUCN status	CITES
Pangshura smithii	Browm Roofed Turtle	Assam, Bihar, Punjab, Uttar Pradesh	Near Threatened	Appendix II
Pangshura smithii smithii	Browm Roofed Turtle	Assam, Bihar, Punjab, Uttar Pradesh	Near Threatened	Appendix II
Pangshura smithii pallidipes	Pale -footed Roofed turtle	Bihar, Uttar Pradesh	Near Threatened	Appendix II
Pangshura sylhetensis	Assam Roofed Turtle	Arunachal Pradesh, Assam, Meghalaya, Mizoram, Nagaland	Endangered	Appendix II
Pangshura tecta	Indian Roofed turtle	Arunachal Pradesh, Assam, Bihar, Gujarat, Jammu, Madhya Pradesh, Meghalaya, Ounjab, Rajasthan, Uttar Pradesh, West Bengal	Least Concern	Appendix I
Pangshura tentoria	Indian Tent Turtle	Andhra Pradesh, Bihar, Gujarat, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Uttar Pradesh, West Bengal	Least Concern	Appendix II
Pangshura tentoria tentoria	Indian Tent Turtle	Andhra Pradesh, Madhya Pradesh, Maharashtra, Orissa	Least Concern	Appendix II
Pangshura tentoria circumdata	Pink-ringed Tent Turtle	Gujarat, Madhya Pradesh, Rajasthan, Uttar Pradesh,	Least Concern	Appendix II
Vijayachelys silvatica	Cochin Forest Cane Turtle	Karnataka, Kerala, Tamil Nadu	Endangered	Appendix II
Geochelone elegans	Indian Star Tortoise	Andhra Pradesh, Gujarat, Karnataka, Kerala, Tamil Nadu, Madhya Pradesh, Rajasthan	Least Concern	Appendix II
Indotestudo elongata	Elongated Tortoise, Yellow-headed Tortoise	Bihar, Meghalaya, Uttar Pradesh, West Bengal	Endangered	Appendix II
Indotestudo travancorica	Travancore Tortoise	Karnataka, Kerala, Tamil Nadu,	Vulnerable	Appendix II
Manouria emys	Asian Giant Tortoise	Assam, Meghalaya, Mizoram, Nagaland	Endangered	Appendix II
Manouria emys phayrei	Burmese Black Giant Tortoise	Assam, Meghalaya, Mizoram, Nagaland	Endangered	Appendix II
Lissemys punctata	Indian Flapshell Turtle	Andhra Pradesh, Bihar, Goa, Gujarat,Kerala, Madhya Pradesh, Orissa, Punjab,Tamil Nadu, West Bengal	Least Concern	Appendix II
Lissemys punctata punctata	Southern Indian Flapshell Turtle	Kerala, Tamil Nadu	Least Concern	Appendix II
Lissemys punctata andersoni	Spotted Northern Indian Flapshell Turtle	Assam, Bihar, Haryana, Jammu, Madhya Pradesh, Meghalaya, Rajasthan, Sikkim, Uttar Pradesh, West Bengal	Least Concern	Appendix II
Lissemys punctata vittata	Central Indian Flapshell Turtle	Andhra Pradesh, Chhattisgarh, Goa, Gujarat,Maharashtra, Karnataka, Madhya Pradesh, Orissa, Rajasthan	Least Concern	Appendix II
Chitra indica	Indian Narrow-headed Softshelled Turtle	Andhra Pradesh, Maharashtra, Madhya Pradesh, Orissa, Punjab, Tamil Nadu, Uttar Pradesh, West Bengal	Critically Endangered	Appendix II

Common Threats to Indian Fresh Water Turtles

Illegal Trade: India's Wildlife Protection Act prohibits both trade and private ownership of all turtle species. However, legal domestic trade in other Asian countries appears to be undermining India's efforts to protect them. In Northern India, larger species are actively hunted by the Kuchmadhia (a semi-nomadic tribe) and other turtle trappers for illegal export to south-East Asia through eastern part of India.

Habitat Loss and Degradation: Depletion of turtle population is mainly due to habitat loss which resulted from 1) Palage (river bed cultivation), 2) collection of sand from nesting sites, 3) unscientific construction of impound-

ments and water diversions resulting in altered stream flow, pollution, and increased sedimentation, 4) It also causes destruction of nests and eggs therein. Habitat degradation due to mining, siltation in wetlands and deforestation also found in the Karbi-anglong foothills. Grassland burning can also hamper nesting sites of many turtle species (i.e., Lissemys punctata). Habitat destruction and pollution: forests and wetlands are declining in the study area. Deforestation and resultant soil erosion has led to increased siltation of lakes and other wetlands. The deep pools that are the favoured habitats are rapidly becoming shallow and choked with silt, leading to a decline in habitat quality.

Nest Destruction: Since most of turtles prefer to nest along river beds, collection of sand from those sites lead to severe loss in nesting sites and damage to nests. Turtles eggs being delicious food invites a number of wild natural predators like fox, racoon, mole, and crow. Humans also attack such nests to collect eggs. Flood, cyclone, and bank erosion, also cause a huge destruction of nests.

Deforestation: The Himalayan fed rivers is perennial and support many turtle species. Degradation of the catchment area due to deforestation has not only reduced the flow but also brought huge quantities of silts to fill up the available deep pools. Such incidences have considerably reduced the habitat stretch of river and turtle were pushed into areas where unfortunately human activities are concentrated.

Netting: In India, gear used by traditional non-mechanised craft causes entanglement of a remarkable number of both marine and freshwater turtles every year. During fishing operations small turtles like *Pangshura* sp. die because of entangling in fishing nets and subsequent drowning. Use of gill-nets and bottom trawl nets are also responsible for the death of turtles by drowning.

Food: It is evident that all fresh water turtle species are being targeted and extensively hunted in India for their meat and calipee (outer cartilaginous rim). Natural food-chain consumers include crocodiles, tigers, and jackals.

Superstitious Beliefs: Hanging a carapace in a cattle-shed is believed to bring good luck, and to keep snakes and burglars away from the premises. We are in the process of trying to dissuade the local people from continuing their customs related to the killing of turtles.

Use as Ethno-medicine: Both the flesh and eggs of turtles are believed to be a remedy for gout and arthritis, while the carapace of Assam Roofed Turtle (*Pangshura sylhetensis*) and other turtle species is also used as 'medicine' for other ailments including asthma. Due to decline of catch, traders are offering increasingly high (very lucrative) prices to tribal hunters and fishermen for carapaces.

Predation: The major factors for population decline of turtles is due to loss of turtle eggs by human collection, domestic and wild animals, and other abiotic factors. Turtles are also exploited for medicine, jewellery, and pet trades other than for food which results in removal many eggs, juveniles and adults from populations.

Construction Work: The nesting habitat of *Nilssonia leithii* may be under threat in certain areas of peninsular India due to change in river morphology from hydrological projects. Other threats to turtles include riverine development projects, sand mining, and construction of hydroelectric projects.

Incidental Catch: incidental catch in fisheries has been reported from many parts of the country, namely, West Bengal, Andaman and Nicobar Islands,

Gujarat, Karnataka, Kerala, Tamil Nadu, Maharashtra, and Andhra Pradesh. Fishery by catch due to extensive fishing also reported in Brahmaputra as well as Bishwanath Ghat in particular and Mora Difolu river.

Major Activities on Turtle Conservation in India: Sea turtle conservation in India by the State and non-governmental organisations in about thirty years old. What started with a conservation program by a group of dedicated individuals in Madras and a research program by the state Forest department at the mass nesting beaches in Orissa has now spread to most coastal states in India. In the early years two catalysts that generated conservation action for turtles, primarily in Asia, were the clarion warning alarms sounded by John Behler (1997) and the subsequent workshop (1999) on Asian Turtle Trade organized by the Wildlife Conservation Society (in collaboration with TRAFFIC Southeast Asia, World Wildlife Fund, Kadoorie Farm and Botanic Garden, and the U.S. Fish and Wildlife Service), in Phnom Penh, Cambodia. The publication of these proceedings (van Dijk et al. 2000) by Chelonian Research Foundation provided the first comprehensive documentation of the emerging and vast Asian Turtle Crisis. Thereafter this regional crisis led to dedicated conservation actions by governments, inter-governmental agencies, and conservation NGOs to improve the regulation of fresh water turtle trade as well as conservation. In India also, different national and international NGOs and government organisations like IUCN/SSC Tortoise and Freshwater Turtle Specialist Group (TFTSG), Turtle Survival India (TSA) India, Turtle Conservation Fund (TCF),WWF, Madras Crocodile Bank Trust, State Forest Departments, Nuclear Power Corporation of India Limited (NPCIL), local communities under different programs, like Rivers for Life, Life for Rivers, either individually or jointly started a lot of hard works on species diversity, conservation status, habitat characteristics, species utilization, *in situ* conservation, nest site assessment and monitoring of different available turtles species. On the basis of species richness, endemism, proportion of endangered turtles and different conservation activities being carried, five prioritized turtle areas have been identified in India. These are Chambal River, and Upper Ganges River system (Central India), the Terai region (Northern India), the state of Assam (northeast India), the Sunderban of West Bangal and state of Orissa (eastern India), and Westernghat and the state of Kerala and Tamilnadu (Southern India).

Chambal River, Upper Ganges River System (Central India), and the Terai Region (Northern India): The Chambal River after originating from the Vindhyan range near Mhow in Madhya Pradesh flows through the boundary of M.P. and Rajasthan and M.P. and Uttar Pradesh, then joins the Yamuna River near Barecha of Etawah District of U.P. The Yamuna, in turn, flows in a southeast direction, till it meets the Ganga River at Allahabad. Kali Sindh, Parbati, Banas and Kuno are the important tributaries of the Chambal River. The Major tributaries of the Ganga River including Chambal and Yamuna are Ken, Son, Ghagra, Girwa and Ramganga. These whole riverine regions inhabit different species of turtles of which two endangered river terrapins, *Batagur kachuga* (Indian Red-Crowned Roofed Turtle) and *Batagur dhongoka* (Three Striped Roof Turtle) have drawn the attention of different conservation workers for decades.

Protected Hatching: It includes collection of eggs from natural habitat-nests that would normally be lost by egg collectors, transportation them to protected nests and careful placement inside the nests where the eggs can incubate and hatch safely without any predatory attacks. The most extensive *Batagur* hatching program in Asia runs in the Chambal Riverine habitats with three target species, *B. dhongoka*, *B. kachuga*, and *B. Baska*. The National Chambal River Sanctuary support two of the species, *B. dhongoka* and *B. kachuga*, and the riverine hatcheries protect thousands of eggs annually from predation and return hatchlings to the river. This year a total of 598 nests (115 nests of *B. Kachuga*) were relocated to protected hatching areas, resulting in 83% of hatching success because of tireless hard work of experienced field staff. In Bareilly, April 2015, 8 turtle nests with 102 eggs were rescued along a stretch of approximately 90 km of the Ramganga and transporting safely to turtle at Firozpur village. All eggs hatched and 82 hatchlings survived out of which 78 hatchlings belonged to the Three Striped Roof Turtle (*Batagur dhongoka*) species and 4 hatchlings to Indian Tent Turtle (*Panghshura tentoria*) species. Brown Roofed Turtle *Panghshura smithii*, also was a part of such hatchling transfer from unprotected nests to Hastinapur forest Training Centre pond for safe rearing. One of India's most iconic and recognizable turtle is the Giant Narrow-headed Softshell Turtle (*Chitra indica*). Since 2007, primary focus on locating and protecting their nests in the upper Ganges, Chambal and lower Yamuna river systems has resulted in thousands of hatchling release that likely would have not survived. In the process, much has been learned about the nesting ecology, abundance and distribution of this heavily hunted species.

Nest Site Assessment and Monitoring: In September 2014, a nest site assessment and monitoring survey of 75 km along the Yamuna River was conducted. A total of seven nests, accounting for more than 700 eggs of Chitra indica were encountered during the survey and translocated to the TSA Turtle Survival Centre on the Chambal River in Garhaita and a riverside hatchery close to Chambal-Yamuna confluence.

Head-starting: Here the hatchlings are reared in captivity for a year or more, allowing them to grow to a size when they are less susceptible to predators. At Narora facility at Ganga, 135 *B. dhongoka* hatchlings are being head-started, by TSA in association with, Nuclear Power Corporation of India Limited (NPCIL). Head starting facilities are also available at the Deori Eco Centre and Garhaita Turtle Centre on the middle and lower Chambal respectively. From the head starting facility of Garhaita Turtle Centre, 168 *B. kachuga* yearlings were 'soft' released near the nesting beaches where they were collected last year. They were maintained in pens constructed in the river until May, for acclimation. After they were released in May, a cohort of the group was tracked using radio telemetry. The data obtained from this study allowed the team to evaluate the effectiveness of such head-start and release programs as a conservation technique for this species and others like it. Additional surveys from further upstream are also planned in an effort to locate more tagged individuals.

The Nest Protection Program: In this program devotee workers protect turtle nests from natural calamities and predators. In such a program, nearly 200 washed away vulnerable nests of *Batagur kachuga* and *Batagur dhongoka* were rescued along upper, middle, and lower stretches of Chambal River following an unprecedented flood. The nests were relocated to higher ground on the same

sand bar and again moved back to the previous beach sites after the flood water receded which resulted more than 80% of hatching success.

Confiscation and Rehabilitation: Apart protecting turtles from natural calamities, the turtle workers along with the Customs and Wildlife Crime Control Bureau (WCCB) often seize them from illegal traders. Survival of such confiscated species in a habitat outside of its distribution range is a great problem. So it is equally important to swiftly rehabilitate and reintroduce the turtles back in their range or rehabilitate them properly. After the confiscation, the turtles are treated regularly and given a special diet to reduce mortality and help them recuperate from stress. For example, 155 Spotted Pond Turtles (*Geoclemys hamiltonii*) were discovered as a result of a car crash involving the smugglers from the Auraiya district. The turtles were then taken to the Etawah range office where they were counted, given water, and placed in containers. In coordination with Uttar Pradesh and Maharashtra Forest Department, the TSA-India Team often transfer such confiscated turtles from Maharashtra to the Kukrail Gharial and Turtle Rehabilitation Center (KGTRC) in Lucknow, from where many Black Spotted Pond Turtles were later released into Nawabganj Bird Sanctuary in a historic interstate repatriation program of its kind for aquatic turtles.

Poacher to Protector Program: Awareness and educational programs conducted by different NGOs and government levels have successfully converted many former turtle poachers to genuine turtle lovers in later stage that with their dedication, hard work and thorough knowledge helped a lot in turtle conservation in many ways. For example, Md. Santram Nishad, a former turtle poacher, as a Field Technician of TSA India program supported by the Beneficia Foundation helped to eradicate 14 illegal fishing nets, rescued multiple wild turtles and tracked six sonic telemetered Red-crowned Roof Turtles (*Batagur kachuga*) from lower Chambal River.

Establishment of Laboratory: The facility is now known as the Laboratory for Aquatic Biology (LAB). The LAB will be used for a variety of objectives, including: 1. Monitoring, researching, and refining the captive management of turtles and other species currently being held at Kukrail and other satellite facilities. 2. Providing a link between *in situ* and *ex situ* conservation projects for freshwater and wetland species in the region. 3. Assisting with freshwater species rescue, rehabilitation and veterinary care using a mobile rescue response team, and 4. Preserving and archiving biological samples and research regarding freshwater species management.

Awareness Program: The primary targets of such programs was riparian communities (especially river bed cultivators) by encouraging community-led monitoring and conservation of turtle nests in their agricultural fields, ensuring a sense of ownership and desire for stewardship towards biodiversity conservation.

Environmental Education: TSA India recently partnered with the Center for Environmental Education (CEE) to increase awareness about freshwater turtles, gharials and other freshwater fauna of northern India. This initiative was spearheaded in conjunction with the Endangered Species Project (Uttar Pradesh (UP) Forest Department) at the Kukrail Gharial Rehab Center, Lucknow. CEE-North conducted nature tours for local schools at the Kukrail Forest Reserve as a part of their Children's Forest Program (CFP). The CFP is just one component of the UP – Participatory Forest Management and Poverty Alleviation

Project, which is supported by the Japan International Co-operation Agency (JICA).

The State of Assam (Northeast India), (Brahmaputra Plain and adjoining areas): NE India along with Himalayan region is a unique transitional zone amongst the Indian, the Indo-Malayan, and the Indo-Chinese biogeographical zones as well as being the meeting point of the Himalayan region with the Peninsular India. This region is constituted by seven north-eastern states and is popularly known as 'seven sisters.' The north eastern region is a 'Hotspot' of tortoises and freshwater turtles and is the richest known assemblage compared to any other regional assemblage in India. Out of 29 species known from India, 21 species (including 14 genera and 3 families) are so far recorded from this region. The Brahmaputra drainage with the Kaziranga National Park (KNP) has been identified as world's highest priority freshwater turtle conservation area. Extensive study on the conservation of these turtle species have been done specially in the following areas, Nongkhyllem Widlife Sanctuary, Meghalaya, Tura Peak Reserve Forest, Meghalaya, Nokrek National Park, Meghalaya, Ngengpui Wildlife Sanctuary, Mizoram, Kaziranga National Park, Assam, Barail Hills, Assam and Nagaland, Sonai-Rupai Wildlife Sanctuary, Assam, and Pakke Tiger Reserve, Arunachal Pradesh.

Protected Hatching from Temple Pond to Village Pond: Black Softshell Turtle (*Nilssonia nigricans*) is a critically endangered species endemic to North-eastern India. It has been confirmed at a few spots in the Brahmaputra River drainage in the state of Assam and in some of the region's temple ponds. The species continues to be hunted extensively for its meat and cartilage, and numbers in the wild became dangerously low. Since 2013, TSA India has worked diligently to improve conditions at selected temple ponds in Assam. As part of that initiative, the TSA India team camped at the Nagshankar temple to observe nesting in the 40-45 adult females at that location. At that time, the team transferred ten nests to a hatchery and protected four nests on site. A considerable number turtles have hatched and hatchlings were head started but neonates and juveniles were not released back into the temple pond due to predation by larger turtles and exotic fishes. So an earthen pond in the nearest village was acquired to provide space for the fast-growing juveniles, improving survival prospects for this extremely rare softshell.

Freshwater Turtle Education Program: It aimed to spread awareness regarding various endangered freshwater turtle species especially *Pangshura sylhetensis*, *Nilssonia nigricans*, and *Pelochelys cantori*. In addition, the project assessed the status and distribution of these three species.

Community-based in situ Conservation and Egg Protection: In an island (Char) in the river Brahmaputra within the district Morigaon, Assam, an *in situ* egg protection program was initiated with the participation of local communities. The place was selected for hatchery due its habitat suitability. During two nesting periods (in the year 2010 and 2011), using old fishing nets and a thorn brush barrier (a defense against jackals, the primary threat to turtle nests in this area), 250 square meters were enclosed by nylon nets with stiff support to create an *in situ* hatchery for enhancing hatching success. The nests were dug at a depth of 24 cm and distance was maintained at 100 cm apart. A total of 51 nests were protected during the incubation periods.

Ex-situ Conservation Efforts: Suitable sand-banks have been created in the corners of the pond for turtle basking and nesting. So far, more than 15 nests of Black softshell turtle are found in the newly created sand-banks. Turtles bask peacefully in the sandbanks. Similar kind of activities will be replicated in two more temple ponds in northeast India very soon.

Rehabilitation of Poachers: It involves development of eco-friendly alternative livelihood options for different socio-economic groups to reduce the anthropogenic pressures on the river ecosystem. Three poachers (egg collectors) have been identified with the help of local communities and rehabilitated as field assistants in the turtle conservation project for a period of 6 months with a minimum incentive of Indian Rs. 3000 for rehabilitation of each poacher. The poachers have been further motivated and converted to small scale Agri-businessman by the end of this project. Rehabilitation program for ex-turtle poachers is being developed.

Conservation Education and Community Participation: Communities residing near the religious temple tanks are excited with the awareness that the pond turtle of the temple are certainly the pride and prestige of that area and being locals it is the need of the hour to protect them.

Conservation Planning Workshop: A participatory workshop for Conservation Planning and Strategic Action Planning for Tortoises and Freshwater Turtles of Northeast India was planned in September 2010. This workshop was delayed due to lack of suitable timing for several experts on chelonians in the country. A separate report will be submitted on this workshop that would include conservation planning and strategic action plans for Tortoises and Freshwater Turtles of North East India.

The Terai Region (Northern India): Terai is the foothills of Himalaya. The Terai landscape Arc (TLA) in India covers approximately 30,000 sq km across the states of Uttarakhand, Uttar Pradesh and Bihar and an almost crescent shaped dense tropical forest, with grasslands or scrub forest land, from Baghmati river (Bihar) in the east to Yamuna (UP) in the west. TAL in India has 9 protected areas (PAs) which are Rajaji National Park, Corbett National Park and Tiger Reserve, Sonanadi Wildlife Sanctuary, Kishanpur Wildlife Sanctuary, Dudhwa National Park and Tiger Reserve, Katerniaghat Wildlife Sanctuary, Suhelwa Wildlife Sanctuary, Sohagibarwa Wildlife Sanctuary and Valmiki National Park and Tiger Reserve.

Tarai being an ecologically diverse area is a turtle priority area and supports more than 50% of India's freshwater turtle species, though it had received little attention in terms of conservation and scientific studies. Here fifteen endangered species of turtles are found and illegal trade is rampant. The well-forested areas of Terai and bhabar also provide an exclusive corridor of suitable habitat for the spread of reptiles from afforested areas in the east, deep into the Gangetic plain areas. The remarkable conservation activities are as follows:

Nest Site Assessment and Monitoring: In spite of thick vegetation in local forests and rough terrain, some workers made an intensive study to search the probable habitats and nesting site of available turtle species during 2008 along Girwa River stretch, sandy riverbank of Amba ghat, Nishangada area, Mahadeva Tal, Katerniaghat Wildlife Sanctuary, and Maila Nullah areas.

Canine Conservation Crews: To overcome the difficult survey of turtles and nests through dense forest areas, Eli, a female Labrador retriever, for first time a dog is being trained as a conservation dog on trial basis. She will join field conservation crews to help in finding forest turtles, turtle nests and illegal turtle products in Tarai, near the Indo-Nepal border.

The Sunderban of West Bangal and State of Orissa (Eastern India): The Sunderbans, a UNESCO World Heritage Site is the largest mangrove forest in the world, located along the border between India and Bangladesh. It is the last refuge not just for Bengal tigers, but for the Northern River Terrapin also. What is unique about this population of tigers is that they feed on fish and turtles, which the other population of tigers do not do. Saving these turtles is saving the complete ecosystem of the Sundarbans. Once Salt Lake, the East Calcutta posh residential area was connected with mangrove forests of Sundarban. But nearly 100 years back, the connecting creeks were blocked for urbanization. River terrapins also deprive of food and shelter gradually vanished from the area. Recovering wild *Batagur* populations, with three target species, *B. dhongoka*, *B. kachuga*, and *B. baska*, is the greatest conservation challenges of Sundarbans. The Turtle Survival Alliance (TSA), in partnership with the West Bangal Forest Department, has been managing for these species by great hard works on effective protection of nests from egg collectors, scientific incubation of eggs and head-starting of hatchlings followed by release of hatchlings at the conservation breeding facility within Sunderbans National Park as mentioned below.

Conservation Breeding Program: At the vast mangrove wilderness of the Sundarbans Tiger Reserve at Sajnekhali the breeding program of the critically endangered terrapin *B. baska* is being carried out. Before this region was declared a world heritage site for tigers, commercial fishing bycatch had depleted this population of *Batagur* to the point of extirpation. These turtles had not had any surviving young due to the absence of proper nesting beach and predators such as mongoose and water monitor lizards. Working with the Forestry Department, TSA India provided critical input to husbandry and management protocols that led to the successful nesting and hatching of this critically endangered turtle species. A large pool and nesting beach was completely covered and fenced to keep out local predators at Sajnekhali representing one of the largest captive colonies of the species.

Nest Site Assessment: In a recent survey in one section of the Sundarban Tiger Reserve, historic nesting beaches were evaluated for the presence of remnant females. The goal is to identify safe and suitable sites for a pilot reintroduction of ten captive-raised *Batagur baska*. Their destination was an area where the last reported nesting sites for *Batagur baska* were documented 20 years ago.

Hatchling Release with Sonotronics: With the support of People's Trust for Endangered Species (PTES) and Ocean Park Hong Kong Conservation Fund (OPHKCF), ten (three males and seven females) juveniles were reintroduced (released) into natural habitat. First these were released into a soft-release pen (contained area of natural habitat that allow the animals to acclimate prior to being fully released to the wild) that was constructed on a 300 meter long secondary channel using 800 pieces of bamboo and 50 fishing nets. The turtles have since been released, but have not yet been tracked due to the vast, rugged terrain that brings with it many logistical challenges and the risk of tiger at-

tack. So these turtles were held in the soft-release pen for about a month where they were observed and tracked using directional hydrophones and man-track units provided by sonotronics that would allow them to be tracked by biologists. However, a two-member research team has continuously been monitoring the area near the release site and plan to increase the search radius, using small motorboats.

Commercial Contract (Turtle Survival Alliance Partners with Turtle Limited): The TSA-India for the first time made collaboration with Turtle Limited, a ready-made men's apparel company based in Kolkata, India. Through this agreement, Turtle Limited has agreed to provide a yearly donation to support turtle conservation work in India. Additionally, the TSA logo will appear on their products, helping to spread the word about the TSA.

Westernghat and the state of Kerala, Tamilnadu and Andhra Pradesh (Southern India). The southern peninsular region including states of Andhra Pradesh, Karnataka, Tamilnadu and Kerala house a number of protected areas like Mudumalai Wildlife Sanctuary, Sathymangalam Tiger Reserve (Tamil Nadu), Kudremukh National Park, Bheemeshwari Wildlife Reserve/Cauvery Wildlife Sanctuary, Tungabadra River Sanctuary, Dandeli Anshi Tiger Reserve, and in Sharavathi River Valley Wildlife Sanctuary, Karnataka which inhabit many rare and endangered turtle species. The habitat of the species has been recognized as rivers and reservoirs.

Habitat Assessment and Monitoring: Preliminary assessment of occurrence of Leith's Softshell Turtle and Asian Giant Softshell Turtle along different rivers in the states of Karnataka and Andhra Pradesh was done in the delta of Godavari River near Rajamundry-Andhra Pradesh and River Netravati in Dakshin Kannada District.

CaptiveBreeding: Madras Crocodile Bank Trust (MCBT) in addition to sea turtles, also maintain breeding activities of many fresh water turtle species which were in a stage of extinction. For example, Peter Praschag as a part of an international breeding loan, sent a male *B. baska* to MCBT to pair with the two long-term captive females, both acquired from a market in Kolkata back in 2001. This effectively creates a much needed second assurance colony for this rare terrapin in India

Conservation Measures: Surveys on distribution and status of different species and developing captive assurance colonies at regional zoos was done with the help of the Madras Crocodile Bank Trust (MCBT) and the Turtle Survival Alliance (TSA).

Questionnaire Surveys: A special survey for Bengali settlers was conducted in 2011 in Sindanoor town in north-eastern Karnataka. Survey respondents indicated that the species is exploited for its fibro-cartilaginous rim or calipee. Local populations in the Tungabhadra, Krishna, and Bhima drainages were apparently being exploited for this purpose

Veterinary Workshop: The Madras Crocodile Bank Trust (MCBT) and TSA recently jointly sponsor and organize veterinary workshop to train veterinarians in advanced chelonian health management techniques. The training program was split into two sessions. Veterinarians who manage chelonians for the forestry departments and NGOs comprised the bulk of the first session. The second session consisted primarily of private practice veterinarians, particularly those associated with wildlife rescue within India. The trained veterinarians can

go to assist the government when confiscated chelonians are in need of triage, treatment, and rehabilitation.

Confiscation and Rehabilitation: Two poached adult specimens were confiscated in Amaravathi, within the Annamalai Tiger Reserve, Tamil Nadu.

Conclusion

Immediate adoption of conservation measures is essential for the survival of many turtle species in India. A very important conservation component is to educate local people about the decline of the tortoise and freshwater turtle population. As a part of the conservation measures, there is a need of participatory conservation initiatives with further research to find alternative means of supporting livelihoods of the many impoverished rural communities in the country. Future planned initiatives include further surveys and ecological research along the rivers with potential turtle habitat in India, establishment of captive breeding centres and release of hatchlings into the wild, and wider management and protection of nest sites. While there are conservation programs all around the country, effective management strategies require scientific information on population, ecology and life history of the turtles. If properly planned and managed, the temple ponds and other community ponds along with innumerable wetlands spread throughout the country can play a major role in future conservation and management of wild turtles as a whole. In many places, the fishermen are good evaluators of population trend of the exploited species. Many fishermen reported sharp decline in catch per effort in the area where they have been fishing for generations. This should start with a well planned conservation education program followed by dialogue and involvement of the local communities in turtle conservation initiatives.

Again, involvement of international scientists can bring any critically species back from the brink. Dr. Gerald Kuchling, renowned turtle reproductive physiologist from Chelonia Enterprise, supervised the laproscopic sexing of captive juvenile turtles at Sajnekhali Forest Station in the Sunderban Tiger Reserve. As with any small population of animals, it is imperative that the group consist of primarily females to ensure the production of offspring and increase genetic diversity. Information regarding such sex-ratio is also extremely useful in the planning of future reintroduction, translocation and captive breeding initiatives.

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Conservation of the Pygmy Hog in India

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Introduction

The pygmy hog (*Porcula salvania*) is a critically endangered suid (Oliver and Deb Roy 1993), previously spread across India, Nepal and Bhutan, but now only found in Assam (Oliver 1980). The current world population is about 150 individuals or fewer. Recent conservation measures have improved survival prospects in the wild of this critically endangered species.

Systematic Position

Kingdom	Phylum	Class	Order	Family
Animalia	Chordata	Mammalia	Cetartiodactyla	Suidae

Geographic Range

In the past, this species was confirmed from only a very few locations in northern West Bengal and north-western Assam in India, but is believed likely to have occurred in tall, wet alluvial grasslands extending in a narrow belt south of the Himalayan foothills from north-western Uttar Pradesh and southern Nepal to Assam, possibly extending at intervals into contiguous habitats in southern Bhutan (Oliver 1980). However, it is now confined to a very few locations in and around Manas National Park in north-western Assam (Narayan and Deka 2002; Narayan and Oliver, in press).

Population

Today, this species is at the brink of extinction, as only a few isolated and small populations survive in the wild. In fact, the only viable population of the species, with a few hundred individuals, exists in small grassland pockets of Manas National Park (500 km^2) and an adjacent reserve forest in the Manas Tiger Reserve and nowhere else in the world (Narayan and Deka 2002). Sixteen captive-bred Pygmy Hogs were released in Sonai Rupai Wildlife Sanctuary in May 2008 and similar reintroductions have been planned in Nameri and Orang

Fig 1. Distribution and Geographic Range.

National Parks of Assam. There are about 75 animals in captivity in northwestern Assam. The current population trend is decreasing and there are 200-500 mature individuals in the wild.

Biology

They are about 55-71 cm long and stand at 20-30 cm, with a tail of 2.5 cm. they weigh 6.6-11.8 kg. Their skin is dark brownish black and hair is dark. Piglets are born greyish-pink, becoming brown with yellow stripes along the body length. Their heads are sharply tapered and they have a slight crest of hair on their foreheads and on the back of their necks. Adult males have the upper canines visible on the sides of their mouths. They live for about 8 years, becoming sexually mature at one or two years old. They breed seasonally before the monsoons giving birth to a litter of three to six after a gestation of 100 days. In the wild, they make small nests by digging a small trench and lining with vegetation. During the heat of the day, they stay within these nests.

Food Habit

They feed on roots, tubers, insects, rodents and small reptiles.

Taxonomy and Systematics

The species was first described as the only member of the genus *Porcula* (Narayan 2006), by Brian Houghton Hodgson (Funk et al. 2007) but was later moved with other pig species in the genus *Sus* and named *Sus salvanius*. A 2007 genetic analysis of the variation in a large section of mitochondrial DNA suggested that the original classification of the pygmy hog as a distinct genus was justified. The resurrection of the original genus status and the species name *Porcula salvania* has been adopted by GenBank. The species name *salvania* is after the sal forests where it was found.

Habitat and Ecology

The Pygmy Hog is the smallest and the rarest wild suid in the world. This species is dependent on early successional riverine communities, typically comprising dense tall grasslands, commonly referred to as 'thatchland', but which, in its pristine state, is intermixed with a wide variety of herbaceous plants and early colonizing shrubs and young trees (Oliver and Deb Roy 1993). There are many species of tall grasses, which dominate in different situations. The most important of these communities for Pygmy Hogs are those which tend to be dominated by *Saccharum munja*, *S. spontaneum*, *S. bengalensis*, *Themeda villosa*, *Narenga porphyrocoma* and *Imperata cylindrical*, which form characteristic associations of 1 to 4 m height, during secondary stages of the succession on well drained ground. These communities are not, therefore, maintained by prolonged inundation, though they may be maintained by periodic burning. However, as they also include some of the most commercially important thatching grasses, some of these areas (including many of those in protected areas) are harvested annually and virtually all of them are subject to wide-scale annual (in some areas, twice-annual) burning. Although it has been suggested by ecologists that any burning be conducted at the beginning of the dry season (in December or early January) in alternate blocks (demarcated by fire-lines) and only once in 2-3 years, most of the grasslands continue to be burnt every year in the dry season, which deleteriously affects their floral and faunal diversity. It has been recognised that some amount of "early" burning may be required in order to preclude the possibility of later, uncontrolled 'hot' burns, which are far more destructive, and possibly to delay natural succession of the grasslands in protected areas. However, early burning also may deprive hogs and other grassland dependant species of cover and other resources for a longer period prior to the re-growth of vegetation and has the same consequences of dramatically reducing floral and faunal diversity.

Threats

The main threats to survival of Pygmy Hog are:

1) Loss and degradation of habitat due to human settlements, agricultural encroachments, dry-season burning, livestock grazing, commercial forestry and flood control schemes; the latter as a result of the disruption of natural successions and the replacements of former grasslands by later stage communities or other developments. In Assam, as elsewhere, most former habitat has been lost to settlements and agriculture following the rapid expansion of the human population (Oliver, 1980, 1981, 1989; Oliver and Deb Roy 1993). Some management practices, such as planting of trees in the grasslands and indiscriminate use of fire to create openings and to promote fresh growth of grass, have caused extensive damage to the habitats the authorities intend to protect (Narayan and Deka 2002). A combination of these factors has almost certainly resulted in the loss of all of the small populations of these animals in the reserve forests of north-western Assam. These losses strongly reinforced the overwhelming importance of the largest and, by the early to mid-1980s, only known surviving population in the Manas (Oliver, 1981, 1989; Oliver and Deb Roy 1993).

2) Hunting for wild meat by tribes was not considered a major problem in the past but is now threatening the remnant populations (Narayan and Deka 2002). The survival of Pygmy Hogs is closely linked to the existence of the tall, wet grasslands of the region which, besides being a highly threatened habitat itself, is also crucial for survival of a number endangered species such as Indian rhinoceros (*Rhinoceros unicornis*), tiger (*Panthera tigris*), swamp deer (*Cervus duvauceli*), wild buffalo (*Bubalus arnee*), hispid hare (*Caprolagus hispidus*), Bengal florican (*Eupodotis bengalensis*), swamp francolin (*Francolinus gularis*), and some rare turtles and terrapins.

Conservation Actions

The Pygmy Hog Conservation Program (PHCP) is a broad-based research and conservation program for this highly threatened species and its equally endangered habitats (Narayan and Deka 2002, Narayan 2006). It is being conducted under the aegis of a formal International Agreement, that was originally signed at New Delhi in 1995 and later renewed as a Memorandum of Understanding in 2001, between IUCN SSC Pigs Peccaries and Hippos Specialist Group, Durrell Wildlife Conservation Trust (DWCT), the Forest Department, Government of Assam, and the Ministry of Environment and Forests, Government of India. A local governing body consisting of representatives of the four signatories and some Indian experts has been constituted to provide guidance to the Program. The implementation of this agreement, the first of its kind in India, is being undertaken by PHCP and the local partner organisation, EcoSystems-India, with funds provided by DWCT, with assistance from the European Union, Darwin Initiative (UK government), Assam Valley Wildlife Society, Zoological Society for the Conservation of Species and Populations (ZGAP), and various other sources. The primary aim of this collaborative program is conservation of the Pygmy Hogs and other endangered species of tall grasslands of the region through field research, captive breeding and re-introduction after adequate restoration of degraded former habitats. One of the main objectives of the Program was to establish a well structured conservation breeding project for pygmy hogs as an insurance against the possible early extinction of the species in the wild and as a source of animals for re-introduction projects. In 1996, six (2 male, 4 female) wild hogs were caught from Manas National Park and transferred to a custom-built research and breeding centre built at Basistha near Guwahati, the capital of Assam. Five more hogs were caught and released at the capture site after fitting three males and a female with radio harness for radio-telemetry studies. The hog population kept in captivity almost doubled in 1997 from 18 to 35 through planned breeding. Between 1998 and 2002, several more hogs were born in captivity and a rescued wild hog was added to the captive population, taking it to over 75 animals which constituted over 1200% increase in 6 years. Although two more enclosures and a quarantine facility were constructed at Basistha, the unanticipated and rapid increase in the captive population created accommodation problems, forcing the program to restrict breeding in captivity. Subsequently, a much larger facility was established at Potasali near Nameri National Park in Assam. This facility includes four holding enclosures and four pre-release enclosures with near natural habitat, where hogs earmarked for reintroduction are reared. Since the animals at Basistha Centre are the only

captive pygmy hogs in the world, the second centre is also an insurance against any catastrophe at the present location. Once the Potasali pre-release enclosures were ready and the habitat at one of the release sites became reasonably suitable, the hogs were allowed to breed again.

Surveys to locate possible release sites in Assam were carried out, as the rapidly increasing captive population necessitated transfer of some of these pygmy hog back to where they belonged. Two potential re-introduction sites were identified in Sonai Rupai Wildlife Sanctuary and Nameri National Park, both in Sonitpur district of Assam bordering Bhutan and Arunachal Pradesh. Habitat management and protection regimes at the potential release sites were assessed in consultation with authorities and recommendations for restoration and scientific management were given. The management authorities are trying to implement the recommendations with limited success. The habitat in a part of Orang National Park was also found suitable, but in absence of any reliable record of the species formerly occurring in this area, further evaluation is considered necessary.

The actual release of hogs was delayed initially due to security problems and later due to presence of factors that were responsible for disappearance of the hogs at the potential reintroduction sites. Once the some of the recommendations were implemented at one of the sites (Sonai Rupai), preparations for soft release were started. In 2007, 23 babies were produced at Basistha. Three social groups comprising 16 (7 male, 9 female) hogs, including 10 yearlings, were transferred from Basistha to Potasali pre-release enclosures in December 2007. They were kept in the pre-release enclosures under minimum human contact. Each of these enclosures is 2,400 to 3,200 m^2 in size and capable of meeting most of the food requirements of a group of 5-6 hogs. These hogs began to behave like wild animals within a few weeks and did not come close even to their keepers except in an area where they were offered a few morsels of their favourite food. They were shifted to a release enclosure in Sonai Rupai after five months, and were given access to go to the wild after about two weeks. Unfortunately, the radio telemetry studies on these hogs could not be done as the radio harness fitted on six of them while they were in pre-release caused injuries when they moved rapidly through very dense grass. The released hogs will be monitored through indirect means (droppings, nests) and by observing them at bait stations.

Community conservation initiatives and awareness campaign have been started in the fringe villages of Manas, Nameri, and Sonai Rupai as it is almost impossible to save the species without the cooperation of the local population. Capacity building and training programs are also being carried out for the front-line protection staff in the above protected areas.

This species is listed on CITES Appendix I (as *Sus salvanius*).

Captive breeding program

The aim of the captive breeding program is to support the conservation of the species by providing animals to be reintroduced into the wild in an effort to increase the size of the wild population and the species range reducing the risk of extinction.

Fig 2. Pigmy hogs in playful mood.

The first attempt at captive breeding the pygmy hogs began in 1971 when the species was rediscovered following a fire in the Barnardi wildlife sanctuary. A tea plantation manager took the first group of 14 hogs into a private captive collection and called on Durrell's Jeremy Mallinson for advice on husbandry techniques. Over the next few years this collection successfully produced over 40 hogs in captivity but unfortunately, due to a lack of experience of the keepers the population soon failed.

Following the formation of the Pygmy Hog Conservation Program (PHCP) in 1995 an official conservation-led captive population was established at custom built facilities in Basistha. A total of 11 wild pygmy hogs were caught during a series of elephant drives where lines of elephants are used to flush out wild hogs into a net where they were captured. Six of these hogs were transferred to the Basistha facility and were the founders of the current captive-breeding program.

Two years later the captive-breeding program had been so successful that the captive population of pygmy hogs had increased by over 600%. A new breeding facility was established at Potasali to house the increasing population. By 2014 over 85 captive-bred hogs have been released into the wild and a further 60 remain in captivity as a safety net population and will continue to produce hogs for future releases.

Releases and field monitoring

With only one small population of pygmy hogs persisting in the wild in the Manas Wildlife Sanctuary and a captive-breeding program successfully producing large numbers of hogs, it was clear that the next steps for the PHCP was a trial release of captive-bred hogs into a new site.

In 2006, a three year project was funded by the Darwin Initiative with the aim of "Implementing a Recovery Plan for the Critically Endangered Pygmy Hog in Assam". The focus of this project was to establish new populations through release of captive-bred hogs and improving the grassland habitat through community work and restoration efforts.

Identification of release site: Extensive habitat surveys and consultations with local authorities took place at three potential release sites; Nameri National

Fig 3. Pre-release enclosures at Potasali are designed to mimic the natural grassland habitat.

Park, Sonai Rupai Wildlife Sanctuary and Orang National Park. All three sites are located in within the pygmy hog's known recent range in north-western Assam though no evidence of the occurrence of populations of pygmy hogs could be found during these surveys. For the trial release Sonai Rupai was selected as the chosen site as it contained considerably more tall grasslands than the other sites.

Pre-release Enclosures

In order to prepare the hogs for release into the wild, unrelated and mostly young hogs were organised into three different social groups at the Basistha breeding centre before being transferred to a specially constructed 'pre-release' facility in Potasali, on the outskirts of Nameri National Park, east of Sonai Rupai Wildlife Sanctuary. In order to encourage natural foraging, nest-building and other behaviours these hogs were maintained in simulated natural habitats and husbandry techniques were adapted to minimise human contact to mitigate tameness and other behavioural characteristics consequent upon their captive management.

In the meantime restoration efforts continued at the release site chosen in the Sonai Rupai Wildlife Sanctuary as PHCP staff continued to work with the Sanctuary authorities and staff to improve protection and management of the site and to control annual dry season burning of grass. Sanctuary staff were also trained in wildlife monitoring and habitat management to help in restoration of the grassland habitat and monitoring of released hogs.

Fig 4. PHCP staff looking for signs of surviving released hogs.

First release of pygmy hogs into the wild

Following a five month period of preparation in the pre-release enclosures at Potasali, in May 2008 the first group of sixteen pygmy hogs were transported to a soft-release enclosure within a relatively secluded but easy to access area of natural habitat within the release site of Sonai Rupai Wildlife Sanctuary. These enclosures were also rigged with two lines of electric fencing and kept under continual surveillance as a precaution against potential predators and to deter incursion by wild elephants.

The hogs were maintained for a further three days in these enclosure before being released, by the simple expedient of removing sections of fence and allowing the animals to find their own way out. Following similar protocols, nine hogs were released in May 2009 and ten more in May 2010, thereby releasing a total of 35 hogs in different locations within the grasslands of Sonai Rupai.

Post-release monitoring

In order to monitor the survival of animals post-release, harnesses designed for attaching radio-tags to the hogs were field-tested whilst they were being kept in the pre-release enclosures. However, unexpected problems in the long-term use of these harnesses were exposed as they caused unacceptable injuries to the hogs and other methods of post-release monitoring were designed and initiated. These included training the hogs to revisit bait stations which were monitored using video camera traps as well as using field signs such as nests and footprints.

Following the first release an estimated 10-12 out of the 16 released animals were thought to have survived several months after being released and video footage showed animals looking healthy. Footprints of newborn hogs were also

detected providing evidence of breeding in the wild, confirming not only their survival but also their adaptation to wild conditions after at least one generation spent in captive management.

Building capacity and raising awareness

Training National Park guards in site protection and wildlife monitoring

All release sites are located within protected areas and National Parks in Assam. Therefore, to ensure the continued protection and improved management of these sites and to assist PHCP staff in protecting and monitoring released hogs the program works closely with the Assam Forest Department, providing support and training to frontline staff at each kay protected area.

As part of the Darwin Initiative project the 'Training Course for Frontline Field Staff of Assam on Monitoring and Protecting Wildlife' was launched conducting intensive training with selected participants from Manas, Nameri, Orang, and Barnadi protected areas. As part of the course posters, manuals, trainee guides and data recording booklets were produced in English as well as in the local language, Assamese, for use and distribution among trainees. A range of field-based tools and infrastructure supporting Assam's capacity for protected area management was also established. Since the end of the project it has been agreed that the Forest Department will take efforts to incorporate the monitoring system as part of the regular duties of frontline field staff and the PHCP support them by continuing to deliver training at the Assam Forest School.

Raising awareness and support in local communities

Delivering a program of community-based biodiversity and environmental education, outreach and sustainable development is key to building community involvement and support for the conservation of the tall grasslands and wildlife including the pygmy hogs. Efforts have been concentrated on the communities surrounding the Manas National Park as these grasslands support the last remaining wild population of pygmy hogs and human pressures are continuing to impact the grasslands despite the protected area status.

The program works closely with local communities to understand their needs in terms of resource use from the grasslands, so that workable, sustainable, and socially acceptable alternatives in the rural areas outside the park can be identified and developed. Proejct staff support villagers in forming Self Help Groups through which member households have acquired new skills and honed their existing ones in weaving, sewing, handicrafts, food preservation, betelnut leaf plate making, piggery, and farming. In support of the project villagers have pledged to reduce resource use from the Manas by promoting sustainable cultivation of cash crops (ginger, vegetables, rubber, etc.) and small timber (bamboo). A trainers' training program for school teachers and local NGO members has been implemented and at least seventy school teachers from local schools in the fringe villages of Manas have been trained in conducting environmental education among community members including school children. Some of the

trainees are being assisted to generate awareness in conservation of pygmy hog and its grassland habitat in schools.

Future steps

Whilst much progress has been made over the past 40 years of conservation of the pygmy hog, there is a long way to go before this species is out of danger and can be considered recovered. In 2015, a new Species Action Plan will be developed by partners to guide future conservation efforts for the species. Currently efforts are being made to raise funds to conduct reintroductions of captive-bred hogs into a third release site in Assam to establish a fourth subpopulation of the species in the wild. Methods of attaching radio-telemetry tags so we can closely monitor the wild hogs and any animals due to be released are still being developed and the next trials will be conducted in 2015. (Pygmy Hog Conservation Program).

Fig 5. Pygmy hog in its dwelling hole.

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Defaunation and Conservation in Indian Context

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Introduction

Defaunation means "the loss of animals from ecological communities." Defaunation differs from extinction; it indicates both the disappearance of species and decline in abundance. Defaunation as a term was probably first used in a symposium of plant-animal interactions at the University of Campinas, Brazil, in 1988 in the context of neotropical forests. Much of Asia, Africa, and Latin America suffers from defaunation due to overhunting and overexploitation of the forest. Tropical regions like the Brazilian Amazon, The Congo Basin of Central Africa, and Indonesia are the most heavily impacted by defaunation.

Driving Factors

Overexploitation: Intensive hunting and harvesting of animals are one of the major causes of defaunation world wide. In the Brazilian Amazon Forest, 23 million vertebrates are killed every year. Large bodied primates, tapirs, white-lipped peccaries, giant armadillos, and tortoises constitute the huge numbers. Thoughout the world local game species decline as villages increase. Hunting of tigers by Raja, Maharajas, and the British caused decline in the number of tigers in Indian forests from several thousands in the eighteenth century to over a thousand in 2002. North America lost all the passenger pigeons in shooting game, about hundred years ago.

Habitat Destruction and Fragmentation: Large species such as elephants, rhinoceros, tigers, large primates, tapirs, and peccaries are the first animals to disappear in fragmented rainforests. Felling of trees in rainforests for logging and extension of agricultural fields leads to fragmentation of the mighty forests, habitat of the big animal species. The extension of agricultural fields in the forest of Terai at the foothills of the Himalayas has made the forest fragmented, leading to man-animal conflicts, particularly with elephants. Unfragmented forests not only support the well being and growth of large animals, but also provide for more habitat for diverse species with larger home ranges. Satellite pictures show a 'fishbone deforestation pattern' in Brazil; a mighty canopy of Amazonian forest has been reduced into thin strips of trees resembling the thin bony skeletons of fishes. The pictures tell about pathetic greedy activities of *Homo sapiens*, reflecting definition and damage to the lung system of the world.

Use of Toxic Materials: Use of pesticides, herbicides, and fertilizers are not often eco-friendly and affects a good number of small animals and micro-faunae, which maintain the normal health of the eco-systems. Indian white-ramped vulture has suffered a near-extinction form ingesting the dead bodies of diclofenac-treated cattle.

Ecological Impacts

Genetic Loss: Loss in number of animals due to defaunation allows in-breeding within a limited group and loss of genetic diversity. This lowers the ability to deal with environmental changes. Gradually a genetically homogeneous community becomes more susceptible to diseases and runs the risk of extinction. Often this mechanism is cited as the reason for near extinct state of the Cheetah.

Dispersal: Hunting limits the dispersal of species.

Invasive Species: A disturbed and defaunating habitat allows invasive species to compote out native species.

Pollinators, Seed Dispersers, and Predators: Loss of species diversity impacts in larger loss of biodiversity. The importance of pollinators and how much loss may occur to the native by indiscriminate use of pesticides have been depicted by Rachel Carson in her book *Silent Spring*. Bats, birds, dung beetles, and seed predators like rodents play an immense role in dissemination of seeds for the maintenance of eco-systems. Lambir Hills National Park in Western Borneo, one of the most diverse forests in the world, currently suffers from loss of herbivores and fruit eaters. Now saplings are becaming crowded, plants get sick, and number of plant species decrease. In turn, defaunation cheeps in for the animals dependent on certain plants. In a nutshell, defaunation, like deforestation, threatens global diversity of living beings.

Marine Defaunation

Defaunation in the oceans is definitely taking place. But much intensive and statistical studies are yet to be done. Apparently it seems that defaunation in the ocean is less intense than on land.

Conservation in Indian Context

Reversing of defaunation is the way for restoring of species. This is in understanding of many, but positive action for it is yet to be realized. India can be exemplary in this context. India is one of the richest countries in the world in terms of biodiversity. India is a megadiversity nation. We have 46,000 plant species and 81,205 animal species. The species list of fauna includes 2,546 fish, 197 amphibians, 408 species of reptiles, 1,258 birds, and 350 mammals, the rest are insects and others. India occupies 2% of the earth's total land mass and has 5% or more species of living organisms. There are four biodiversity hotspots in India with high faunal density and endemic species. They are the Western Ghats, The Eastern Himalayas, North Eastern India, the Indo-Burma region-south

of Brahmaputra rivers, and Nicobar Island. Agasthyamalai Hills in the extreme south of the Western Ghats harbor the highest concentration of species. The Himalayan newt (*Tylototriton verrucosus*), the only salamander species (adult amphibian with tail) in India, can be located in the hills of the Darjeeling district in the Eastern Himalayas. Much of the Indian biodiversity is intricately related to the socio-cultural practices and mythological stories of the land.

Biodiversity in India and Socio-Cultural Practices

Rich cultural heritage in India goes back thousands of years. Religious tradition in India advocates non-violence and compassion towards animals. According to Hinduism, all life forms, including plants and animals, are manifestations of God as limited beings (*jivas*) and possess souls. All beings are children of '*Prajapati*' (Creator God *Brahma*) only.

Although the concept of 'Go-Mata' (cow is mother) is belittled by the modernity, it has a deep root in Indian psyche. In Hinduism, the cow is a symbol of wealth, strength, abundance, and selfless giving; their numbers are used to measure the wealth of a king or kingdom. They fulfill the earthly requirements of man in a big way. Besides tilling and fertilizing the agricultural lands, all the products of a cow, such as milk, dung, urine, hoof, horn, and hide serve the earthly needs of humans. Thus, the 'Go-Mata' concept is symbolic recognition to the great contribution of the cow, unique of Indian in the world.

Similar attitude and respect to the existence of other organisms, wild species, insects and worm, inculcated by the stories in mythology, in a way allowing India to become one country of permanent biodiversity. One third of Indians are vegetarian, highest in the world. Still Indian forests provide shelter to the 70% of tigers existing in the world. Although earlier hunting by the kings and royals from other lands, and poaching for body parts to use in potions by neighboring countries, the number of tigers in India was reduced to 1,411 in 2006, but positive steps of conservation in recent time have raised the tiger population to 2,500 in 2016. Decline and rejuvenation of tiger population in India through the years is a typical example of defaunation and reversing by conservation. Protection measures are still faulty. That is why a small news item in the paper (*The Statesman*, p. 3) on 23 November, 2016 reports that poaching kills 29 tigers in this year. It pains much any nature lover.

India has a long tradition of maintain 'deva-sthanas' (sacred places) having trees and water bodies surrounding temples and '*majars*', where all kind of small animals, birds, and fishes can thrive. Sometimes a forest was regarded as sacred and thus hunting was forbidden there. The concept of sanctuary in earlier time was reality. Such places still exist in Uttarakhand and Himachal in India. Respect and devotion to the religion really help in flourishing of animals.

The Bishnoi people living in Thar Desert of Rajasthan is now champion throughout the world as the protectors of blackbuck (*Antelope cervicapra*). The do not tolerate killing of wild animals and felling of a green tree. A blackbuck to them is the reincarnation of Bhagwan Jamboji, the founder of the Bishnoi Sect some five hundred years back. Similarly, the Maldhari tribe in Gujarat is associated with the increase in a population of Asiatic lions in Gir, while the lion population in Africa is on the decline.

Animal welfare Measures in India

Compassion towards animals in India guided the government to pass a number of animal welfare reforms since 1960 and formation of many NGOs in recent time. One point needs to be mentioned here that India is also one of the world's leading producers of animal products. Traditional consciousness for animals in India allowed Briton Cloesworthly Grant to found the first Indian Society for the Prevention of Cruelty to Animals (SPCA) in 1861 in Calcutta. SPCA's anti-cruelty legislation was extended to all places of India in 1890-91.

National parks and protected areas in India were established way back in 1935, and substantially expanded since then. In 1972, India enacted the Wildlife Protection Act and Project Tiger to safeguard crucial habitat; further protections were promulgated in the 1980s. Along with over 500 wildlife sanctuaries, India now hosts 15 biosphere reserves, four of which are part of the World Network of Biosphere Reserves, and 25 natural wetlands.

Article 48 of the constitution of India specifies that "The state shall endeavour to protect and improve the environment and to safeguard the forest and wildlife of the country" and Article 51-A states that "it shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures." To fulfill the ethos in the article, the university Grants Commission introduced compulsory Environmental Studies at undergraduate level courses throughout India, more than a decade and half ago.

Let India be champion to Lead the World for Compassion and Protection of Animals and Erase the Word Defaunation

Traditionally, India is possibly the only country in the world with much love for nature and animals. Indians do not view the animals only for exploitation. That is why the Indians have '*mantra*' (religions verse) from age old time to spread some rice and other foods outside for '*Prani prana rakshyarthang*' (serving animals and living beings). They associated the different animals with various deities as '*vahanas*' (carriers) and *bahanas* are also worshiped along with the deities. India was booed earlier for its love and regards to the animals and equated with primitingty by the outsiders and our own people enlightened with western light.

India needs to mend many modern practices to retain its championship as an animal lover. Modern Indians under the influence of western thought and habits are indulging themselves to be less sensitive to animal causes. We are getting cruel to animals in their painful transportation, smuggling, illegal hunting, and promoting meat eating. We are now gullible to western thought and technology, instead of promoting the logics and means of protecting nature and wildlife developed over the centuries in India. We are now vexed with the problem of tinkering with the genetic materials of the living creatures developed through many years on Indian soil. Although our main focus of this article is on wildlife, the agricultural varieties of plants and animals derived from wild stocks and thus, deserved some attention in the present context.

Much thinking is necessary in adaptation of the technologies in agriculture. In the name of gaining in production as device by foreign technologies, we should not lose the good genes and good qualities of the agricultural varieties developed indigenously.

The government of India in a way mismanaged cow breeding. Over the past few decades, exotic cow varieties where imported to gain a boost in milk production. In Punjab, for example, 80% of the state's cattle are exotic breeds. They are not well-adapted to Indian conditions and have lesser resistance to diseases. About 69% of cows are owned by the economically poor strata of our society. They cannot afford to house these exotic breeds in regulated climate conditions. Whereas India has 37 pure cattle breeds known for their milking prowess. Both milch and draught (ploughing, carrying load) quality cows are good in India developed since time immemorial, loss of these varieties may come under the purview of the event of defaunation. We are living in the *Anthropocene Era*, and a global wave of anthropogenic activity driven biodiversity loss.

I could find enormous varieties of butterflies flying and tasting the flowers in the small garden in front of our university quarters some thirty five years ago. Nowadays almost none, seldom some small varieties as one or two visit our garden. The reasons, after some enquiry and discussion, seems to be the pesticides used in the tea garden in Terai. One way better and higher production of tea, other way threatening the existence of beautiful winged pollinators, which one is to chose? Possibly we need to find a balanced in between solution.

Final Comment

In India, multiple aspects, such as religious tradition, experience, heritage of knowledge, feeling, and sensitivity are woven into human quality. Majority of Indians in heart are ecofriendly and animal lovers—the message needs to be viral for the rest of the world.

I hope, without being under foreign influence, India will be able to restore the phenomenon of defaunation with indigenous cheaper technology in different countries. Tiger had been declared extinct in Cambodia. Let Indian experts get involved in changing people's attitude and restoration of the habitat of regenerate tiger population in Cambodia after reintroduction of the animal, as they are doing the different reserve forests in India. Let restoration of the population of the tiger in Cambodia increase the confidence and conviction of India.

Water Crab of the Forest of the Himalaya—its Threats and Conservation

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Abstract

Freshwater crabs are one of the major component in the forests. Among the total 98 species of freshwater crab occuring in Indian territory, 45 species (50%) were reported from the Himalayas of the Indian part. The eastern part of Himalyas, or eastern India, are more diversed by harbouring a total 34 species exclusively in its nest, whereas the western Himalayas are very poor in species diversity and only 5 species are exclusively reported from there, which are not present in eastern India. Interestingly, only 6 species are common in both of these two widely sparated regions. A check-list of 45 species of crabs has been prepared providing recent generic and species names of the group along with State-wise distribution in the Himalyas of the Indian territory. Threats and conservation measures of these crabs are also discussed in this communication.

Introduction

The freshwater crab belongs to the infraorder brachyura of the order decapoda in the class malacostraca of phylum Arhtropoda. They are adapted not only in freshwater but also in semiterrestrial and terresetrial habitat. Freshwater crabs have a great role in nutrient cycle in freshwater ecosystems; these species has a significant use as food for rural people. Recently, these species are considered as bio-indicator in environmental monitoring. Some species of freshwater crab recently found as a carrier of paragonimiasis, a serious disease caused by the lung-fluke from Manipur and Arunachal Pradesh. Freshwater crab constitutes only a small fraction of the brachyuran fauna of our country. True freshwater crabs are those which spend their entire lives in freshwater without return to the sea for whatever reason. There are some crabs which occasionally wander or even live in freshwater habitats, especially those occurring near the sea, but they are always common in estuarine areas and their larval development occurs in the open sea. True freshwater crabs belong to two superfamilies viz. Potamoidea and Gecarcinucoidea. All the members of the Potamoidea and Gecarcinucoidea spend their entire lives in freshwater or surrounding wetland areas.

In recent years there has been a drastic change in the taxonomy of freshwater crabs. For example, Alcock (1910) dealt all freshwater species under a single family, the Potamonidae. But presently these are treated under two families namely, Gecarcinucidae and Potamidae. Many of the genera dealt therein are either split or merged and several new genera have been erected (Ng et al. 2007).

The Himalyas are known to be a geologically young and dyanamic mountain range system supporting a highly diverse fauna and flora, many of which are endemic. The Indian Himalayas extends over 2,500 km from Jammu and Kashmir in the west to Arunachal Pradesh in the east, covering an area of about 5,33,600 km^2. Geographically, the eastern Himalayas are characterized by high rainfall, heavy snowfall, and conditions more akin to temperate regions. Both the climate condition as well as geographical variations play a great role in the distribution of fauna and flora in the eastern and western Himalayas. Among the total 90 species of freshwater crab occuring in the Indian territory there are only 11 species recorded from the western Himalayas and 40 species that are recorded from the eastern Himalayas in Indian part. These data suggest that the eastern Himalayas are much more diverse than the western Himalayas, with a total of 14 genera recorded from the eastern Himalayas and 6 genera reported from the western Himalayas. Only 6 species, namely *Barytelphusa cunicularis* (Westwood 1836), *Maydelliatelphusa masoniana* (Henderson 1893), *Sartoriana spinigera* (Wood-Mason 1871), *Himalayapotamon atkinsonianum* (Wood-Mason 1871), *Himalayapotamon koolooense* (Rathbun 1904), and *Eosamon tumidum* (Wood-Mason 1871), are common in both parts of the Himalayas. While only 34 species are found exclusively in the eastern Himalayas, there are only 5 species, namely *Himalayapotamon ambivium* (Alcock 1909), *Himalayapotamon babaulti* (Bouvier 1918), *Himalayapotamon kausalis* (Pretzmann 1966), *Himalayapotamon emphyseteum* (Alcock 1909), and *Larnaudia larnaudi* (A. Milne Edwards 1869), distributed exclusively in the western Himalayas.

In the present communication, a check-list of 45 species of crabs have been prepared providing recent generic and species names of the group as far as possible. State-wise distribution along the Himalyas of these crabs have been presented. Threats and conservation measures of these crabs are also discussed in this communication.

Review of the Literature

From the perusal of literature, it appears that the first freshwater crab reported from freshwater habitat of India collected by Daldorff was *Cancer senex* (= *Oziotelphusa senex*; Fabricius 1798). Herbst (1799) and Nobili (1903) recorded the species *Potamon leschenaudii* (Edwards) = *Oziotelphusa senex* (Fabricius 1798) from Pondichery. Lucas (1850) recorded *Thelphusa indica* from the Coromandel Coast. H. Milne Edwards (1853) reported three species from "Inde" (=India) namely, *Thelphusa indica*, *T. perlata*, and *T. leschenaultia*. In 1869, Hilgendorf also recorded the species *Thelphusa leschenaultia* (Milne Edwards) from Pondichery. In addition, he also reported *Telphusa guerini* which was probably collected from India. Heller (1862) described the crab *Thelphusa wüllerstorfi* (= *Spiralothelphusa wüllerstorfi*) based on collections from Madras, Nicobar, Sri Lanka, and Tahiti. In1865, he described another species, *Thelphusa corrugata* on the basis of collec-

tions from Madras and Java. Both the species are now merged with the species *Spiralothelphusa wüllerstorfi*. The crab *Thelphusa leschenaudii* was also recorded by him from Nicobars and Madras (Wood-Mason 1871a, b 1875, Bürger 1894).

Alcock (1909a, b) described several species from India. In 1910, he published catalogue of the Indian decapod crustacean which is still considered invaluable publication in the study of the freshwater crabs of the Indian subcontinent. Henderson (1893, 1912, and 1913), Rathbun (1904, 1905), Bouvier (1918), Roux (1931), Bott (1964, 1969, 1970), Pretzman (1963, 1966a, b) have also studied the freshwater crabs of India and reported several new species. Dutta (1983), Ghatak and Ghosh (2008), Ghosh and Ghatak (1999, 2000), Ghosh et al. (1999), have studied the freshwater crabs of Assam, Meghalaya, Manipur, and Tripura. Yeo and Ng (2007) have made significant contributions on the taxonomy of freshwater crabs belongs to family Potamidae.

Taxonomic Account

The following is the check-list of species with detailed synonymy which have been arranged chronologically for convenience to indicate the extent of work on the species done in Himayan region of India. The distribution of species is shown in paraenthesis. The check-list is prepared based on recent classification of Ng et al. (2008).

Superfamily Gecarcinucoidea Rathbun, 1904
Family Gecarcinucidae Rathbun, 1904
Subfamily Gecarcinucinae Rathbun, 1904

1. *Barytelphusa cunicularis* **(Westwood, 1836)**

1836. *Thelphusa cunicularis* Westwood, In: Sykes and Westwood, Trans. Entom. Soc. London, 1:183, pl. 19, fig. 1.

1853. *Thelphusa indica*: H. Milne Edwards, Ann. Sci. nat. (Zool.), (3), 20: 209.

1871. *Thelphusa indica*: Wood-Mason, J. Asiat. Soc. Bengal, 40(2): 196.

1893. *Thelphusa indica*: Henderson, Trans. Linn. Soc. Lond. Zool., (2), 5: 380 (Very common in Hill-streams at Kotagiri and elsewhere in Nilgiri Hills at an elevation of 6, 000 ft.).

1970. *Barytelphusa* (*Barytelphusa*) *cunicularis*: Bott, Abhandl. Sencken. Naturfors. Ges, 526: 31, pl. 2, fig. 18-20; pl. 26, fig. 13 (Bombay, Belaghat, Karnataka – North Kannada (Castle Rock), Mangalore, Dandheli, Shimoga Jog Falls; Malaiyandipattanams Pollachi, Annamalai, Nilgiris – Gudalur and Masinigudi).

1998. *Barytelphusa* (*Barytelphusa*) *cunicularis*: Deb, Zool. Surv. India State Fauna series 3: Fauna of West Bengal, Part 10: 387 (West Bengal – Darjeeling district: Kalimpong; Jalpaiguri district: Jalpaiguri; Puruliya district: Manbhum and Barabhum).

2005. *Barytelphusa* (*Barytelphusa*) *cunicularis*: Ghosh, Ghatak and Roy, Zool. Surv. India State Fauna Series 5: Fauna of Andhra Pradesh (Part 5): 556 (Andhra Pradesh: Pulicat and Station 3, Matchrela, Dist. Nalgonda; Pedamindu, Kolleru Lake).

2005. *Barytelphusa* (*Barytelphusa*) *cunicularis*: Srivastava, Rec. zool. Surv. India, 104: 118, pl. 1, fig. 3.

2006. *Barytelphusa* (*Barytelphusa*) *cunicularis*: Srivastava and Krishnan, Zool. Surv. India Fauna of Bilgiri Rangaswamy Temple Wildlife Sanctuary, Conservation Area Series, 27: 17, 18 (Karnataka –

Kolar Road, Honametti Bedaguli, Basavangodu, Kadakkinagandi, Hanakere, Biligiri Rangaswamy Temple, Doddasempige, all from BRTWLS).

2007. *Barytelphusa* (*Barytelphusa*) *cunicularis*: Srivastava, Zool. Surv. India Fauna of Andhra Pradesh, State Fauna Series, 5 (Part 4): 246, fig. 1 (Chittor district: Talakona waterfalls, Naynargardikey; Nellore district: Kadivedu; Karnool district: Lalalabugga; Anantpur district: Pennadam).

2008. *Barytelphusa cunicularis*: Bahir and Yeo, Raffles Bulletin of Zoology, Supplement, 16: 312, fig. 3. (Maharashtra: Poona, Bombay, south western India; Balaghat, south western India. Karnataka: "Indien, Dandheli, Kalu-fluss, N-Kanara"; Dharwar district, freshwater channels, in deep burrows in muddy areas. Kerala: Chathankodu near Ponmudi, Lat. 08º 39´ 45.1´´ N, Long. 77º 09´ 03.5´´ E., altitude 100 m; near Ponmudi, Lat. 08º 43´ 04.5´´ N- 08º 44´ 19.0´´ N, Long. 77º 07´ 41.4´´ E. - 77º 09´ 09.7´´ E., altitude 120 – 339 m; Kalikavur on Manjeri-Trissur Road, Lat. 11º 10´ 0.6´´ N, Long. 76º 19´ 51.7´´ E., altitude 52m; Palaruvi waterfall, Lat. 08º 56´ 30.7´´ N, Long. 77º 09´ 52.4´´ E., altitude 600m; Chalakudy.

Type locality: Bombay, Western Ghats.

Habitat: Muddy areas beside the water body

Distribution: Darjeeling (W.B.); West Bengal, Andhra Pradesh, Tamil Nadu, Maharashtra, Kerala.Karnataka, Gujarath, Madhya Pradesh, Chhattisgarh, Bihar, Jharkhand, Himachal Pradesh and Odisha.

Conservation Status: It is categorised as Least Concern in IUCN Red List 2013.

Remarks: mainly occupied in peninsular India, but now invaded in Eastern as well as western part of India. It's an Edemic species to India.

Genus *Globitelphusa* **Alcock, 1909**

1909b. *Globitelphusa* Alcock, Rec. Indian Mus., 3(4): 250.

Type species: *Paratelphusa* (*Globitelphusa*) *bakeri* Alcock, 1909, by original designation, gender: feminine.

2. *Globitelphusa bakeri* **(Alcock, 1909)**

1909b. *Paratelphusa* (*Globitelphusa*) *bakeri* Alcock, Rec. Indian Mus., 3 (4): 378.

1910. *Paratelphusa* (*Globitelphusa*) *bakeri*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 114, pl. 8, fig. 30 (Assam: Ganjam, north Cachar).

1970. *Liotelphusa laevis bakeri*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 50, pl. 33, figs. 13-16 (Ganjan, North Cachar; Darbund, Cachar).

Type locality: Cachar, Ganjam.

Habitat: Hill stream and River

Distribution: Assam (North Cachar.)

Remarks: Endemic to Assam

Conservation Status: It is categorised as Data Defficient in IUCN Red List 2013.

3. *Globitelphusa cylindra* **(Alcock, 1909)**

1909b. *Paratelphusa* (*Globitelphusa*) *bakeri cylindrus* Alcock, Rec. Indian Mus., 3(4): 378 (Naga Hills and Assam).

1910. *Paratelphusa* (*Globitelphusa*) *bakeri cylindrus*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 115 (Assam; Nagaland: Naga Hills).

1970. *Liotelphusa cylindra*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 51, pl. 33, figs. 21-24 (Assam; Naga Hills).

Type locality: Naga Hills (Nagaland, Northeast India)

Habitat: No data available

Distribution: Nagaland

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Remarks: Endemic to Nagaland of Northeast India.

4. *Globitelphusa pistorica* **(Alcock, 1909)**

1909b. *Paratelphusa* (*Globitelphusa*) *pistorica* Alcock, Rec. Indian Mus., 3(4): 378 (Assam: Cachar).

1910. *Paratelphusa* (*Globitelphusa*) *pistorica*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 116, pl. 8, fig. 31 (Assam: Sibsagar; Darband Pass, Cachar).

Type locality: Darbund – Pass, Assam

Habitat: Freshwater River and Stream.

Distribution: Assam (North Cachar: Ganjam)

Remarks: Endemic to Assam.

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

5. *Liotelphusa gagei* **(Alcock, 1909)**

1909a. *Paratelphusa* (*Phricotelphusa*) *gageii* Alcock, Rec. Indian Mus., 3(3): 251(Sureil near Kurseong).

1910. *Paratelphusa* (*Phricotelphusa*) *gageii*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 105, pl. 13, fig. 26 (West Bengal: Kurseong, Darjeeling; Sikkim: S. E. Sikkim).

1970. *Liotelphusa laevis gagei*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 48, pl. 35, figs. 39-42 (Sikkim).

1998. *Liotelphusa laevis gagei*: Deb, Zool. Surv. India State Fauna Series 3: Fauna of West Bengal, Part 10: 385 (West Bengal – Darjeeling district: Kurseong. Sikkim).

2003. *Liotelphusa laevis gagei*: Roy, Ghosh and Ghatak, Zool. Surv. India State Fauna Series 9: Fauna of Sikkim, Part 5: 118 (South East Sikkim, no other data, information based on literature).

Type locality: Kurseong, 5,000 ft.

Habitat: River and small stream.

Distribution: West Bengal (Darjeeling, Sureil, Kurseong), Sikkim. **Abroad:** Bhutan.

Conservation Status: It is categorised as Near Threatened in IUCN Red List 2013.

Remarks: Restricted distribution in eastern Himalaya and Bhutan.

6. *Liotelphusa laevis* **(Wood-Mason, 1871)**

1871. *Telphusa laevis* Wood-Mason, J. Asiat. Soc. Bengal, 40: 201, pl. 14, figs. 1-6.

1910. *Paratelphusa* (*Liotelphusa*) *laevis*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2):109, pl. 13, fig. 65 (Assam: Cachar; Meghalaya: Shillong, Cherrapunji).

1970. *Liotelphusa laevis laevis*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 49, pl. 6, figs. 63-65, pl. 27, fig. 28 and pl. 33, figs. 17-20 (Sibsagar, Cherrapunji, Darjeeling and Naga Hills).

1999. *Liotelphusa laevis laevis*: Ghosh and Ghatak, Zool. Surv. India State Fauna Series 4: Fauna of Meghalaya, Part 9: 570 (Meghalaya – Khasi Hills: Cherrapunji; Mardphalang; Mawblong; Mawphlong; Mawpat; Shillong. Garo Hills: Tura near Debasipara hill stream).

2008. *Liotelphusa laevis laevis*: Zool. Surv. India Fauna of Kopili Hydro Electric Project Site, Wetland Ecosystem Series, 8:36, 37 (Assam - River Kopili).

Type locality: Cherrapunji (laevis). Sibsagar (quadrata).

Habitat: Hill Stream and Rivers

Distribution: Meghalaya: (Cherrapunji;) Assam: (Sibsagar) Nagaland; West Bengal: (Sureil, Darjeeling). **Abroad:** Bhutan

Conservation Status: It is categorised as Near Threatened in IUCN Red List 2013.

Remarks: Ristricted to Eastern Himalaya and Bhutan.

7. *Liotelphusa quadrata* **(Alcock, 1909)**

1909. *Paratelphusa* (*Liotelphusa*) *laevis* (Wood-Mason) var. quadrata Alcock, Rec. Indian Mus., 3(4): 377 (Assam, Meghalaya and Nagaland).

1910. *Paratelphusa* (*Liotelphusa*) *laevis* (Wood-Mason) var. quadrata:Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 110, fig. 28(Assam: Sibsagar, Goalpara; Meghalaya: Khasi Hills; Nagaland: Naga Hills).

Type locality: Sibsagar.

Habitat: Hill stream

Distribution: Meghalaya; Assam; Nagaland.

Conservation Status: It is categorised as Vulnerable in IUCN Red List 2013.

Remarks: Endemic to North-eastern states and as per IUCN it's a very threatened species.

Genus *Maydelliathelphusa* **Bott, 1969**

1969. *Barytelphusa* (*Maydelliathelphusa*) Bott, Senckenbergiana biol., 50: 361.

Type species: *Telphusa masoniana* Henderson, 1893, by original designation, gender: feminine.

8. *Maydelliathelphusa edentula* **(Alcock, 1909)**

1909. *Potamon lugubre edentula* Alcock, Rec. Indian Mus., 3(4): 247.

1909. *Paratelphusa* (*Barytelphusa*) *edentula*: Alcock, Rec. Indian Mus., 3: 376.

1910. *Paratelphusa* (*Barytelphusa*) *edentula*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 84, pl. 5, fig. 19 Assam: Sibsagar, Darbund Pass; Nagaland: Naga Hills).

1970. *Barytelphusa* (*Maydelliathelphusa*) *lugubris edentula*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 36, pl. 3, fig. 30-32; pl. 26, fig. 17 (Upper Assam; Naga Hills).

1983. *Paratelphusa* (*Barytelphusa*) *edentula*: Dutta, J. Bombay nat. Hist. Soc., 80(2): 539 (Assam– Kamrup district: Maligaon; Sibsagar district: Panbesa near Sibsagar; Lakhimpur district: Corella beel; Dibrugarh district: Dibrugarh).

Type locality: Assam: Sibsagar.

Habitat: Hill stream and River

Distribution: Upper Assam; Naga Hills, Mizoram. **Abroad:** Bhutan

Conservation Status: It is categorised as Near Threatened in IUCN Red List 2013.

Remarks: Restricted to Esatern Himalaya including Bhutan.

9. *Maydelliathelphusa falcidigitis* **(Alcock, 1910)**

1909a. *Potamon lugubre* var. *falcidigitus* Alcock, Rec. Indian Mus., 3(3): 248 (Cachar, Cherrapunji, Khasi Hills, Garo Hills and Naga Hills).

1910. *Paratelphusa* (*Barytelphusa*) *falcidigitis* Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 94, pl. 7, fig. 24 (Meghalaya: Cherrapunji, Khasi Hills).

1924. *Paratelphusa* (*Barytelphusa*) *falcidigitis*: Kemp, Rec. Indian Mus., 26: 41 (Common in the stream leading from cave mouth to the Someswari River).

1970. *Barytelphusa* (*Maydelliathelphusa*) *lugubris falcidigitis*: Bott, Abhandl. Sencken. Naturfors.Ges., 526: 35, pl. 34, fig. 29-32 (Ganjam, North Cachar; Dumpep, Khasi Hills).

1999. *Barytelphusa* (*Maydelliathelphusa*) *lugubris falcidigitis*: Ghosh and Ghatak, Zool. Surv. India State Fauna Series 4: Fauna of Meghalaya, Part 9: 571 (Meghalaya – New Tasku Village, Lailad, East Khasi Hills; Unsing

2008. *Barytelphusa* (*Maydelliathelphusa*) *lugubris falcidigitis*: Zool. Surv. India Fauna of Kopili Hydro Electric Project Site, Wetland Ecosystem Series, 8: 35, 36 (Assam - River Kopili).

Type locality: India - Naga Hills.

Habitat: Hill Rivers and streams.

Distribution: Assam, Meghalaya, Nagaland and Mizoram

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Remarks: Endemic to Eastern Himalaya

10. *Maydelliathelphusa harpax* **(Alcock, 1909)**

1909a. *Potamon lugubre* var. *harpax*: Alcock, Rec. Indian Mus., 3: 247 (Assam, Cachar, Khasi Hills, Garo Hills, Naga Hills, Sylhet).

1910. *Paratelphusa* (*Barytelphusa*) *harpax*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 95, pl. 7, fig. 25 (Assam: Cachar, Barak River near Silchar; Hill stream near Harmutti; Meghalaya: Khasi Hills, Garo Hills; Nagaland: Naga Hills).

1913. *Paratelphusa* (*Barytelphusa*) *harpax*: Kemp, Rec. Indian Mus., 8: 302 (Assam: near Sadiya).

1983. *Paratelphusa* (*Barytelphusa*) *harpax*: Dutta, J. Bombay nat. Hist. Soc., 80(2): 540, fig. 3(Assam – Sibsagar district: Puronipukhuri beel near Gurisagar; Lakhimpur district: North Lakhimpur; Dibrugarh district: Proper Dibrugarh).

Type locality: Nagaland

Habitat: Hill stream and river, Shallow water River bed.

Distribution: India – Assam, Meghalaya, Nagaland, Mizoram. **Abroad:** Bangladesh.

Conservation Status: It is categorised as Least Concern in IUCN Red List 2013.

Remarks: Mostly confined to the North eastern india and adjacent areas of Bangladesh.

11. *Maydelliathelphusa lugubris* **(Wood-Mason, 1871)**

1871. *Telphusa lugubris* Wood-Mason, J. Asiat. Soc. Bengal, 40(2): 197, pl. 12, fig. 5-7 (Sikkim: Pankabaree; Teesta Valley; Meghalaya: Cherrapunji).

1893. *Telphusa lugubris*: Henderson, Trans. Linn. Soc. Lond. Zool., (2), 5: 381(Environs of 'Calcutta'. Labelled as Telphusa indica and were collected possibly from Himalayas).

1909a. *Potamon lugubre* var. *nigerrimum*: Alcock, Rec. Indian Mus., 3: 247 (North Lushai).

1909a. *Potamon lugubre* var. *plantum*: Alcock, Rec. Indian Mus., 3: 247 (Assam and Khasi Hills).

1910. *Paratelphusa* (*Barytelphusa*) *lugubre*: Alcock, Rec. Indian Mus., 3: 376.

1910. *Paratelphusa* (*Barytelphusa*) *lugubris*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 91, pl. 12, fig. 58 (Meghalaya: Cherrapunji, Garo Hills; Dafla Hills; Manipur Hills; West Bengal: Teesta Valley, Punkabari; Sikkim).

1910. *Paratelphusa* (*Barytelphusa*) *lugubris nigerrima*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 93 (Changsil, North Ludhai).

1910. *Paratelphusa* (*Barytelphusa*) *lugubris plauta*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 93, pl. 6, fig. 23 (Sibsagar, Khasi Hills, Naga Hills).

1970. *Barytelphusa* (*Maydelliathelphusa*) *lugubris lugubris*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 34, pl. 3, fig. 24-26; pl. 26, fig. 15 (Naga Hills; Garo Hills; North India; Kolkata: Assam, North Lushai, Changil).

1998. *Barytelphusa* (*Maydelliathelphusa*) *lugubris lugubris*: Deb, Zool. Surv. India State Fauna Series 3: Fauna of West Bengal, Part 10: 387 (West Bengal – Darjeeling district: Kalimpong, Darjeeling, Teesta Valley; Jalpaiguri district: Mahananda river, Siliguri).

1999. *Barytelphusa* (*Maydelliathelphusa*) *lugubris lugubris*: Ghosh and Ghatak, Zool. Surv. India State Fauna Series 4: Fauna of Meghalaya, Part 9: 572 (Meghalaya – West Garo Hills: Phulbari, Rangui River; Mahadeo River, Mahadeo; Bogai River; Siju Cave; North East of Barangapara; Rangranchidekgray near Williamnagore; Balat; Chinabat; Nengkhra Crossing; Bogai River; Tura; Dobasipara near hillstream and Valleysite; Jakrem River near hotspring. Khasi Hills: Norblong Village near Byrnihat; Shillong. Kyrdemkulai stream; Kyrdemkulai Dam, No. 1, Damside; Synrangmmanarati River; Mawmai Cave and Mawluh, Cherrapunjee;. Jayantia Hills: Jowai-Chongpung, Bridle Path; Stream near Mawlyngkneng; Jowai stream, Jowai; Garampani; Kollasiv).

2000. *Barytelphusa* (*Maydelliathelphusa*) *lugubris lugubris*: Ghosh and Ghatak, Zool. Surv. India State Fauna Series 7: Fauna of Tripura, Part 4: 274 (Tripura – North Tripura: Jumpoi Hills: Fuldungsei, Vangmun, Subal Lake; Salema; Boruma).

2003. *Barytelphusa* (*Maydelliathelphusa*) *lugubris lugubris*: Roy, Ghosh and Ghatak, Zool. Surv. India State Fauna Series 9: Fauna of Sikkim, Part 5: 117 (North Sikkim – Namak; Singhik; Phodong; Mamul. East Sikkim: Pakyong; Singham; Panyong. South Sikkim: Manpur Village, Mohanpur Village, Mantur Village, Rollu Village, Damthang).

2004. *Barytelphusa* (*Maydelliathelphusa*) *lugubris lugubris*: Roy, Ghosh and Ghatak, Zool. Surv. India State Fauna Series 10: Fauna of Manipur, Part 3: 122 ((Manipur – Maram and Karong, Dist. Senapati; Loktak Lake; Bishnupur; Keibul-Lamjao; Thanga, Moirang).

2008. *Barytelphusa* (*Maydelliathelphusa*) *lugubris lugubris*: Zool. Surv. India Fauna of Kopili Hydro Electric Project Site, Wetland Ecosystem Series, 8:36 (Assam - River Kopili).

Type locality: Sikkim, Pankabaree, Altitude 200ft.

Habitat: River bed, but this crab are used to live in holes beside the rivers in to dense forest area also.

Distribution: West Bengal, Sikkim, Meghalaya, Manipur, Assam, Nagaland, Bihar and Mizoram

Abroad: Bangladesh, Bhutan and Nepal.

Conservation Status: It is categorised as Least Concern in IUCN Red List 2013.

Remarks: Widely distributed in Eastern Himalaya and adjacent Countries, very possibly it my also distributed in Myanmar. It's the most frequently higly priced edible crab in North-east Indian states.

12. *Maydelliathelphusa masoniana* **(Henderson, 1893)**

1893. *Telphusa masoniana* Henderson, Trans. Linn. Soc. Lond. Zool., (2), 5: 381(River Jumna; North-West Provinces).

1904. *Potamon* (*Potamon*) *masonianus*: Rathbun, Nouv. Arch. Mus., sér. 4, 6: 299, pl. 11, fig. 10 (Himalayas).

1910. *Paratelphusa* (*Barytelphusa*) *masoniana*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 96, pl. 12, fig. 59 (Uttar Pradesh: Hardwar, Saharanpur, Dehra Dun, Naini Tal and Rurki; Bihar: Darbhanga; Bijnor).

1970. *Barytelphusa* (*Maydelliathelphusa*) *lugubris masoniana*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 36, pl. 3, figs. 27-29, pl. 26, fig. 16 (Nishangal, North India; Sikkim; Ringrengiri, Meghalaya).

1995. *Paratelphusa* (*Barytelphusa*) *masoniana*: Krishnamurthy, Zool. Surv. India Himalayan Ecosystem Series, Part 1, Uttar Pradesh: 23.

Type locality: North India - River Jamuna (Henderson).

Habitat: River and hill stream.

Distribution: Assam, Bihar, Chattisgarh, Sikkim, Meghalaya, Himachal Pradesh, Uttaranchal, Uttar Pradesh and Jammu and Kashmir.

Conservation Status: It is categorised as Least Concern in IUCN Red List 2013.

Remarks: Endemic to India. Common in Both the Esatern and Western part of Himalayas. This species is also distributed in Terai region of Himalayan foot hills.

Genus *Travancoriana* **Bott, 1969**

1969. *Travancoriana* Bott, Senckenbergiana. biol., 50(5/6): 361.

Type species: *Travancoriana schirnere* Bott, 1969, by original designation, gender: feminine.

13. *Travancoriana napaea* **(Alcock, 1909)**

1909a. *Potamon napaeum* Alcock, Rec. Indian Mus., 3(3): 248 (Ganjam, North Cachar, 4000 ft.)

1909b. *Paratelphusa* (*Barytelphusa*) *napea*: Alcock, Rec. Indian Mus., 3(4): 376.

1910. *Paratelphusa* (*Barytelphusa*) *napaea*: Alcock, Cat. Indian Decapod Crust. Indian Mus. 1(2): 85, pl. 5, fig. 20 (Assam: Ganjam, North Cachar).

Type locality: India: Assam - Ganjam, North Cachar.

Habitat: Unknown.

Distribution: Assam.

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Remarks: Endemic to Assam. Thre is not any collection of this species after Alcock, 1909.

Genus *Sartoriana* **Bott, 1969**

1969. *Sartoriana* Bott, Senckenbergiana biol., 50: 361.

Type species: *Paratelphusa* (*Paratelphusa*) *spinigera* Wood-Mason, 1871, by original designation, gender: feminine.

14. *Sartoriana spinigera* **(Wood-Mason, 1871)**

1871. *Paratelphusa spinigera* Wood-Mason, J. Asiat. Soc. Bengal, 40(2): 194, pl. 10, figs. 1-4 (Museum Tank of Calcutta).

1876. *Paratelphusa spinigera*: Wood-Mason, Ann. Mag. nat. Hist., ser. 4, 17: 121, 122.

1893. *Paratelphusa spinigera*: Henderson, Trans. Linn. Soc. Lond. Zool., (2), 5: 386 (Calcutta, Roorke, Ganjam, North-West Provinces, Sind).

1910. *Paratelphusa* (*Paratelphusa*) *spinigera*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 72, pl. 11, fig. 53.(West Bengal: Kolkata; Assam: Balaganj, Cachar; Bihar: Darbhanga, Kissenganj: Orissa: Sur Lake, Puri District; Punjab: Safed-bein Canal, Jullunder District; Uttar Pradesh: Hardwar, Saharanpur; Kashmir: Khewrah Gorge, Jhelum District).

1970. *Sartoriana spinigera*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 39, pl. 4, figs. 35-37; pl. 26, fig. 18.

1999. *Sartoriana spinigera*: Ghosh and Ghatak, Zool. Surv. India State Fauna Series 4: Fauna of Meghalaya, Part 9: 575 (Meghalaya – Khasi Hills: Umiam. Garo Hills: Phulbari, Rangai River; Damra bazaar).

1998. *Sartoriana spinigera*: Deb, Zool. Surv. India State Fauna Series 3: Fauna of West Bengal, Part 10: 387 (West Bengal – Kolkata, Pulta, Chinsura, Raigunj, Dinajpur, Jalpaiguri, Coochbihar).

1983. *Paratelphusa* (*Paratelphusa*) *spinigera*: Dutta, J. Bombay nat. Hist. Soc., 80(2): 544, fig. 5 (Assam-Goalpara district: Dipo; Kamrup district: Kukurmara beel, Lankeswar dhum near Jalukbari, Boko, Bebejapara near Bozali, Bhulukmara beel near Amingaon, Durmari beel near Chetoli, Gogiakur near River Saulkhua, Mongoldoi, Kali Kuchi, River Kulsi; Nowgong district: Hapakati beel near Morigaon; Karbi-Anglong district: River Jamuna; Cachar district: River Karimganj;

Sibsagar district: Nawpukhuri beel, River Namdang near Joysagar, Jorhat, Golaghat, Bokakhat, Gorisagar, Sunari; Lakhimpur district: Pohumara near Singar, North Lakhimpur; Dibrugarh district).

2000. *Sartoriana spinigera*: Ghosh and Ghatak, Zool. Surv. India State Fauna Series 7: Fauna of Tripura, Part 4: 273 (Tripura – North Tripura: Dharmanagar: Birjanagar, Kadamtala, Kanchanpur, Bagon; Bormara; Khusdinpara Chamanu Road; Manubari; Gerania; Champak Nagar. South Tripura: Kamalcherra River, Dullubari; Surmai River, South of Gondacherra; Dhanyasagar, Udaipur. West Tripura: Asrambari).

2008. *Sartoriana spinigera*: Zool. Surv. India Fauna of Kopili Hydro Electric Project Site, Wetland Ecosystem Series, 8:36, 37 (Assam - River Kopili).

Type locality: Bangladesh: Jessore district.

Habitat: Freshwater Ponds, bill, canals, Paddyfield and wetland area.

Distribution: India: Meghalaya;Uttar Pradesh:(Sharanpur) Uttarakhand (Hardwar) Punjab; Orissa (Puri district) ; West Bengal:(All districts of the plain area;) Assam: (Cachar; Bihar: Darbhanga,) Bihar (Kissenganj); Tripura, Mizoram, Nagaland, Jharkhand.

Abroad: Bangladesh, Pakistan, Sri Lanka, Myanmar

Conservation Status: It is categorised as Least Concern in IUCN Red List 2013.

Remarks: Appears as the most widely distributed and highly populated crab of the northern part of India. It's an edible species and consumed by the local people very frequently.

15. *Sartoriana trilobata* **(Alcock, 1909)**

1909. *Paratelphusa* (*Paratelphusa*) *trilobata*: Alcock, Rec. Indian Mus., 3: 375 (Assam – Sibsagar).

1910. *Paratelphusa* (*Paratelphusa*) *trilobata*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 74, pl. 11, fig. 15 (Assam: Sibsagar).

Type locality: Sibsagar.

Habitat: unknown

Distribution: India – Assam.

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Remarks: Endemic to Assam. Known from its type locality only. No further collection of this crab was made after Alcock, 1909. This species was erected on the basis of single female example.

Genus *Sommaniathelphusa* **Bott, 1968**

1853. *Parathelphusa* H. Milne Edwards, Ann. Sci. nat. (Zool.), 3, 20: 213 (in partim).

1871. *Paratelphusa*: Wood-Mason, J. Asiat. Soc. Bengal, 40(2): 213 (in partim).

1968. *Sommaniathelphusa* Bott, Senckenbergiana biol., 49: 407

Type species: *Parathelphusa sinensis* H. Milne Edwards, 1853, by original designation, gender: feminine.

16. *Sommaniathelphusa sinensis* **(H. Milne Edwards, 1853)**

1853. *Parathelphusa sinensis* H. Milne Edwards, Ann. Sci. nat. (Zool.), 3, 20: 213.

1983. *Paratelphusa* (*Paratelphusa*) *sinensis*: Dutta, J. Bombay nat. Hist. Soc., 80(2): 540, fig. 4 (Kamrup district: R. Pagladia near Uttarkuchi; Darrang district: Proper Tezpur; Karbi Anglong district: Proper Diphu).

1970. *Sommanniathelphusa sinensis sinensis*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 111, pl. 20, figs. 42-44 and pl. 30, fig. 81.

Type locality: China.

Habitat: Freshwater pond and Wet land.

Distribution: India - Assam.

Abroad: China, Hong Kong. So far recorded from Assam of India.

Conservation Status: In IUCN conservation list it it categorized as Data Deficient.

Remarks: This species is reported for first time by Dutta from different parts of Assam from India. There are no records of this species after Dutta, 1983.

Family Potamidae Ortmamm, 1896

1838. Thelphusidae MacLeay: [priority suppressed, ICZN plenary powers (Opinion 712].
1896. Potamoninae Ortmann, Zool. Jb. (Syst.), 9: 445.
1896. Potamidae Ortmann: [spelling corrected from Potamonidae Ortmann, 1896, and name given priority over Thelphusidae under ICZN plenary powers) [Opinion 712].
1970. Potamiscinae Bott: Abhandl. Sencken. Naturfors. Ges., 526: 157.
1970. Sinopotamidae Bott: Revue Suisse (Zool.), 77: 333.
1970. Isolapotamidae Bott: Revue Suisse (Zool.), 77: 333.

Subfamily Potaminae Ortmann, 1896

1838. Thelphusidae MacLeay: [priority suppressed ICZN plenary powers (Opinion 712].
1896. Potamoninae Ortmann, Zool. Jb. (Syst.), 9: 445.
1896. Potamidae Ortmann: [spelling corrected from Potamonidae Ortmann, 1896, and name given priority over Thelphusidae under ICZN plenary powers) [Opinion 712].

Remarks: The main character of this subfamily is a transverse ridge on the joint of the 7th and 8th thorasic sternite in the longitudinal median line of the abdominal cavity. (Yeo and Ng, 2007)

Genus *Acanthopotamon* Kemp, 1918

1910. *Potamon* (*Acanthotelphusa*): Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 61.

1918. *Potamon* (*Acanthopotamon*) Kemp, Rec. Indian Mus., 14: 101.

2007. *Acanthopotamon*: Yeo and Ng, Raffles Bull. Zool., Supplement, 16: 274.

Type species: *Paratelphusa martensi* Wood-Mason, 1875, by original designation.

17. *Acanthopotamon fungosum* (Alcock, 1909)

1909a. *Potamon* (*Paratelphusula*) *fungosum* Alcock, Rec. Indian Mus., 3(3): 250 (Cachar).

1910. *Potamon* (*Acanthopotamon*) *fungosum*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 65, fig. 12 (Assam: Cachar).

Type locality: Assam.

Habitat: Water falls

Distribution: India - Assam. (Darband Pass, Cachar, Assam);

Abroad: Thailand (Phangnga Province).

Conservation Status: It is categorised as Data Deficient IUCN Red List 2013.

Remarks: This species seems to be rare in India.

18. *Acanthopotamon martensi* **(Wood-Mason, 1875)**

1875. *Paratelphusa martensii* Wood-Mason, Proc. Asiat. Soc. Bengal: 230 (Throughout the Gangetic valley from Hardwar to Jessore(Bangladesh).

1876. *Paratelphusa martensii*: Wood-Mason, Ann. Mag. nat. Hist., 4, 17: 121, 122 (North India: Hardwar, Purneah, Allahabad).

1893. *Paratelphusa martensii*: Henderson, Trans. Linn. Soc. Lond. Zool., 2, 5: 386 (Roorke, North-West Provinces).

1910. *Potamon* (*Acanthotelphusa*) *martensi*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 68, pl. 11, fig. 52 (West Bengal: Baranagar and Santipur near Kolkata; Bihar: Purnea, Kissengunj, Darbhanga; Uttar Pradesh: Lucknow, Roorke; Abjulgar, Bijnor).

1970. *Acanthopotamon martensi*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 145, pl. 38, fig. 22and pl. 45, fig. 20 (Terai, Nishangar; Ganges Banaras).

1998. *Acanthopotamon martensi*: Deb, Zool. Surv. India State Fauna Series 3: Fauna of West Bengal, Part 10: 382 (West Bengal - Baranagar near Kolkata; Kasai canal, Midnapore; Teesta River at Jalpaiguri).

1999. *Acanthopotamon martensi*: Ghosh and Ghatak, Zool. Surv. India State Fauna Series 4: Fauna of Meghalaya, Part 9: 571(Meghalaya - West Garo Hills: Willamnagore. Muktapur Road, Dawki).

Type locality: Jessore, Bangaladesh.

Habitat: Reiverine crabs.

Distribution: Assam, Meghalaya; Arunachal Pradesh; Bihar; Uttar Pradesh; Uttarakhand; West Bengal; Rajasthan;

Abroad: Bangladesh, Myanmar.

Remarks: Throughout the Gangetic valley down to Calcutta where brackishwater conditions sustained and where it occurred both in fresh and brackishwater like several of its congeners (Wood-Mason, 1875).

Conservation Status: It is categorised as Least Concern in IUCN Red List 2013.

Genus *Alcomon* **Yeo and Ng, 2007**

2007. *Alcomon* Yeo and Ng, Raffles Bull. Zool., Supplement, 16: 275.

Type species: *Potamon* (*Geothelphusa*) *superciliosum* Kemp, 1913 by Yeo and Ng in Raffles Bull. Zool., Supplement, 16: 275 (2007) by original designation.

19. *Alcomon lophocarpus* **(Kemp, 1913)**

1913. *Potamon* (*Geotelphusa*) *adiatretum* var. *lophocarpus* Kemp, Rec. Indian Mus., 8: 300, pl. 18, figs. 15-18 (Upper Rotung; Egar stream between Renging and Rotung; Lalek stream near Renging; neighbourhood of Rotung; 3 miles south of Yembung; Sipro valley between Janakmukh and Renging; stream near Balek).

2007. *Alcomon lophocarpus*: Yeo and Ng, Raffles Bull. Zool., Supplement, 16:

Type locality: Small stream between 2 and 3 miles of South of Yembung (Arunachal Pradesh)

Habitat: Hill stream

Distribution: Rotung, Renging, Balek area of Arunachal Pradesh.

Conservation Status: It is categorised as Least Concern in IUCN Red List 2013.

Remarks: This species also collected by Kemp, 1913; after that it was not collected till date. It is endemic to Arunachal Pradesh of India.

20. *Alcomon superciliosum* **(Kemp, 1913)**

1913. *Potamon* (*Geotelphusa*) *superciliosum* Kemp, Rec. Indian Mus., 8: 300, pl. 18, figs. 15-18 (Yembung River; Eager stream between Renging and Rotung; stream near Balek).

2007. *Alcomon superciliosum*: Yeo and Ng, Raffles Bull. Zool., Supplement, 16: 303.

Type locality: A stream near Balek (Arunachal Pradesh)

Habitat: Hill stream and River of the altitude of 600 ft to 2000ft.

Distribution: Yembung, Rotung, Balek (Arunachal Pradesh)

Abroad: Myanmar (Mainland)

Remarks: The presnt author collected this species from Namdapha Biosphere Reserve of Arunachal Pradesh and also from Mizoram.

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Genus *Himalayapotamon* **Pretzmann, 1966**

1966. *Potamon* (*Himalayapotamon*) Pretzmann, Annln. Naturh. Mus. Wien, 69:

Type species: *Telphusa atkinsonianum* Wood-Mason, 1871, by original designation, gender: neuter.

21. *Himalayapotamon ambivium* **(Alcock, 1909)**

1909a. *Potamon* (*Potamon*) *atkinsonianum* var. ambivium: Alcock: Rec. Indian Mus., 3(3): 243 (Dharampur near Simla, 5,000 ft.).

1910. *Potamon* (*Potamon*) *atkinsonianum* var. *ambivium*: Alcock: 30 (Himachal Pradesh, Dharampur, Simla, 5000 ft.).

Type locality: Simla (Himachal Pradesh)

Habitat: Hill stream

Distribution: Himachal Pradesh

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Remarks: Endemic to Himachal Pradesh; so far no other speciemens were collected beside the type species.

22. *Himalayapotamon atkinsonianum* **(Wood-Mason, 1871)**

1871. *Telphusa atkinsonianum* Wood-Mason, J. Asiat. Soc. Bengal, 40: 205, pl. 14, figs. 12-16.

1893. *Telphusa atkinsoniana*: Henderson, Trans. Linn. Soc. Lond. Zool., ser. 2, 5: 385 (Kangra, Simla).

1904. *Potamon* (*Potamon*) *atkinsonianum*: Rathbun, Nouv. Arch. Mus, sér. 4, 6: 271[in partim].

1909a. *Potamon* (*Potamon*) *atkinsonianum* var. *ventriosum*: Rec. Indian Mus., 3(3): 244 (Kumaon, about 6,000 ft., probably an aberrant individual).

1910. *Potamon* (*Potamon*) *atkinsonianum*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 26, pl. 10, fig. 39.

1910. *Potamon* (*Potamon*) *atkinsonianum* var. *ventriosum*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 29.

1970. *Potamon atkinsonianum*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 140, pl. 37, figs. 14, 15 and pl. 44, fig. 13.

1975. *Potamon atkinsonianum*: Sharma, J. Bombay nat. Hist. Soc., 72(1): 223 (Kashmir: Poonch Valley).

Type locality: Sikkim.

Habitat: Hill streams connected with Rivers.

Distribution: West Bengal, Sikkim, Himachal Pradesh, Kashmir.

Conservation Status: It is categorised as Least Concern in IUCN Red List 2013.

Remarks: Though this species is reported from Eastern Himalaya and as well as Western Himalaya but this species is actually occurs in Eastern Himalaya only (Brandis,2001), as it is very close to *H. emphyseteum*, there are many chance to miss identify this species with the later ones.

23. *Himalayapotamon babaulti* **(Bouvier, 1918)**

1918. *Potamon babaulti* Bouvier, Bull. Mus. Hist. Nat., 24: 392 (Western Himalayas).

Type locality: Western Himalayas.

Habitat: Unknown

Distribution: Only reported from Himachal Pradesh. No collection has been made after type.

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Remarks: There is no collection of this species after 1918.

24. *Himalayapotamon emphyseteum* **(Alcock, 1909)**

1909a. *Potamon* (*Potamon*) *atkinsonianum* var. *emphyseteum* Alcock, Rec. Indian Mus., 3(3): 243 (Punjab Himalayas at Bilaspur and Kangra).

1966. *Potamon* (*Himalayapotamon*) *atkinsonianum gordoni* Pretzmann, Annln. Naturh. Mus. Wien, 69: (Himalaya).

1970. *Potamon emphysetum*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 141, pl. 37, fig. 17 and pl. 44, fig. 15 (Himachal Pradesh: Dharampur, Simla, Aurkhad, Hari Talyangar).

Type locality: Bilaspur and Kangra, Himachal Pradesh

Habitat: Hill stream, Bowri and Rivers.

Distribution: Punjab, Himachal Pradesh, Jammu and Kashmir.

Conservation Status: It is categorised as Least Concern in IUCN Red List 2013.

Remarks: This species is abundant in Western Himalaya.

25. *Himalayapotamon kasaulis* **(Pretzmann, 1966)**

1966. *Potamon* (*Himalayapotamon*) *koolense kasauli* Pretzmann, Annln. Naturh. Mus. Wien, 69: (Himachal Pradesh, former Punjab).

Type locality: Kasauli (Near Simla), Himachal Pradesh.

Habitat: Not recorded.

Distribution: Only at Kasauli (Himachal Pradesh)

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Remarks: No further collection after type.

26. *Himalayapotamon kooloonense* **(Rathbun, 1904)**

1904. *Potamon* (*Potamon*) *kooloonense* Rathbun, Nouv. Arch. Mus., sér. 4, 6: 270, pl. 10, fig. 1 (North India: Kooloo Valley).

1910. *Potamon* (*Potamon*) *kooloonense*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 24, pl. 10, fig. 38 (Himachal Pradesh: Simla, Dharamsala, 4000-5000 ft.; Uttarakhand: Ramnee (Garwhal), Bhim Tal (Kumaon), Naini Tal; Uttar Pradesh: Hazara; River Ravi, Chamba; Nepal Terai; Afghanistan).

1966. *Potamon* (*Himalayapotamon*) *koolense kausalis* Pretzmann, Entom. Nadhr.-Bl., 13: 4.

1966. *Potamon* (*Himalayapotamon*) *koolense kausalis* Pretzmann, Ann. nat. Mus. Wien, 69: 300, pl. 3, fig. 9-11.

1970. *Potamon kooloonense*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 143, pl. 38, fig. 19 and pl. 45, fig. 17 (Simla; Tons River, 3600 m; Molta; Kooloo;).

1999. *Potamon kooloonense*: Ghosh, H.C and Ghatak, S.S. fauna of Meghalaya. Part 9, 569-570. (Meghalaya: Macesphlang forest hills).

Type locality: Kooloo Valley, Himachal Pradesh.

Habitat: Bowri, Hill Stream.

Distribution: India - Uttar Pradesh, Uttarakhand, Himachal Pradesh; West Bengal (Darjeeling), Meghalya, Sikkim.

Abroad: Afghanistan, Nepal.

Conservation Status: It is categorised as Least Concern in IUCN Red List 2013

Remarks: One of the most common species of the western Himalayas.

27. *Himalayapotamon monticola* (Alcock, 1910)

1910. *Potamon* (*Potamon*) *fluviatile* var. *monticola*, Wood-Mason (name only) or *Potamon ibericum* var. *monticola*: 23 (Khasi Hills; Darjeeling Hills).

Type locality: Darjeeling, West Bengal.

Habitat: Rivers and Streams

Distribution: Darjeeling (W.B); Khasi Hills (Meghalya).

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

28. *Himalayapotamon bifarium* (Alcock, 1910)

1910. *Potamon* (*Potamon*) *bifarium* Alcock Cat. Indian Decapod Crust. Indian Mus., 1(2): 30-31, pl.1, fig. 3.

Type locality: Sikkim or Myanmar.

Habitat: Unknown

Distribution: Sikkim/Myanmar

Remarks: The distribution of this species still debatable, as this species was described from a single specimen that was labeled as Sikkim or Burma.

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Genus *Lobothelphusa* Bouvier, 1917

1917. *Hydrothelphusa* (*Lobothelphusa*) Bouvier, C. R. Acad. Sci. nat. Paris, 165: 620 (in partim).

Type species: *Paratelphusa crenulifera* Wood-Mason, 1875, by subsequent designation by Bott, 1970, Gender: Masculine.

29. *Lobothelphusa wood-masoni* (Rathbun, 1905)

1905. *Potamon* (*Paratelphusa*) *woodmasoni*: Rathbun, Nouv. Arch. Mus., sér. 4,7:262, pl. 12, fig. 2.

1875. *Paratelphusa edwardsi*: Wood-Mason, Proc. asiat. Soc. Bengal, 231.

1876. *Paratelphusa edwardsi*: Wood-Mason, Ann. Mag. nat. Hist., (4) 17: 121.

1898. *Parathelphusa edwardsi*: De Man, Ann. Mus. civ. Stör. nat. Genova, 19: 438.

1905. *Potamon* (*Parathelphusa*) *woodmasoni*: Rathbun, Nouv. Arch. Mus., (4) 7: 262, T. 12 F.12.

1909a. *Paratelphusula milneedwardsi*: Alcock, Rec. ind. Mus., 3: 250.

1909b. *Paratelphusula woodmasoni*: Alcock, Rec. ind. Mus., 3: 250.

1910. *Paratelphusa wood-masoni*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 63, pl.11, fig. 50 (Meghalaya - Garo Hills; Assam - Sibsagar).

1966. *Potamon* (*Spinopotamon*) *crenuliferum woodmasoni*, Bott, Senckenbergiana biol., 47: 477, Abb. 11.

1970. *Lobothelphusa wood-masoni*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 149, pl. 38, fig. 26 and pl. 46, fig. 24 (Meghalaya: Garo hills)

Type locality: Garo Hills, Meghalaya.

Habitat: Hill stream, Terrestrial.

Distribution: Assam, Tripura, Meghalya and Mizoram.

Abroad: Bangladesh, Myanmar.

Conservation Status: It is categorised as Least Concern in IUCN Red List 2013.

Remarks: As per IUCN species evaluation committee it's categorized as Least Concern in view of its wide distribution, presumed large population, and because it is unlikely to be declining fast enough to qualify for listing in a more threatened category. But in reality its population is declining and it need to revise its position in conservation categories.

Subfamily Potamiscinae Bott, 1970

In this subfamily there is no transverse ridge between the 7th and 8th thorasic sternite in the longitudinal midlines of the abdominal cavity (Yeo and Ng 2007).

Genus *Eosamon* Yeo and Ng, 2007

2007. *Eosamon* Yeo and Ng, Raffles Bull. Zool., Supplement, 16: 281.

Type species: *Potamon* (*Potamon*) *smithianum* Kemp, 1923, subsequent designation by Yeo and Ng in Raffles Bull. Zool., Supplement, 16: 281.

30. *Eosamon tumidum* (Wood-Mason, 1871)

1871. *Telphusa tumida* Wood-Mason, J. Asiat. Soc. Bengal, 40(2): 453, pl. 27, figs. 6-10.

1910. *Potamon* (*Potamon*) *tumidum*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 41, pl. 10, fig. 45 (West Bengal: ? Darjeeling).

1970. *Potamiscus tumidus*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 161, pl. 38, fig. 32 and pl. 51, fig. 52.

1998. *Potamiscus tumidus*: Deb, Zool. Surv. India State Fauna Series 3: Fauna of West Bengal, Part 10: 387 (West Bengal – Darjeeling district: Darjeeling).

Type locality: Jünnan, Hotha.

Habitat: Hill stream

Distribution: India – Darjeeling Districts of West Bengal. Himachal Pradesh.

Abroad: - China (Yunnan); Myanmar (Myanmar (mainland).

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Remarks: Dev Roy and Mitra (2013) reported it from Himachal Pradesh.

Genus *Aspermon* **Yeo and Ng, 2007**

31. *Aspermon feae* **Rathbun, 1905**

1898. *Paratelphusa feae* DE MAN, Ann. Mus. civ. Stör. nat. Genova, (2) 19: 393, T. 4 F. 3.

1905. *Potamon* (*Parathelphusa*) *feae*: Rathbun, Nouv. Arch. Mus., (4) 7: 241.

1910. *Potamon* (*Acanthotelphusa*) *feae*: Alcock, Cat. Indian Decapod Crust. Indian Mus.,1 (2): 66, T. 11 F. 51

1913. *Potamon* (*Acanthotelphusa*) *feae*: Kemp, Rec. ind. Mus., 8: 301.

Type locality: Upper Irrawaddy, Myanmar

Habitat: Hill stream and River.

Distribution: India – Assam, Arunachal Pradesh, Mizoram (Present Record).

Abroad: Myanmar (Upper Irrawaddy River, Teinzo)

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Genus *Indochinamon* **Yeo and Ng, 2007**

2007. *Indochinamon* Yeo and Ng, Raffles Bull. Zool., 16: 282.

Type species: *Potamon villosum* Yeo and Ng, 1998, by subsequent designation by Yeo and Ng in Raffles Bull. Zool., 16: 282.(2007).

32. *Indochinamon andersonianum* **(Wood-Mason, 1871)**

1871. *Telphusa andersoniana* Wood-Mason, J. Asiat. Soc. Bengal, XL (2): 451, pl. 27, figs. 16-29.

1910. *Potamon* (*Potamon*) *andersonianum*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 32, pl. 10, fig. 40.

1970. *Potamon andersonianum*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 142, pl. 37, figs. 16 and pl. 44, fig. 14.

2003. *Potamon andersonianum*: Roy, Ghosh and Ghatak, Zool. Surv. India State Fauna Series 10: Fauna of Manipur, Part 3: 122 ((Manipur Hills. No specimen other than the collection of H. H. Godwin-Austein).

Type locality: Upper Hills, Kakhyien Hills, Ponsee.

Habitat: Hill stream

Distribution: India - Manipur. **Abroad:** Myanmar, China.

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Remarks: It's rare in India.

33. *Indochinamon asperatum* **(Alcock, 1909)**

1909a. *Potamon* (*Potamon*) *andersonianum asperatum* Alcock, Rec. Indian Mus., 3: 244 (Assam: Ganjam in Cachar Hills, 4,000 ft.).

1910. *Potamon* (*Potamon*) *andersonianum asperatum*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 35 (Assam: Ganjam, Cachar Hills, 4000 ft.).

1910. *Potamon* (*Potamon*) *andersonianum* var. *asperatum*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 35 (Ganjam Hills, about 1,000 ft.).

2007. *Indochinamon asperatum*: Yeo and Ng, Raffles Bull. Zool., Supplement, 16: 304.

Type locality: Assam.

Habitat: Freshwater but microhabitat is unknown.

Distribution: India – Assam

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Remarks: Endemic to Assam.

34. *Indochinamon beieri* **(Pretzmann, 1966)**

1966. *Potamon beieri* Pretzmann, Annln. Naturh. Mus. Wien, 69: (Himalayas).

1904. *Potamon* (*Potamon*) *rangoonense* Rathbun, Nouv. Arch. Mus. Hist. nat., 4, 6: 279, pl. 11, fig. 2, Abb. 18a-c [Opinion 1640].

1910. *Potamon* (*Potamon*) *andersonianum rangoonense*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 34, fig. 41.

1970. *Ranguna* (*Ranguna*) *rangoonensis*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 163, pl. 38, fig. 35 and pl. 47, fig. 31 (Assam; Naga Hills).

Type locality: Sukli, E.side of Dawane Hills, 1200 ft (Myanmar).

Habitat: Hill stream

Distribution: Assam, Nagaland, Mizoram. **Abroad:** Myanmar

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Remarks: On a recent survey by the present author it seems that this species is quite common in Mizoram and it's a highly economic edible species in that area.

35. *Indochinamon edwardsi* **(Wood-Mason, 1871)**

1875. *Paratelphusa edwardsi* Wood-Mason, Proc. Asiat. Soc. Bengal: 231(Cachar, Sadya and the Garo hills, Naga and Dafla hills).

1876. *Paratelphusa edwardsi*: Wood-Mason, Ann. Mag. nat. Hist., 4, 17: 121.

Type locality: Cachar, Sadya and the Garo hills, Naga and Dafla hills

Habitat: Hillstream and river

Distribution: India - Assam, Meghalaya, and Nagaland.

Abroad: Myanmar

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

36. *Indochinamon manipurense* **(Alcock, 1909)**

1909a. *Potamon* (*Potamon*) *andersonianum manipurense*: Alcock, Rec. Indian Mus., 3: 244 (Manipur Hills).

1910. *Potamon* (*Potamon*) *andersonianum manipurense*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 35, pl. 14, fig. 68 (Manipur Hills).

1910. *Potamon* (*Potamon*) *andersonianum* var. *manipurense*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 35 (Manipur Hills).

Type locality: Manipur Hills.

Habitat: River and hill stream

Distribution: Manipur.

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Remarks: Endemic to Manipur.

Genus *Larnaudia* **Bott, 1966**

37. *Larnaudia larnaudii* **(A. Milne Edwards, 1869)**

1869. *Thelphusa larnaudii*: A. Milne Edwards, Nouv. Arch. Mus., 5: 166, pl. 10, fig. 4.

1893. *Thelphusa larnaudii*: Henderson, Trans. Linn. Soc. Lond. Zool., 2, 5: 385.

1900. *Potamon larnaudii*: Doflein, S.-B.math.-phys. Cl. Akad. Wiss. München, 1900: 140 [in partim] (Simla, Himalaya and Kolkata).

1905. *Potamon* (*Potamon*) *larnaudii*: Rathbun, Nouv. Arch. Mus., sér. 4, 6: 275, pl. 10, fig. 7.

1910. *Potamon* (*Potamon*) *larnaudii*: Alcock, Cat. Indian. Decapod Crust. Indian Mus., 1(2): 47.

1970. *Larnaudia larnaudii*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 175, pl. 39, fig. 50 and pl. 50, fig. 46.

Type locality: Bangkok.

Habitat: Freshwater

Distribution: India – West Bengal (?); Himachal Pradesh.

Abroad: Thailand (Bangkok, Cochinchina, Mois Chero).

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Remarks: According to Alcock (1910) this species does not occur in British India. However, he included the same in the Catalogue of Indian Decapod Crustacea as other authors reckoned it as Indian.

Genus *Potamiscus* **Alcock, 1909**

1909. *Potamon* (*Potamiscus*) Alcock, Rec. Indian Mus., 3(3): 250.

1966. *Ranguna* Bott: [Opinion, 1640].

Type species: *Potamon* (*Potamiscus*) *annandalei* Alcock, by original designation, gender: masculine.

38. *Potamiscus annandalei* **(Alcock, 1910)**

1909a. *Potamon annandalii* Alcock, Rec. Indian Mus., 3(3): 246 (Assam – Nemotha, Cachar).

1910. *Potamon* (*Potamiscus*) *annandalei* Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 57, pl. 3, fig. 10 (Assam: Nemotha., Cachar).

1970. *Potamiscus annandalei*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 158, pl. 38, fig. 28 and pl. 46, fig. 26.

Type locality: Nemotha, Cachhar (Assam)

Habitat: freshwater but Microhabitat unknown

Distribution: India – Assam.

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Remarks: Endemic to Assam.

39. *Potamiscus decourcyi* **(Kemp, 1913)**

1913. *Potamon* (*Potamiscus*) *decourcyi* Kemp, Rec. Indian Mus., 8: 292, pl. 17, figs. 1-3 (Sirpo valley near Renging; Rotung; a few miles south of Kebang; bank of Siyon River below Debuk Damda. All specimens were collected from small hill streams at altitudes of between 1000-1500 ft., under stones).

1970. *Potamiscus decourcyi*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 159, pl. 38, fig. 29 and pl. 46, fig. 27.

1999. *Potamiscus decourcyi*: Ghosh and Ghatak, Zool. Surv. India State Fauna Series 4: Fauna of Meghalaya, Part 9: 570 (Meghalaya - Khasi Hills: Mawphlang).

Type locality: Sirpo Valley near Renging, Arunachal Pradesh

Habitat: Hill streams (under stones)

Distribution: Arunachal Pradesh, Meghalaya and Mizoram.

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Remarks: So far recorded from Eastern Himalaya only. It's an endemic species to North east Indian hill states.

40. *Potamiscus pealianus* **(Wood-Mason, 1871)**

1871. *Telphusa pealiana* Wood-Mason, J. Asiat. Soc. Bengal, 40(2): 204, pl. 14, figs. 7-11.

1909a. *Potamon* (*Potamon*) *pealianum* var. *antennarium* Alcock, Rec. Indian Mus., 3: 245 (Two specimens were collected from Sibsagar (Assam) and two from un recorded locality).

1910. *Potamon* (*Potamon*) *pealianum antennarium*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 40, pl. 14, fig. 70 (Assam: Sibsagar).

1910. *Potamon* (*Potamon*) *pealianum*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 38, pl. 10, fig. 44 (Assam: Sibsagar).

1970. *Potamiscus pealianus*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 159, pl. 38, fig. 33 and pl. 47, fig. 29.

Type locality: Assam, Sibsagar.

Habitat: Hill stream

Distribution: Assam, Mizoram. **Abroad:** Myanmar.

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Remarks: restricted distribution in two of the Northeasternstates of India and Myanmar.

41. *Potamiscus tumidulum* **(Alcock, 1909)**

1909 *Potamon* (*Potamon*) *tumidulum* Alcock, Rec. ind. Mus., 3: 245.

1910 *Potamon* (*Potamon*?) *tumidulum* Alcock, Cat. decap. Crust. ind. Mus., 1 (2):43, T. 2 F. 6.

Type locality: Sikkim

Habitat: Rivers and Streams

Distribution: Sikkim. **Abroad:** Myanmar; China.

Conservation Status: It is categorised as Least Concern in IUCN Red List 2013.

Genus *Quadramon* **Yeo and Ng, 2007**

2007. *Quadramon* Yeo and Ng, Raffles Bull. Zool., Supplement, 16: 292.

Type species: *Potamon* (*Potamiscus*) *aborense* Kemp, 1913, by subsequent designation by Yeo and Ng in Raffles Bull. Zool., Supplement, 16: 292 (2007).

42. *Quadramon aborense* **(Kemp, 1913)**

1913. *Potamon* (*Potamiscus*) *aborense* Kemp, Rec. Indian Mus., 8: 294, pl. 18, figs. 4, 5 (Abor Country: Vicinity of Rotung at elevations between 1,000 and 1,300 ft., Egar stream, between Rotung and Sireng stream).

2007. *Quadramon aborense*: Yeo and Ng, Raffles Bull. Zool., Supplement, 16: 292.

Type locality: Rotung, Arunachal Pradesh.

Habitat: Hill stream, behind rocks.

Distribution: India - Arunachal Pradesh, Mizoram

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Remarks: it's also an endemic form of Eastern Himalaya.

Genus *Teretamon* **Yeo and Ng, 2007**

2007. *Teretamon* Yeo and Ng, Raffles Bull. Zool., Supplement, 16: 295-296.

Type species: *Potamon* (*Geotelphusa*) *adiatretum* Alcock, 1909 by subsequent designation by Yeo and Ng in Raffles Bull. Zool., Supplement, 16: 295-296 (2007).

43. *Teretamon adiatretum* **(Alcock, 1909)**

1909 *Potamon* (*Geotelphusa*) *adiatretum* Alcock, Rec. ind. Mus., 3: 250.

1910 *Potamon* (*Geotelphusa*) *adiatretum* Alcock, Cat. ind. decap. Crust. ind. Mus., 1 (2): 59, T. 3 F. 11. (Dafla Hills: Arunachal Pradesh).

Type locality: Mawlamynie (Formerly known as Moulmein), Myanmar.

Habitat: Unknown

Distribution: India – Arunachal Pradesh

Abroad: Myanmar

Conservation Status: It is categorised as Least Concern in IUCN Red List 2013.

Remarks: It seems to be rare as no collection was made after its record from Arunachal Pradesh.

44. *Tiwaripotamon austenianum* **(Wood-Mason, 1871)**

1871. *Telphusa austeniana* Wood-Mason, J. Asiat. Soc. Bengal, 40(2): 203, pl. 13.

1905. *Potamon* (*Potamon*) *austenianus*: Rathbun, Nouv. Arch. Mus., sér. 4, 6: 287 (Cherra Punji).

1910. *Potamon* (*Potamon*) *austenianum*: Alcock, Cat. Indian Decapod Crust. Indian Mus., 1(2): 44 (Meghalaya: Cherrapunji).

1970. *Tiwaripotamon austenianum*: Bott, Abhandl. Sencken. Naturfors. Ges., 526: 151 (Cherra Punji).

1999. *Tiwaripotamon austenianum*: Ghosh and Ghatak, Zool. Surv. India State Fauna Series 4: Fauna of Meghalaya, Part 9: 570 (Meghalaya: Cherrapunji).

Type locality: Cherra Punji (Meghalaya)

Habitat: Hill Stream and River.

Distribution: India - Meghalaya.

Conservation Status: It is categorised as Data Deficient in IUCN Red List 2013.

Remarks: This species is known only from a single locality in India. Further information on its extent of occurrence, ecological role, and population trends should be required to conserve this species.

Genus *Trichopotamon* **Dai and Chen, 1984**

45. *Trichopotamon sikkimensis* (Rathbun, 1905)

1905. *Potamon* (*Geotelphusa*) *sikkimensis*: Rathbun, Nouv. Arch. Du Mus., Paris, sér. 4, 7: 219, vi, pl. 17, fig. 7.

1910. *Potamon* (*Potamiscus*) *sikkimense*: Alcock: 56, fig. 48 (West Bengal – Kurseong; Dafla Hills; Rajasthan – Ajmere).

Type locality: Sikkim

Habitat: Hill stream

Distribution: Darjeeling District of West Bengal, Sikkim, Arunachal Pradesh and Rajasthan.

Abroad: Bhutan and Nepal.

Conservation Status: It is categorised as Least Concern in IUCN Red List 2013.

Remarks: Interstingly this species occurs in the eastern Himalaya as well as Rajasthan, the dry western part of India.

Discussion

A total of 45 species belonging to 2 families and 20 genera of freshwater crab have been recorded from different states of the eastern and western Himalayan part of Indian Territory. The extent of distribution of these species specified areas are summarized in Table 1. Among these, 16 species occur in the family Gecarcinucidae, and the Potamidae is represented by 29 species. The Subfamily Potaminae consists of 13 species only and the Subfamily Potamiscinae is represented by 16 species. From the northeastern states, 40 species have been recorded so far, of which 22 species are recorded from the state of Assam. The remaining species are reported from Meghalaya, Manipur, Nagaland, Tripura, Sikkim, and Mizoram. The occurrence of a higher number of species in these areas may be attributed to the wet climatic conditions. The present study shows that out of 45 species, 20 (44.44%) are distributed exclusively (endemic) to the Indian part of the Himalayas. Interestingly, 15 species are endemic to the eastern Himalayas and only 4 species are endemic to western Himalayas. One species, *Barytelphusa cunicularis* (Westwood, 1836), is common in both areas and is also an endemic species of India but it's particularly a peninisular species and probably recently invaded the Himalayan regions. A list of species distributed in different states of the Indian part of Himalayas is listed here with the number of endemic species harbourded in each state.

Table 1. Species diversity and endemicity of freshwater crabs in different states, geographically situated in the Indian part of the Himalayas.

Name of the State	Number of Species	Endemic Species
Assam	22	9
Manipur	4	1
Mizoram	10	4
Nagaland	10	3
Sikkim	7	0
Meghalya	10	3
Tripura	3	0
Arunachal Pradesh	6	2
WestBengal (Darjeeling)	9	3
Himachal Pradesh	9	5
Jammu and Kashmir	3	2

Uttaranchal	4	2
Jammu and Kashmir	3	2
Uttaranchal	4	2

Phylum ARTHROPODA Latreille, 1829 Subphylum CRUSTACEA Brünnich, 1772 Class MALACOSTRACA Latreille, 1802 Order DECAPODA Latreille, 1802 Suborder PLEOCYEMATA Burkenroad, 1963 Infraorder BRACHYURA Linnaeus, 1758 Superfamily GECARCINUCOIDEA Rathbun, 1904	**Distribution in Indian Part of Himalayas**

Table 2. Distribution of freshwater crabs in different states of the Indian Himalayan territory.

Family GECARCINUCIDAE Rathbun, 1904	
i. Genus *Barytelphusa*	
1. *Barytelphusa cunicularis* (Westwood, 1836)	Darjeeling of West Bengal, Himachal Pradesh
ii. Genus *Globitelphusa*	
2. *Globitelphusa bakeri* (Alcock, 1909)	Assam
3. *Globitelphusa cylindra* (Alcock, 1909)	Assam and Nagaland
4. *Globitelphusa pistorica* (Alcock, 1909)	Assam
iii. Genus *Liotelphusa*	
5. *Liotelphusa gagei* (Alcock, 1909)	Darjeeling of West Bengal
6. *Liotelphusa laevis* (Wood-Mason, 1871)	W.B (Darjeeling hills) Meghalaya, Assam, Nagaland, Arunachal Pradesh
7. *Liotelphusa quadrata* (Alcock, 1909)	Assam
iv. Genus *Maydelliathelphusa*	
8. *Maydelliathelphusa edentula* (Alcock, 1909)	Assam, Nagaland, Mizoram
9. *Maydelliathelphusa falcidigitis* (Alcock, 1910)	Assam, Meghlaya,Nagaland, Mizoram
10. *Maydelliathelphusa harpax* (Alcock, 1909)	Assam, Nagaland, Meghalya, Mizoram
11. *Maydelliathelphusa lugubris* (Wood-Mason, 1871)	Assam, Meghlaya, Nagaland, Tripura, Manipur, Sikkim, Mizoram, Darjeeling(W.B)
12. *Maydelliathelphusa masoniana* (Henderson, 1893)	Assam, Mehgalya, Himachal Pradesh, JandK
v. Genus *Travancoriana*	
13. *Travancoriana napaea* (Alcock, 1909)	Assam
vi. Genus *Sartoriana*	

14. *Sartoriana spinigera* (Wood-Mason, 1871)	Assam, Meghlaya, Nagaland, Tripura, Manipur, Sikkim, Mizoram,
15. *Sartoriana trilobata* (Alcock, 1909)	Assam
vii. Genus *Somanniathelphusa*	
16. *Somanniathelphusa sinensis* (H. Milne Edwards, 1853)	Assam
Superfamily POTAMOIDEA Ortmann, 1896	
Family POTAMIDAE Ortmann, 1896	
Subfamily POTAMINAE Ortmann, 1896	
viii. Genus *Acanthopotamon*	
17. *Acanthopotamon fungosum* (Alcock, 1909)	Assam
18. *Acanthopotamon martensi* (Wood-Mason, 1875)	Meghalaya, Assam
ix. Genus *Alcomon*	
19. *Alcomon lophocarpus* (Kemp, 1913)	Arunachal Pradesh
20. *Alcomon superciliosum* (Kemp, 1913)	Arunachal Pradesh, Mizoram
x. Genus *Himalayapotamon*	
21. *Himalayapotamon ambivium* (Alcock, 1909)	Himachal Pradesh
22. *Himalayapotamon atkinsonianum* (Wood-Mason, 1871)	Darjeeling (W.B.), Sikkim, Himachal Pradesh, J and K
23. *Himalayapotamon babaulti* (Bouvier, 1918)	Himachal Pradesh
24. *Himalayapotamon bifarium* (Alcock, 1909)	Sikkim(?)
25. *Himalayapotamon emphyseteum* (Alcock, 1909)	Himachal Pradesh, Uttarakhand, JandK
26. *Himalayapotamon kausalis* (Pretzmann, 1964)	Himachal Pradesh
27. *Himalayapotamon kooloense* (Rathbun, 1904)	Darjeeling (W.B.), Meghalaya, Himachal Pradesh, Uttarakhand
28. *Himalayapotamon monticola* (Alcock, 1910)	Darjeeling (W.B.), Khasi Hills (Meghalaya)
xi. Genus *Lobothelphusa*	
29. *Lobothelphusa woodmasoni* (Rathbun, 1905)	Assam, Tripura, Meghlaya, Mizoram
Subfamily POTAMISCINAE Bott, 1970	
xii. Genus *Aspermon*	
30. *Aspermon feae* (de Man, 1898)	Assam, Arunachal Pradesh, Mizoram
xiii. Genus *Eosamon*	
31. *Eosamon tumidum* (Wood-Mason, 1871)	Darjeeling (W.B.), Himachal Pradesh
xiv. Genus *Indochinamon*	
32. *Indochinamon asperatum* (Alcock, 1909)	Assam

33. *Indochinamon beieri* (Pretzmann, 1966)	Assam, Nagaland, Mizoram
34. *Indochinamon edwardsi* (Wood-Mason, 1871)	Assam, Meghalaya, Nagaland (Known only from type locality)
35. *Indochinamon manipurense* (Alcock, 1909)	Manipur
36. *Indochinamon andersonianum* (Alcock, 1909)	Manipur
xv. Genus *Larnaudia*	
37. *Larnaudia larnaudi* (A. Milne Edwards, 1869)	Himachal Pradesh
xvi. Genus *Potamiscus*	
38. *Potamiscus annandali* (Alcock, 1909)	Assam
39. *Potamiscus decouryi* (Kemp, 1913)	Assam, Nagaland, Mizoram
40. *Potamiscus pealianus* (Wood-Mason, 1871)	Assam, Mizoram
41. *Potamiscus tumidulus* (Alcock, 1909)	Sikkim
xvii. Genus *Quadromon*	
42. *Quadromon aborense* (Kemp, 1913)	Arunachal Pradesh, Mizoram
xviii. Genus *Teretamon*	
43. *Teretamon adiatretum* (Alcock, 1909)	Arunachal Pradesh
xix. Genus *Tiwaripotamon*	
44. *Tiwaripotamon austenianum* (Wood-Mason, 1871)	Meghalaya
xx. Genus *Trichopotamon*	
45. *Trichopotamon sikkimense* (Rathbun, 1905)	Sikkim, Darjeeling (West Bengal)

Threats and Conservation

Freshwater crabs are found in ponds, lakes, streams, rivers, and marshes. A few species however, are able to live in brackish water. They subsist on fallen leaves and algae and thereby help in nutrient cycling by consuming detritus within the freshwater ecosystems. Forest floors and protected areas are essential to the survival of these small animals from over exploitation by humans, as these animals are considered an important and cheap source of protein particularly for tribal communities and rural people. They also support small-scale fisheries, especially in the rural sectors and thus provide a primary source of protein for the local people. Apart from these, they are an important source of food for a wide range of animals such as fish, amphibians, reptiles, and mammals. Freshwater crabs are considered an important environmental marker (especially for rainforests). This necessitates the need for correct identification. They are also excellent indicators of good water quality, as most of them require pristine water for survival. They are important as markers for the study of biogeography, plate tectonics, and animal evolution. Some colourful species are also important in the aquarium trade. Freshwater crabs are medically important as vectors of the deadly disease Paragonimiasis which affects about 20 million people world-wide. As such, identification of the correct crab vector is important for the control

of this disease. They are also considered important in the biological control of pests. Perhaps the most widely used of all the traditional pest management practices is the use of decomposing crabs in the control of rice bugs (as the filling of paddy grain starts, locally available crabs are smashed and put on pointed bamboo sticks in terraced paddy fields). This is a traditional practice throughout the entire state by all communities in Meghalaya. This method is environmentally friendly, as some farmers replace the crab baits as soon they dry up. The crab bait traps can be used in connection with other traditional methods of managing the pest.

Like other parts of the world, freshwater crabs of India are also subjected to tremendous pressure of threats. Major threats to freshwater crabs of India are due to habitat destruction and pollution. Loss of natural forests to land development and agriculture has impacted almost every habitat in which freshwater crabs live. Rapid urbanization, industrialization, poor sloping-land management, and unwise land-use change in the high lands continues to be a serious problem resulting to habitat loss and wiping out the freshwater crabs. Only a handful of freshwater crab species have wide distribution and able to tolerate land-use change. Wide use of pesticides for agriculture is also causing serious concern. At present, their regulation addresses only human safety issues and has no impacts on other non-target organisms or the environments in general. In addition, water quality is also deteriorating very fast even in key natural habitats. Many of the freshwater crabs are extremely sensitive to polluted or silted waters and will not survive when exposed to these features. However, a National Committee for the study of Freshwater Crabs may be set up involving Zoological Survey of India towards conservation action.

IUCN has recently included 1,280 species of freshwater crabs of the World in the Red List of Threatened Species, of which, 227 has been considered as Near Threatened, Vulnerable, Endangered, or Critically Endangered. Further, for another 628 species, adequate data are not available to assess their status. According to the estimation of IUCN, nearly two-thirds of freshwater crabs are going to be extinct, with one in every six species particularly vulnerable. So far, from the Indian part of the Himalaya, all the 45 species has been enlisted in the IUCN Red List data. Among these, only 13 species are enlisted as **Least Concern** whereas a single species, *Liotelphusa quadrata* (Alcock 1909), are categorized as **Vulnerable**. Three species namely *Liotelphusa gagei* (Alcock 1909), *Liotelphusa laevis* (Wood-Mason, 1871), and *Maydelliathelphusa edentula* (Alcock 1909), are considered as **Near Threatened**. Surprisingly, 26 species are still enlisted as **Data Deficient** as there is no collection data or any further report of those species. However, most of the freshwater crabs need to be brought under a Rapid Assessment Survey to ascertain their status in India.

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Eastern Ghats: Faunal Composition and Conservation

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Introduction

Humans, being a part of the Earth's biodiversity, have influenced its ecosystem more than any other species on earth. The single species *Homo sapiens* is steadily transforming the ecosystems into depauperate systems (Vitousek et al. 1997), which leads to an imbalanced biogeochemical process. Although the relationship between humans and biodiversity is as old as human evolution, the relationship between biodiversity and ecosystem functioning has emerged as a central issue in ecological and environmental sciences during the last two decades (see Loreau et al. 2001). Thus, conservationists are now more conscious in knowing biodiversity (species richness) to deal with the catastrophic impacts humans are going to face in near future. We must understand biodiversity to save species from extinction. In this paper, we discuss the faunal composition of Eastern Ghats, the poor sister of Western Ghats in Peninsular India. However, before coming to the real topic we throw light on various issues related to biodiversity conservation in the country, importance of taxonomy in species conservation, and the real-time challenges before us to protect the fauna of Eastern Ghats.

The Indian subcontinent probably represents one of the greatest paradoxes in conservation. It sustains the second largest human population in the world and it is also home to arguably one of the richest and most diverse biological communities (Singh 1985). In the latter half of the twentieth century, the unprecedented growth in human population and changes in socio-economic value triggered a decline in wildlife populations and in some instances led to (local) extinction of native flora and fauna. This was when the Government of India took pro-active measures to restrain further deterioration. Wildlife (Protection) Act of 1972 was framed and under this Act Protected Areas (PAs) were made free of human disturbances and were managed to prevent further decline of wildlife. During 1960s and 1970s the selection and creation of protected areas have largely been a result of lobbying by concerned individuals or organizations (Rodgers 1985). The protected areas notified during that period had

several inadequacies as reviewed by several researchers (Rodgers and Panwars 1988, MacKinnon and MacKinnon 1986, Pressey et al. 1993, Gadgil and Meher-Homji 1982). Later the National Wildlife Action Plan in 1983 led to a review of the existing PA network in the country and adoption of a biogeographical framework to streamline the process of identification, selection, design, and management of reserves. The need for a rational PA network planning was felt as early as the 1960s in India (Badshah and Bhadran 1962) and consequently, the Wildlife Institute of India (WII) was commissioned to bring out a broader biogeographical classification of the country. In 1988, W.A. Rodgers and H.S. Panwar of WII developed and scripted an important document for wildlife conservation in India, the biogeographical classification system for the country (Rodgers and Panwar 1988). This classification received worldwide recognition as many conservation planners, managers, and biologists adopted it.The Rodgers and Panwar classification is a three-tier system in which three levels of biogeographical units are arranged in an hierarchical manner such as Biogeographical Zones, Provinces, and Regions. Zones and Provinces were used in the analysis of representativeness of PA network in India by them. The criteria for classification are not explicit in their report. However, they mention that their emphasis was considered geomorphologicallyand that the classification needs to be revisited using distribution of floral and faunal components.

Figure 1. Flying squirrel (*Petaurista philippensis*) at the Baisipalli Wildlife Sanctuary.

The Rodger and Panwar (1988) and Rodgers et al. (2000) classification of biogeographic zones of India comprises 10 zones viz. Trans-Himalayan zone, Himalayan zone, Desert zone, Semiarid zone, Western ghat zone, Deccan plateau zone, Gangetic plain zone, North east zone, Coastal zone, and Islands present near the shore line. As per their classification Eastern Ghats falls into the Deccan plateau zone without any special identity. The Deccan plateau zone is further divided into Central highlands, Chotta-Nagpur plateau, Eastern highlands, Central plateau, and Deccan south, of which Eastern Ghats comprises the eastern mountainous ranges of the later three provinces. However, several researchers are now considering Eastern Ghats as a distinct biogeographic zone on the basis of a geomorphology and biodiversity point of view (Mani 1974, Das 1998, Pullaiah 2002).

Geology of Eastern Ghats

The reason for considering Eastern Ghats as a separate zone is primarily based on geology and uniqueness of biodiversity of the region. The Eastern Ghatslandscape has a complex geologic history related to the assembly and breakup of the ancient supercontinent of Rodinia and the assembly of the Gondwana supercontinent. The Ghats are much older than the Western Ghats and Himalayas. The Eastern Ghats Belt (EGB) is a high-grade terrain along the east coast of India, and is bounded to the north by the Singhbhum craton and to the west by the Bastar craton, the Dharwar craton and the Nellore-Khammam Schist Belt (Mukhopadhaya and Basak 2009). The Eastern Ghats along the eastern coast of Peninsular India expose a deep crustal section of a Proterozoic orogenic belt. Dobmeier and Raith (2003) presented a subdivision of the EGB into four provinces based on distinct geological history and the provinces are Jeypore Province, Krishna Province, Eastern Ghats Province, and Rengali Province. Furthermore, based on major crustal units Eastern Ghats Belt is divisible into four major units such as the Late Archaean Jeypore and Rengali Provinces, the Late Palaeoproterozoic Ongole Domain, and the Meso-Neoproterozoic Eastern Ghats Province (Dobmeier and Raith 2003). The nature of the north-

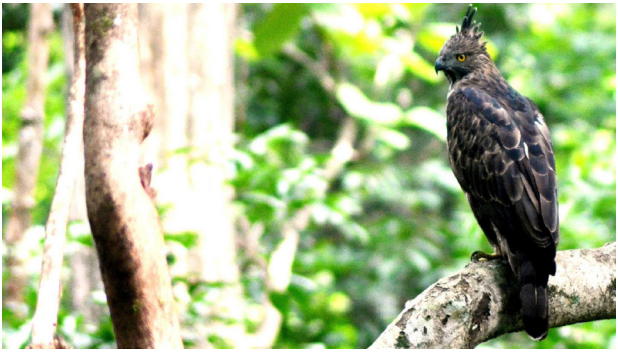

Figure 2. A changeable hawk eagle (*Lophotriorchis kienerii*).

ern boundary of the EGB is less well understood. North of Khariar the EGBSZ veers to the east and continues north of the Bolangir anorthosite pluton, but its continuation further east is unclear; it probably continues to Rairakhol to terminate against the Kerajang Fault near Angul (Crowe et al. 2003, Mukhopadhaya and Basak 2009).The Rengali and Jeypore Provinces are Archaean metamorphic terrains bordering the Singhbhum and Bastar cratons (Mukhopadhaya and Basak 2009). The rocks preserve a complex history of high-grade metamorphism and intense deformation suggestive of several phases of crustal reworking during a prolonged evolution (Chetty 2010).

Physiography of Eastern Ghats

The broken hilly terrain running parallel to the east coast of India in Peninsular India is popularly known as Eastern Ghats (Mani 1974, Jaykumar et al. 2008). The Eastern Ghats (11° 31'and 21° 0' North and 77° 22'and 85° 21' East) extending over a length of 1,750 km between the rivers Mahanadi and Vaigai is spread over 75000 km^2 with an average width of 200 km in the north and 100 km in the south (Pullaiah 2002). The mountain ranges are of mid-elevation with highest peak of 1750m at the Biliriangan Hills, Tamil Nadu (Das 1998). The northern most boundaries of the Eastern Ghats consist of the Mahanadi basin, while the Nilgiri Hills form the southern boundary of the Eastern Ghats (Das and Baur 2000). Towards the west, the Eastern Ghats merge with the tips of the Bastar, Telangana and Karnataka plateaux and Tamil Nadu uplands, while the coastal area in the east limits its eastern part (Pullaiah 2002). The Eastern Ghats are not contiguous because the rivers Mahanadi, Godavari, and Krishna cut across them. A gap of 130 km in the Guntur district formed by Godavari delta cuts across the Ghats dividing it in to Northern and Southern sections. Important mountain ranges of Eastern Ghats are Mahendragiri (1515m), Deomali (1672 m), Nallamalais (1100 m), Velikonda and Seshachalam Hills (900 m), Javadi Hills (1150 m), the Kollimalai (1300 m), the Pacchamalai (100 m), the Kalrayan (1300 m), the Shevoray (1623 m) and the Biligirirangan Hills. The climate of the Eastern Ghats is tropical. The region falls within the tropical monsoon climatic distribution, receiving rainfall from the southwest monsoon, and the

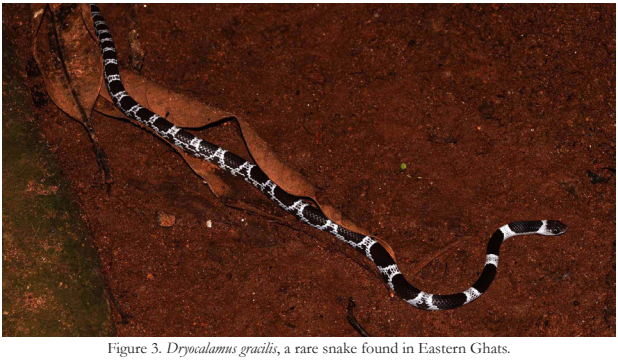

Figure 3. *Dryocalamus gracilis*, a rare snake found in Eastern Ghats.

northeast retreating monsoon, ranging from 1,200 to 1,600 mm in the northern part, whereas it is lower in the central and southern parts (600 and 1,000 mm, respectively). The climate is semiarid, except in the hilly peaks (Kumara et al. 2013). The dominant vegetation of the Eastern Ghats consists of dry decicuous type with patches of Tropical Semi-Evergreen Forests, Tropical Moist Deciduous Forests, Dry Savannah Forests, Tropical Dry Evergreen Forests, Shola and Tropical Dry Evergreen Scrub (Legris and Meher-Homji 1982, Subba Rao et al. 1982, Das 1998, Pullaiah 2002).

Table 1. Distribution of Eastern Ghats Mountains across India

State	Districts	PAs (Sanctuaries, National Parks, Tiger Reserve)
Odisha	Angul (part), Dhenkanal (part), Sambalpur (part), Nayagarh, Khurdha, Cuttack (part), Puri (part), Pulbani, Kalahandi, Ganjam, Gajapathi, Koraput and Rayagada	Satkosia Tiger Reserve, Baisipalli, Khalasuni-Usakothi, Badrama, Chandaka, Nandankanan, Nalabana bird sanctuary, Kotagarh, Karlapat and Lakharivalley
Andhra Pradesh	Srikakulam, Vijayanagaram, Visakapatnam, East Godavari, West Godavari, Khammam, Krishna, Guntur, Prakasam, Kurnool, Mahaboobnagar, Cuddapah, Anantapur, Nellore and Chittoor.	Coringa, Gundla Brahmeswaram, Kambalakonda, Krishna, Koundinya, Nagarjunsagar-Srisailam Tiger Reserve (part), Papikonda, Rollapadu Bird Sanctuary, Sri Lankamalleswara Wildlife Sanctuary, Sri Venkateswara National Park
Telengana	Khammam, Mahabubnagar, Nalgonda	
Tamil Nadu	Chengalput, Dharmapuri, North Arcot, Salem, Tiruchirapalli, Namakkal, South Arcot and parts of Coimbatore.	Vedanthangal Bird Sanctuary, Annamalai, Mudumalai.
Karnataka		Biligiriranga tiger reserve

Biogeographic Significance of Eastern Ghats

This landscape has been identified as a separate biogeographic zone based on several unique elements (Mani 1974). The biodiversity of Eastern Ghats has affinities with the Indo-Malayan and Western Ghats relicts. In contrary to the Satpura hypothesis, several researchers considered Eastern Ghats as an important route for dispersal of biodiversity among South-east Asia and Western Ghats. Eastern Ghats spans over a majority of the geographical area in Odisha, Andhra Pradesh, Telengana, and Tamil Nadu with a smaller portion entering to Karnataka. In addition to biodiversity, this landscape is diverse in terms of culture and natural resources. However, our knowledge of species diversity of Peninsular India in Eastern Ghats is inadequate in comparison to Western Ghats, which creates a shortfall in conservation planning for the lesser known species.

It is yet premature to derive any conclusive theory regarding the faunal biogeography of Eastern Ghats because of sporadic and incomplete assessments in most of the groups. However, with the involvement of numerous researchers and use of modern techniques, interesting results are coming up regarding faunal distribution, dispersal mechanism and divergence of various species. Several connecting links are established even in higher vertebrates for the disjunctly distributed species (see Palei 2014, Mohapatra et al. 2014, Nayak et al. 2015).

The biodiversity of Indian subcontinent is mostly concentrated in the wet zones (Gower et al. 2016) and these wetter zones across Eastern Ghats harbor relict population of once widely distributed humid forest species (Abdulali 1949,

Mani 1974 and Mohapatra et al. 2014). Many of the species are disjunctly distributed which resulted due to fragmentation of the wet zone during Pleistocene climatic fluctuations, by Late Miocene wet-zone contraction, or by more ancient events (Karanth 2003). The disjunct distribution of biodiversity has also been attributed due to different biogeographic histories which has resulted to limited wet forest contiguity both spatially and temporally (Mani 1974, Roy et al. 2006, Ponton et al. 2012). Several studies in the past reveal that peninsular Indian faunal assemblages exhibit significant beta diversity with differing hill ranges, drainages, elevations and habitat types (Inger et al. 1987, Vijaykumar et al. 2006, Vasudevan et al. 2006, Naniwadekar and Vasudevan 2007). Mani (1974) has also pointed out that Eastern Ghats due to its further inland location and lower height than Western Ghats is much drier and supports an impoverished biota. The wet-zone pockets in the hills are considered as refugia providing stable habitat which has resisted the past climatic fluctuations that impacted the biotic evolution in the surrounding plains (Ponton et al. 2012). In peninsular India, the Eastern Ghats is reported to be rather faunally poor and depauperate (Srinivasulu and Das 2008, Dinesh et al. 2009) despite many "ecological islands".

Faunal Assemblage in the Eastern Ghats of India

Unlike Western Ghats there is no ready-made compiled information on faunal assemblage of Eastern Ghats, except for few groups. However, obscure and sporadic records on distribution are available from various parts of the Ghats. On mammals the important faunal surveys are by Behura and Guru (1967), Agrawal and Bhattacharyya (1976), Krishna Raju et al. (1987), Ghosh (1989), Das et al. (1993), Acharjyo et al. (1997), Tulsi Rao et al. (1999), Srinivasulu and Nagulu (2002), Kumara et al. (2013). Distribution records of various mammals in Eastern Ghats were also extracted from the works by Jerdon (1853), Prater (1965) Alfred et al. (2002), Sharma et al. (2014) and Menon (2014).

The avifaunal explorations in Eastern Ghats are well compiled with more than 400 articles in the literature (see Narwade et al. 2005) including those of Ali (1933 a, b, c; 1934a, b), Ali (1942-1943), Abdulali (1945), Trevor Price (1978, 1979), Krishna Raju (1985), Ripley et al. (1987-1988), Baskaran (1992), Bhushan (1994), Karthikeyan et al. (1995), Srinivasulu and Rao (2000), Uttangi (2000), Aravind et al. (2001), Shyamal (2003), and Srinivasan and Prashanth (2005).

Regarding the herpetofaunal surveys in Eastern Ghats there are several papers from various regions on inventories, rediscoveries, and redescriptions. The earliest zoological collections from these hill ranges were made by Thomas Claverhill Jerdon (1811-1872) and described several species such as *Microhyla rubra* (Jerdon 1854), *Hoplobatrachus crassus* (Jerdon 1854), *Hemidactylus subtriedrus* (Jerdon 1853), and *Oligodon taeniolatus* (Jerdon 1853). Other important surveys on this group are by Kinnear (1913), McCann (1945), Sharma (1969, 1971, 1976), Pillai and Murthy (1983), Murthy (1986), Sharma (1969, 1971, 1976), Sanyal et al. (1993), Sarkar et al. (1993), Daniels and Ishwar (1993), Sanyal et al. (1993), Sarkar et al. (1993), Nagulu et al. (1998), Rao and Rao (1998), Balachandran and Pittie (2000), Bauer and Das (2000), Chettri and Bhupathy (2010), Rao et al. (2005), Srinivasulu et al. (2005, 2006), Javed et al. (2007), Javed et al. (2010), Murthy and Murthy (2010), Srinivasulu and Das (2008), Sreekar et al. (2010),

Seetharamaraju et al. (2011), Reddy et al. (2013), Srinivasulu et al. (2006, 2009), Srinivasulu and Das (2007), Seetharamaraju et al. (2009), Mohapatra et al (2009), Mohapatra et al. (2010), Mohapatra et al (2011), Agarwal et al. (2012), Dutta Roy et al. (2013), Seetharamaraju and Srinivasulu (2013). A total of 115 species of amphibians and reptiles were reported from the Eastern Ghats (Daniels 2000). A recent compilation of amphibian faunal diversity of the Eastern Ghats by Deuti et al. (2011) reported occurrence of 24 species belonging to 11 genera and 5 families (3 species of Bufonidae, 5 species of Microhylidae, 9 species of Dicroglossidae, 3 species of Ranidae, and 4 species of Rhacophoridae). From Eastern Ghats several new species are described in last two decades by Das and Bauer (2000), Mahony (2009), Agarwal et al. (2011), Agarwal et al. (2013), Vogel and Ganesh (2012) and Srinivasulu et al (2015).

The systematic checklist of the mammals, avifauna, and herpetofauna of Eastern Ghats is provided in Annexure 1.

The mammalian diversity of Eastern Ghats is represented by 97 species comprising 11 orders (Proboscida, Scandentia, Cercopithyecidae, Rodentia, Logomorpha, Socicomorpha, Eulipotyphla, Choroptera, Pholidota, Carnivora and Artiodactyla), 30 families, and 64 genera. The list of mammalian diversity is compiled as per the existing information available by various researchers such as Mennon (2005) and Mohapatra et al. (2014).

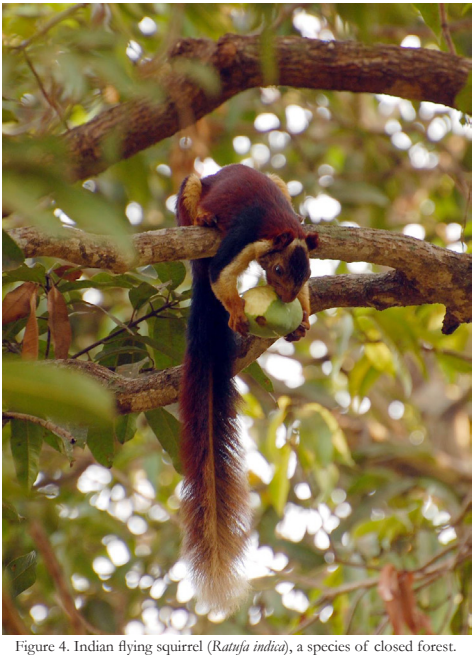

Figure 4. Indian flying squirrel (*Ratufa indica*), a species of closed forest.

The order Proboscida is represented by one family (Elephantidae) and one species, the Asian elephant (*Elephas maximus*). The elephants of Eastern Ghats are from East-Central (EC) and South Indian (SI) populations. The EC elephant population is distributed along the Odisha part of Eastern Ghats, extending to the Srikakulam district in northern Andhra Pradesh. The SI elephant population is mostly distributed in the Biligirirangans and the hilly tract along the Cauvery River of the Eastern Ghats and more recently in a small area of southern Andhra Pradesh (Sukumar 1989).The southern Andhra Pradesh population of elephants has dispersed from the Hosur-Dharmapuri forests of Tamil Nadu during 1980s and now ranges as scattered groups in the Kuppam and Palamaner forest divisions of the Chittoor district (Manakadan et al. 2010, Baskaran et al. 2011). Along the Eastern Ghats there are four elephant reserves namely Mahanadi (2002), South Odisha (proposed), Rayala (2003), and Nilgiri (2003), harbouring more than 3,000 elephants.

Five species of Primates (Order Primate) comprising two species of monkeys, two species of langurs and one species of Loris are recorded from this landscape. The rhesus monkey is distributed in northern parts of the Ghats in Odisha range and towards south this species is found in sympatry with the Bonnate macaque.

The Order Rodentia is highly diverse and comprises 16 species represented by three suborders, namely Sciuromorpha (one family and four species), Myomorpha (one family and 10 species), and Hystricomorpha (one family and one species).

Among the least diverse group, Order Logomorpha, Scandentia, Eulipotyphla, and Pholidota comprises one species each. The monotypic Madras tree shrew (*Anathana elliotii*) is distributed in the fringe forests of Eastern Ghats and specific locality records are from Satkosia TR, Barbara, Deomali, Gupteswar, and Nallamala hills. On the other hand the Madras hedgehog (*Paraechinus nudiventris*) is distributed only in the southern parts of Eastern Ghats. The Indian pangolin is another uncommon species of Eastern Ghats distributed along the rocky outcrops habitats in deciduous forest tracts in Northern Eastern Ghats.

One of the most diverse groups of mammalian fauna of Eastern Ghats is Order Chiroptera (34 species). The bat diversity of Eastern Ghats is represented by eight families such as Pteropodidae (4 species), Rhinolophidae (4 species),

Figure 5. *Coelognathus helena nigriangularis*, a new subspecies of snake described from this landscape.

Hipposideridae (5 species), Megadermatidae (2 species), Rhinopomatidae (2 species), Emballonuridae (5 species), Vespertilionidae (11 species), and Molossidae (1 species).

The second most diverse group of mammals in Eastern Ghats is Order Carnivora, comprising 23 species. This group is represented by two suborders, namely Feliformea and Caniformia. The suborder Feliformea is further represented by four families and 15 species such as Felidae (7 species), Viveridae (3 species), Hyaenidae (1 species), and Herpestidae (4 species). Among these species, the royal Bengal tiger and fishing cat are listed as Endangered as per IUCN categorization. On the other hand, the suborder Caniformia comprises three families and eight species namely Canidae (4 species), Ursidae (1 species), and Mustelidae (3 species).

The Order Artiodactyla is represented by 11 species, one species of Suidae, 3 species of Cervidae, 4 species of Bovidae and two species of Antilocapridae.

Among the mammals of Eastern Ghats the large Indian civet is only known from two localities in extreme north Eastern Ghats (Satapada in Puri district and Hindol in Dhenkanal district, Odisha) and the wild buffalo is only known from the confluence of Eastern Ghat and Bastar plateau (Kunduli area of Koraput district in Odisha). Similarly *Semnopithecus priam*, *Loris lydekkerianus*, *Ratufa macroura*, *Cremnomys elvira*, *Paraechinus nudiventris*, and *Rhinolophus beddomei* are the

Figure 6. Asian elephant (*Elephas maximus*). Eastern Ghats harbours two distinct populations of Elephants, the Central Indian population in the Northern parts and South Indian population towards the south.

species only known from southern Eastern Ghats. On the other hand there are species like *Taphozous perforates*, *Miniopterus schreibersii*, *Hisperoptenus tickelli*, and *Felis silvestris*, are only known from Central Eastern Ghats.

Aves

The Eastern Ghats is rich in avifaunal diversity. Although very few systematic and comprehensive ornithological surveys have been undertaken so far in the entire Eastern Ghats region, there are many sporadic records and inventories from PAs as well as areas out side PAs. The Vernay scientific survey of the Eastern Ghats (Whistler and Kinnear 1930-1937) and the Hyderabad State Ornithological Survey (Ali 1933-1934) are the significan surveys of the region.

The Eastern Ghats support nearly 490 species and subspecies of birds (see annex. 1) including the summer and winter migrants. Abdulali (1949) mentioned more than 10 species of evergreen bird species such as Blue robin, Pied thrush (*Zoothera wardii*), Black-winged cuckooshrike (*Coracina melaschistos*), Ultramarine flycatcher (*Ficedula superciliaris*), Blue-throated blue flycatcher (*Cyornis rubeculoides*), Rusty-tailed flycatcher (*Muscicappa ruficauda*), Pale-footed bush babbler (*Cettia pallidipes*), Black-naped oriole (*Oriolus chinensis*), Chestnut winged cuckoo (*Clamator coromandus*), Black baza (*Aviceda leuphotes*), and Eurasian woodcock (*Scolopax rusticola*) which are using Eastern Ghats highway for their dispersal between Western Ghats and Himalayas. Similarly, the author mentioned about 16 more species which are winter visitors from Himalayas to extreme south India and follow the Eastern Ghats route. There are also examples of avifaunal species which are exclusively found in NE India and Eastern Ghats but do not appear in southern peninsula, such as Rufous-fronted babbler (*Stachyridopsis rufifrons*), Pin-striped tit babbler (*Macronus gularis*), and Abbott's babbler (*Malacocincla abbotti*).

Srinivasulu and Nagulu (2002) recorded 302 species from Nallamala hills of Andhra Pradesh and some of the interesting species found there are white stork, wooly-necked stork, pied avocet, Indian pied hornbill, yellow-throated bulbul, yellow-browed bulbul, and little pied flycatchers. Another study by Srinivasan and Prashanth (2006) reported 254 species from BR Hills, where the authors

Figure 7. Black-breasterd Baya (*Ploceus benghalensis*) at Ganjam, a rare local migrant in Northern Eastern Ghats. (Photo: Rabindranath Sahu).

revisited the work of Abdulali (1949) and reported that many of the bird species that appear to have dispersed along the Eastern Ghats route (exclusively or in addition to other routes) have been recorded from BR Hills. The authors mentioned about 19 species of wet zone birds which have dispersed to the Western Ghats exclusively along the Eastern Ghats.

Summarizing the distribution pattern of avifauna of India it is clear that the species composition of Eastern Ghats is almost similar to that of the Peninsular India with some peculiarities. Like other faunal groups, the resident avifaunal diversity is amalgamation of species commonly distributed throughout the country and elements from Indo-Malayan and Western Ghats region.

As mentioned earlier, there are several theories of faunal dispersion hence at this point it is difficult to validate any specific theory without a complete assessment. Considering the distribution limit provided by Grimmet et al. (2011) as a standard, it is easy to understand that the wet zone species such as Jerdon's baza, black baza, vernal hanging parrot, chestnut-winged cuckoo, blue-bearded beeeater, chestnut-headed beeeater, spickled piculet, heart-spotted woodpecker, bronzed drongo, ashy wood swallow, and little spiderhunter might have dispersed between Western Ghats and Himalayas through the Eastern Ghats. Similarly, there are 15 avian species discussed here are found in NE India and Eastern Himalayas but not recorded from southern peninsula. Of these Pale-capped pigeon, green-billed malkoha, oriental pied hornbill, fulvous-breasted woodpecker, grey-headed woodpecker, large wood shrike, black-crested bulbul, Abbott's babbler, pin-striped tit babbler, and ruffous fronted babbler have interesting distribution patterns. Furthermore, the painted bush quail and white-bellied woodpecker are distributed only in the Eastern and Western Ghats with very scanty information from Deccan Peninsula. Apart from these, there are species like the Malayan night heron, mountain imperial pigeon, lesser coucal, brown-backed needletail, fork-tailed swift, golden-headed cisticola, and great-eared nightjar have disjunct distribution patterns (resident to Western Ghats and NE India but not yet reported from Eastern Ghats). It is also evident from

Figure 8. Leopard (*Panthera pardus*), an elusive large cat of deciduous forests of Eastern Ghats.

recent findings that the disjunctly distributed species might be actually occurring in Eastern Ghats, like the great-eared nightjar recently recorded from Karlapat wildlife sanctuary (Palei 2014).

The Critically Endangered Jerdon's Courser (*Rhinoptilus bitorquatus*) is found in the Eastern Ghats. Apart from this, the Yellow-throated Bulbul (*Pycnonotus xantholaemus*), which is endemic to southern peninsular India, is also found in the southern part of the Eastern Ghats. The occurrence of Tree Sparrow (*Passer montanus*), Abbot's Babbler (*Malacocincla abbotti*), and Little Spiderhunter (*Arachnothera longirostra*) in the northern parts of the Eastern Ghats is of zoogeographical interest since these species are considered as Himalayan/Southeast Asian relicts (Ripley et al. 1987-1988). The Eastern Ghats in their southernmost part run in a southwest direction to meet the Western Ghats. Species such as the Yellow-browed bulbul (Iole indica) and the White-bellied Treepie (*Dendrocitta leucogastra*), which are mainly confined to Western Ghats, are found in this region as well (Ali and Ripley 1987). Apart from these resident species, the Eastern Ghats are important flyways for winter visitors. Coastal wetlands and forested watersheds in the Eastern Ghats hill ranges act as important wintering ranges for migrant bird species (Bhushan 1994).

Herpetofauna

In the present work about 153 species of herpetofauna comprising 119 species of reptiles and 34 species of amphibians are recorded from Eastern Ghats. Additionally there are several species complex in this group on which taxonomic works are underway. The reptile fauna is represented by family Crocodylidae (1 species), Gavialidae (1 species), Bataguridae (3 species), Testudinidae (2 species), Trionychidae (5 species), Agamidae (6 species), Chamaeleonidae (1 species), Eublepharidae (1 species), Gekkonidae (18 species), Lacertidae (4 species), Scincidae (18 species), Varanidae (2 species), Boidae (3 species), Ahaetullidae (1 species and one subspecies), Colubridae (28 species), Psammophidae (1 species), Sibynophidae (2 species), Elapidae (8 species), Typhlopidae (5 species), Uropeltidae (5 species) and Viperidae (3 species). Among the reptiles, species such as Gharial, tricarinate hill turtle, elongated tortoise are only recorded from extreme northern part of Eastern Ghats. On the other hand, species like *Cnemaspis otai* and *Cnemaspis yercaudensis* are only restricted to southern Eastern Ghats.

The amphibian fauna comprises two orders namely Anura (5 families and 33 species) and Apoda (1 family and 1 species). Anuran diversity is represented by 4 species under family Bufonidae, 13 species Dicroglossidae, 3 species Ranidae, 6 species Microhylidae and 6 species Rachophorodae. Among the Caecilian, there is one species under the family Indotyphlopidae and the earlier record of Icthyophis peninsularis (see Pilai and Murthy 1982) is probably dubious.

Endemic Fauna of Eastern Ghats

The only Eastern Ghats endemic mammal is the Large Rock Rat or Elvira Rat (*Cremnomys elvira*). This species is a medium sized, nocturnal and burrowing rodent distributed in Tropical dry deciduous shrubland forest mostly in rocky outcrops at and elevation of about 600 m above mean sea level (Alfred et al 2002). Other Indian endemics like Madras tree shrew (*Anathana ellioti*), Bonnet

macaque (*Macaca radiata*), flat-haired mouse (*Mus platythrix*), Indian giant squirrel (*Ratufa indica*), Cutch Cremnomys (*Cremnomys cutchicus*) and Bare Bellied Hedgehog (*Parachinus nudiventris*), are distributed in this landscape.

Among birds the Jerdon's Courser (*Cursorius bitorquatos*) is endemic to Eastern Ghats and species like rock bush quail, painted bush quail, southern mottled wood owl, white bellied treepie, yellow-throated bulbul, white naped tit, Andaman bulbul, vigors's sunbird, white-spotted fantail flycatcher and Malabar whistling thrush are Indian endemics.

The reptile fauna of Eastern Ghats shows more endemism. There are six species of skinks such as *Eutropis nagarjunii*, *Lygosoma ashwamedhi*, *Eutropis trivitata*, *Barkudia insularis*, *Barkudia melanosticta*, and *Sepsophis punctata* are endemic to the Eastern Ghats and the Three-lined grass skink (*Eutropis trivitattata*) is Indian endemic species distributed in this landscape. Another very interesting and endemic skink is *Lygosoma vosmaeri* which was rediscovered from Jaggayapet, Andhra Pradesh-Eastern Ghats (see Seetharamaraju et al. 2009), far from the historical locality Bengal. Among the geckos, the golden gecko, is endemic to eastern Ghats and species like *Cyrtodactulus nebulosus*, *Geckoella jeyporensis*, *Hemidactylus gigantius*, *H. reticulatus*, *H. graniticolus*, *H. gracilis*, *H. treutleri*, and *Hemiphyllodactylus aurantiacus* are Indian endemics. This landscape also harbours three Indian endemic Agamids (*Psammophilus blanfordanus*, *P. dorsalis*, and *Draco dussumieri*) and four snake species (*Coluber bholanathi*, *Lycodon travancoricus*, *Gerrhopilus beddomei*, and *Uropeltis ellioti*).

Among the amphibians, *Duttaphrynus hulolius*, *Raorchestes sanctisilvaticus*, *R. terebrans*, *R. similipalensis*, *Sphaereotheca dobsonii*, and *Fejervarya orissaensis* are Indian endemic species distributed in Eastern Ghats. In addition to these the only known caecilian,species endemic to Eastern Ghats is the East-Indian Geg (*Gegeneophis orientalis*), which is sister to all other (Western Ghats) *Gegeneophis* and the diver-

Figure 9. Gangetic soft-shell turtle (*Nilssonia gangeticus*), distributed in major river systems of Odisha is facing the threats from poaching and pollution.

gence between Eastern and Western Ghats *Gegeneophis* likely occurred during > 35 Ma (Gower et al. 2016).

Threatened Fauna of Eastern Ghats

Among the mammalian fauna there is one species listed as critically Endangered (*Cremnomys elvira*), five of Endangered category (*Elephas maximus*, *Prionailurus viverrinus*, *Panthera tigris*, *Cuon alpines*, and *Bubalus arnee*), seven species of Vulnerable category (*Prionailurus rubiginosus*, *Melursus ursinus*, *Aonyx cinera*, *Lutrogale perspicillata*, *Rusa unicolor*, *Bos gaurus*, and *Tetracerus quadricornis*), eight species of Near Threatened category (*Semnopithecus priam*, *Ratufa macroura*, *Miniopterus schreibersii*, *Manis crassicaudata*, *Panthera pardus*, *Viverra zibetha*, *Hyaena hyaena*, and *Antilope cervicapra*), 74 species of Least Concerned category and one species (*Herpestes auropunctatus*) is not yet evaluated.

As per Wildlife (Protection) Act of 1972 18 species are listed in Schedule-I, 18 in Schedule-II (Part-2), 6 in Schedule-III, 3 in Schedule-IV, 15 in Schedule-V and rest 36 species are not listed in any of the Schedules of Wildlife (Protection) Act of 1972. Other rare mammals of Eastern Ghats are *Eonycteris spelaea*, *Rhinolophus pusillus*, *Taphozous perforates*, *Myotis montivagus*, *Murina cyclotis*, *Tadarida aegyptiaca*, and *Aonyx cinereus* (see Bates and Harrison 1997, Srinivasulu and Nagulu 2001, Mohapatra et al. 2015).

This landscape harbours several globally threatened avifaunal species. Rahmani and Nair (2012) mentioned about 6 Critically Endangered, four Endangered, 11 Vulnerable and 22 Near Threatened species of birds from Odisha, of which four species are distributed in the Eastern Ghat ranges of Odisha. Among the CR category White-rumped vulture (*Gyps bengalensis*), Red-headed vulture (*Aegyps calvus*), Baer's pochard (*Aythys baeri*) and Spoon-billed sandpiper (*Eurynorhynchus pygmeus*) are the extant species and the pink-headed duck is thought to be extinct in Odisha (northern most Eastern Ghat range; Khurdha vide Taylor 1887). Other rare and Critically Endangered species in this landscape is the Great Indian Bustard, which has completely disappeared from Harryana, Punjab, Uttar Pradesh, Tamil Nadu and Odisha but thrives with a small population in Andhra Pradesh. Among the Endangered species Egyptian vulture, Black-bellied tern and Jerdon's cursor are quite important from conservation point of view.

The Eastern Ghats landscape is home for two critically endangered reptiles, namely Gharial, Jeypore hill gecko, and Barkud spotted skink. Among the endangered category there are two species such as Indian Narrow-headed Softshell Turtle and Elongated Tortoise. Other herpetofaunal species listed under vulnerable category are Indian Softshell Turtle, Indian Peacock Softshell Turtle, Leith's Softshell Turtle, Tricarinate Hill Turtle, Mugger, Ashwamedh Writhing Skink and King cobra are distributed in this landscape. There are also many species of data deficient category, such as Blanford's Mabuya, Vosmer's Writhing Skink, Russell's Legless Skink, Jerdon's gecko, Sharma's Racer and Beddome's Worm Snake which need urgent conservation attention. Similarly the only known caecilian species (East Indian Geg) is also of Data Deficient category.

Threats to the Fauna

Most of the natural vegetation is in a highly degraded state, leaving behind only few pockets of habitats which harbour many faunal novelties. Hence, assessment, valuation, protection, and conservation of the remaining biodiversity rich areas should be considered high priority while developing a management plan for this landscape. Habitats of many threatened species are vanishing at a faster rate due to several anthropogenic factors some of which are beyond the control of forest managers. This is due to lack of coordination between policy makers, politicians, forest managers, local community, NGOs, field biologists, and conservationists. The most referred working plan/management plans of the state have underestimated the biodiversity component both qualitatively and quantitatively, this has failed to address the proper valuation of biodiversity. Extensive surveys of biodiversity have not been conducted for most taxonomic groups and ecosystem types. Such lack of information severely hinders the assessment of the value of existing species, their status and threats which might affect their long-term conservation.

Most of the areas in the Eastern Ghats are rich in mineral resources, hence the "developmental activities" are carried out at the stake of biodiversity. Furthermore, the major threats to the species arise from poaching (large scale in past) and habitat destruction due to anthropogenic activities. Other severe threats to the biodiversity include habitat fragmentations, deterioration and loss of habitat, poaching, invasion of exotic species, livestock grazing, environmental pollution, and last but not the least habitat destruction due to mining activities. There are also prevailing threats due to increasing commercialization of biodiversity products as per the demand of global market, which has been carried out without sharing the benefits with the local community. Although steps have been taken by the state Government, it needs serious attention. The primary deciduous forests all across the Eastern Ghats have undergone many

Figure 10. The Royal Bengal tiger (*Panthera tigris*), one distributed across the forested landscape of Eastern Ghats is now mostly restricted to the Tiger Reserves.

changes owing to various need-based forest managements, such as timber extraction for industry, railway sleepers, charcoal, and forest clearance for hydroelectric projects and agriculture, during preindependence and postindependence periods (Jayakumar et al. 2009).

Tigers, which were once abundant in the entire forested landscape of Eastern Ghats, are now struggling for survival even in the tiger reserves. Relentless poaching for feeding the Chinese demand for tiger body parts, extermination of deer and other prey species through over hunting by local communities, large scale habitat loss due to mining and other developmental activities, and poisoning of tigers in retaliation for livestock depredation have made the status of tigers extremely critical. A similar fate faces the elephant population and elephants are particularly affected by habitat loss as their age-old migration corridors between forest landscapes are being broken by developmental activities causing the isolation of their populations and forcing them into deadly conflict with farmers. Elephant corridors, i.e., habitats linking one elephant habitat with another, are extremely important as these are used by different sub-populations of elephants for interbreeding and healthy genetic exchange, as well as for migrating to rich foraging areas in pinch-seasons.

Some species of mammals like slender Loris is severely threatened due to rampant killing spurred by superstitious beliefs and the need for folk medicine (Srinivasulu and Nagulu 2001). Mohapatra et al. (2015) summarized threats to the Pangolins of India in detail and suggested various measures for conservation.

Habitat Loss

Habitat degradation in terms of mining, industrialization, sand mining, stone quarries, human intrusion, logging, residential and commercial development, and fragmentation of forests seriously affect the population of as many

Figure 11. Spotted deer (*Axis axis*), the major prey base for carnivores.

as 70% of the terrestrial faunal species in this landscape. Although such processes cannot be stopped completely, levelheaded planning will be helpful in preventing the damage. Deleterious impact of of habitat loss or fragments on mega fauna is well known to us. However, mammals like smaller ungulates, many species of habitat specific birds, herpetofauna such as Jeypore hill gecko, King cobra, and Leith's softshell turtle are severely affected by habitat loss in this Eastern Ghats landscape. Conversion of wetlands for construction purposes affects aquatic species like otters, aquatic birds, many reptiles and amphibians. Due to utilization of virgin lands for human settlement, a clear majority of these agricultural and open fields are gradually vanishing. Hence, there is a threat to future survival of some frog species. Major parts of Eastern Ghats are also seriously affected by extensive 'podu' (slash and burn) cultivation, which pose serious threat to various faunal species.

Pollution

In broad terms pollution is the impact of anthropogenic activities. Air, water, and solid waste pollution directly affect the aquatic species causing various genetic and morphogenesis deformities. Sometimes the overdose can cause complete extirpation of the population. Industrial effluents drained to aquatic ecosystems, eutrophication, and runoff of agricultural pesticides are some of the major threats to aquatic species.

Poaching

Poaching is the commercial exploitation of various faunal species for purposes such as traditional medicine, meat, skin, and for pet trade. Despite legislative protection, illegal exploitation and trade in wild animal body parts continues to occur in India, which is having a seemingly deleterious effect on wild populations of certain species. Various methods are adapted by poachers to hunt wild animals in Eastern Ghats. Poaching for commercial use of animal body parts is a serious threat to many wild animals like tigers, elephants, sloth bear and many more animal species.

Poaching of tigers and leopards are mostly done by gun shoot, poisoning, foot trap and some tribe kill the tigers by bow and arrow. The tiger once killed is difficult to trace as all the body parts are used by the poachers. In Odisha there is recent market of tiger bone (pers. obs.). Elephant poaching is a serious conservation issue as the tuskers are targeted for ivory. The Central Indian and South Indian elephant population the male tuskers are targeted and there are reports of involvement of Lisu tribe from Arunanchal Pradesh, who are hiered by local poachers. The Lisu tribe use poisoned arrow to shoot the elephants and ones the animal succumbs, the ivory is removed in a brutal way. Most poachers use gun to kill the elephants. Apart from poaching lephants are killed by electrocutation. Intentional sagging of electric wire or live wire spreaded on ground near the crop fields easily victimise the elephants and other animals (including humans). Similarly various deer species are poached by gun, bow and arrow and by communal hunting methods. Various tribal communities in Eastern Ghats hunt for small to large "game animals" as a communal ritual. Another serious

conservation issue related to sloth bear is from demand of bear bile and use of bear oil in traditional medicine to cure arthritis. Sloth bears in this landscape are poisoned, apart from other general hunting methods, to meet the increasing demand for their body parts. Among other small mammals poaching of pangolins is a serious problem in its distribution range and Mohapatra et al. (2012) dealt on this issue in detail. Additionally cave dwelling animals like porcupine and pangoline are poached by using smoke. In this method all the openings of the burrow are sealed except the main entrance. Then the poachers lit fire and fan near it to fill the burrow with smoke and then the entrance is sealed. The following day dead animals are then collected by entering in to the den. Poaching of otters by using hunting dogs and using nets for pelt are discussed in detail by Mohapatra et al. (2014).

Apart from mammals many birds face the threat of poaching for bush meat and use of body parts in traditional medicine. Specifically hornbills are killed to extract oil from the fats, which is believed to cure arthritis and joint pain. Peafowls are also poached for their feathers and in some cases farmers use poison to kill these birds, as they cause damage to the crop fields. Many birds are also poached for pet trade (Munias, parakeets and hill myna).

Among the reptiles crocodiles are poached for their skin, which is used to make belt and shoes. Eggs of crocodiles are also collected by some tribe as observed by the authors in Saleru River. Various turtle species are generally poached for local consumption of meat, use of their body parts in traditional medicine, and for trading to other states of the country. The poaching methods used are hooking, floating hook chains, harpooning, baiting, and poaching of eggs (Mohapatra et al. 2009). Sometimes turtles are caught during fishing activities. Thousands of olive ridley sea turtles and fresh water species like Indian Soft Shell turtles, Indian Peacock Shell Turtles, and Narrow headed soft shelled turtles are caught. Mostly the edible species are consumed whereas non-edible species like the olive ridley and hard-shelled turtles die unnatural deaths. Lizards, especially monitor lizards, are poached for meat and for the use of their skin in

Figure 12. The Critically Endangered White-rumped vultures (*Gyps bengalensis*) is only represented by few individuals in wild.

making musical instruments. Hunting of monitor lizards involves hand capture and some communities use trained dogs for hunting purposes. Other lizards such as the chameleon and the fat-tailed gecko, are poached for use of their body parts in tradition medicine and to keep them as pets. Apart from intentional poaching, lizards are killed or persecuted for the blind belief associated with them. Many of them are thought to be highly poisonous and hence killed when sighted. Snakes on the other hand are poached for use in displays, keeping as pets, meat, and skin. Most of the snake species are persecuted for blind beliefs associated with them. Snakes are probably the most dreaded reptiles in terms of death rates and the myths associated with them. So irrespective of their nature of venom (whether potentially dangerous or harmless) snakes are invariably killed.

Many of the amphibians (mostly the Hoplobatrachus species and the green pond frog) are consumed for their meat. Although poaching of these frogs has recently reduced, still there are some reports of such cases in rural areas. Fortunately, there is no commercial exploitation of frogs in Odisha, except some people use these species as a luxury meat or essential meat for cure of asthma and both the above species are included in Wildlife (Protection) Act of 1972. In addition, the export of these species requires permits under CITES and the Indian Wildlife (Protection) Act of 1972.

Diseases

Wild animals throughout their distribution range are prone to diseases, mostly spread by the domestic livestock. Several cases of diseases are recorded but remain unreported due to several reasons (well known to conservationists). One of the most common diseases is foot-and-mouth viral infection in Gaurs, which is primarily spreaded by domestic cattle. There are also sporadic reports of anthrax, nematode parasite infection, tick infection, pneumonia etc. among wild animals. Carnivores are also vector of Rabbis and they transmit the virus to domestic animals through contamination. Among the reptiles snakes and monitor lizards are often infected by ticks and mites in their natural habitats which make them sick. However, impacts of such diseases are not well studied. Furthermore, diseases are often climate related, so surveillance and monitoring such diseases in nature will be effective to control any epidemic in future.

Climate Change

Studies conducted elsewhere in the worldhaveshown that many lizard populations have already gone extinct, seemingly from climate warming. Smaller animals, especially amphibians and reptiles are being driven to local extinction by climate-driven changes in vegetation, specifically by changes in plant canopy structure and habitat, which alters operative heat loads on adults (Ruibal 1961), and by soil moisture potential and temperatures in lizard nests (Muth 1980). Climate change and other habitat-related threats are not yet studied in detail in the Eastern Ghat landscape. However, comparison of historical data and the present studies shows that many species adapt to the climatic variation and some are seriously threatened. Studies have also shown that many amphibian species adapted to prolonged breeding periods and skipped hibernation.

Incomplete Assessment

Many of the ecological assessment projects made for clearance of developmental activities have underestimated the actual species diversity either in favour of the companies or due to ignorance. Similarly, road traffic poses some serious threats on faunal species as the road kill incidents increases and many small mammals, reptiles and amphibians are completely cut-off from the nearby populations. Hence, developmental projects without scientific validation of impact assessments severely affect the local fauna. Furthermore, with the advancement of modern techniques and scientific thought, a better management strategy can be developed without affecting much to the ecosystem.

Conservation of Faunal Diversity of Eastern Ghats

Species conservation is the foundation of biodiversity conservation. Every possible measure needs to be taken to ensure the survival of our remaining species and their habitats in healthy populations and over large landscapes. While most of the critically endangered, endangered, vulnerable, and near-threatened species are given highest protection under the Wildlife (Protection) Act of1972 (amended in 2006), by it self is not adequate to save them from extinction. In a recent hearing, the Supreme Court has identified that implementation of the WPA has failed in protecting endangered species and an exclusive parliamentary legislation for the preservation and protection of endangered species has been called for.

Prioritization of Eastern Ghats Landscape

It is high time to prioritize landscapes across Eastern Ghats by conducting systematic biodiversity assessments incorporating geological and geospatial data. The areas can be classified as different zones based on biodiversity value. Developmental projects like mines and industries can be carriedout only in the specified zones. In the process areas with high biodiversity values shall be left undisturbed including protected areas. As most of the forested landscape of Eastern Ghats are affected by slash andburn cultivation, an integrated approach to biodiversity conservation and better agricultural practices should be adopted. Primary and mature forests should be identified, mapped, and given immediate protection, until a scientifically-based management plan is developed.

Conservation Breeding Programmes

The Central Zoo Authority was created by the Government of India in 1992 through an amendment of the Wildlife (Protection) (Amendment 1991) Act of 1972. The main objective was to enforce minimum standards and norms for upkeep and healthcare of animals in Indian Zoos so that the zoos of the country come up to a standard where they can complement and strengthen the national efforts in conservation of wild fauna. Attempts for saving some of the endangered or critically endangered species have already been experimented with in India. Species like Pangoline, Gharial, vultures, and Mugger have

been tried for ex situ breeding. However, it is important to remember that mere breeding programs cannot save species unless the root threats of habitat destruction and anthropogenic pressures are addressed.

In-situ and ex-situ conservation breeding followed by reintroduction of a species into the wild may help in the conservation of endangered species, but in many instances the rate of breeding success of endangered species is very high in ex-situ enclosures and, without planned reintroduction into natural habitats, these initiatives fail to meet their objective.

PA networks and Restoration of habitats

A series of protected areas (PAs) have been established by the government to conserve the regional biodiversity, but their effectiveness is often questionable.The Government of Andhra Pradesh has declared Papikonda as a National Park in the Eastern Ghats to conserve wildlife and associatedhabitat. Further a network of Protected Areas including those in Eastern Ghats havebeen established to protect and conserve wildlife including rare animals and their habitats.

A Study on the ecological status in PAs of Andhra Pradesh conducted by Rawat (1997) shows that habitat of large bodied and wide ranging species, rare species, and habitat specialists are particularly prone to extinction because of rapid human modifications of landscapes.The study also reports that Srivenkateshwara National Park in the Seshachalam Hills, Gundlabrahmeshwaram Sanctuary in Nallamalais, and some parts of Srisailam-Nagarjunasagar Tiger Reserve, had the least degraded forests due to their PA status. Similar studies were also conducted by Balaguru (2006) in Shervarayan hills, Eastern Ghats of Tamil Nadu and Dash et al. (2007) in Niyamgiri hills, Odisha.

Rawat (1997) recommended habitat restoration for endangered species neededto be done on apriority basis. Furthermore, apart from protected areas, local biodiversity hot-spots can be identified and secured because many of thesehabitats are on the verge of depletion and need our attention before it is too late.

There are four IBAs in Eastern Ghats part of Odisha namely Chandaka-Dampada Wildlife Sanctuary, Chilika Lake and Wildlife Sanctuary, Mangalajodi and Satkosia Gorge Wildlife Sanctuary. The Secondary Bird Area in Eastern Andhra Pradesh (SA: s071) is identified for the Endangered Jerdon's Courser (Rhinoptilus bitorquatus) which is a poorly known nocturnal bird, thought extinct for 86 years (King 1978-1979) until its rediscovery in January 1986. Another Critically Endangered bird found in the Eastern Ghats is Great Indian bustard which is distributed in Rollapadu wild life sanctuary (6.14 km^2), Andhra Pradesh. The major threats and conservation issues for this species in this sanctuary are due to poaching, irresponsible management inputs, irrigation projects and lack of grazing policy (Ghouse and Indira 2015).

Another most important issue related to conservation of wild mammals is spreading of diseases by the livestock population residing in and around PAs. Although it is part of the management to immunize the livestocks for various viral diseases, in most cases such programmes are only done in pen and paper.

Law andenforcement

Strict enforcement measures to curb poaching and habitat degradation are necessary if we are to save our endangered species. Although most of the rare and endangered species are given highest protection status under law, enforcement and conviction are rare in India. Judicial initiatives for wildlife protection are therefore welcome.

The National Wildlife Action Plan (2002-2016) formulated in 2002, emphasized people's participation and their support for wildlife conservation. In the changing global scenario, additional research on biodiversity (other than knowing the richness) is imperative to quantify the value of ecological services being provided. Understanding the gamut of factors governing the sustainability of biodiversity resources along with building the capacity of local community and other stakeholders are essential to achieve the goal of biodiversity conservation. The Biological Diversity Act of 2002 also provides space for sustainable use, conservation, and judicious equitable sharing of benefit out of the commercial utilization bioresources of any localities.The above steps shall be helpful for a critical assessment of conservation priorities in this data-deficient region.

Lack of Awareness

Lack of coordination and understanding between scientists, conservationists, the forest department, and other line agencies is a major constraint for conservation of endangered species. This can be overcome by regular status assessment exercises and time to time implementation of recommended conservation measures as well as greater interaction and coordination between all concerned parties. Use of traditional knowledge for sustainable and wise use of resources can be practiced to preserve the habitat of these rare species.

Local communities need to be engaged in conservation measuresthrough awareness, capacity building, provision of alternate means of livelihood, and reduction of their dependence on forest resources. Wherever consensus is achieved, voluntary relocation of communities from remote parts of protected areas is an excellent tool for both species conservation as well as social upliftment. Odisha has tremendous potential for ecotourism, which can serve a dual purpose by creating awareness among public about biodiversity as well as uplifting the socioeconomic condition of local communities.

Conclusion

Systematic surveys, documentation, and valuation of ecosystem services (services-provisioning, regulating, and cultural that local people obtaining form these ecosystems) are the priorities. The extent of Protected Areas in the Eastern Ghats landscape is inadequate, on the other hand the community-managed forests and some Reserve Forests are refuges for many threatened and rare biodiversity, which need urgent attention in terms of landscape level conservation action planning. Assessing the biodiversity status and level of dependency on these habitats can be undertaken to prioritize the sites on the Eastern Ghats landscape. Traditional knowledge and management of forests still has a vital

role to play in forest management today. Hence valuation of different ecosystem services provided by a landscape is a prerequisite before any developmental activities.

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Web

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Appendix 1

Systematic Checklist of Extant Mammals, Birds, Reptiles, and Amphibians of Eastern Ghats

Class Mammalia Linnaeus, 1758
Subclass Theria Parker and Haswell, 1897
Infraclass Placentalia Owen, 1837
Order Proboscidea Illiger, 1811
Family Elephantidae Gray, 1821
1. *Elephas maximus*
Order Scandentia Wagner, 1855
Family Tupaiidae Gray, 1825
2. *Anathana ellioti* (Waterhouse, 1850)
Order Primates Linnaeus, 1758
Suborder Strepsirrhini Geoffroy Saint-Hilaire, 1812
Infraorder Simiiformes Haeckel, 1866
Superfamily Cercopithecoidea Gray 1821
Family Cercopithecidae Gray, 1821
3. *Macaca mulatta* (Zimmermann, 1780)
4. *Macaca radiata* (E. Geoffroy, 1812)
5. *Semnopithecus entellus* (Dufresne, 1797)
6. *Semnopithecus* priam (Blyth, 1844)
Suborder Strepsirrhini É. Geoffroy Saint-Hilaire, 1812
Infraorder Lorisiformes Gregory, 1915
Family Lorisidae
7. *Loris lydekkerianus (*Cabrera, 1908)
Order Rodentia Bowdich, 1821
Suborder Sciuromorpha Brandt, 1855
Family Sciuridae Fischer, 1817
8. *Funambulus palmarum* (Linnaeus, 1766)
9. *Funambulus pennantii* Wroughton, 1905
10. *Ratufa indica* (Erxleben, 1777)
11. *Ratufa macroura* (Pennant, 1769)
12. *Petaurista philippensis* (Elliot, 1839)
Suborder Myomorpha Brandt, 1855
Superfamily Muroidea Illiger, 1811
Family Muridae Illiger, 1811
13. *Bandicota bengalensis* (Gray and Hardwicke, 1833)
14. *Bandicota indica* (Bechstein, 1800)
15. *Madromys blanfordi* (Thomas, 1881)
16. *Golunda ellioti* (Gray, 1837)
17. *Cremnomys Elvira* (Ellerman, 1946)
18. *Mus boduga* (Gray, 1837)
19. *Mus musculus* (Linnaeus, 1758)
20. *Rattus norvegicus* (Berkenhout, 1769)
21. *Rattus rattus* (Linnaeus, 1758)
22. *Vandeleuria oleracea* (Bennett, 1832)
23. *Tatera indica* (Hardwicke, 1807)
Suborder Hystricomorpha Brandt, 1855
Infraorder Hystricognathi Tullberg, 1899
Family Hystricidae Fischer, 1817
24. *Hystrix indica* (Kerr, 1792)
Order Lagomorpha Brandt, 1855
Family Leporidae Fischer, 1817
25. *Lepus nigricollis* (F. Cuvier, 1823)
Order Soricomorpha Gregory, 1910
Family Soricidae Fischer, 1814
26. *Suncus etruscus* (Savi, 1822)

27. *Suncus murinus* (Linnaeus, 1766)

Order Eulipotyphla

Family: Erinaceidae

28. Paraechinus nudiventris (Horsefield, 1851)

Order Chiroptera Blumenbach, 1779

Family Pteropodidae Gray, 1821

29. *Cynopterus sphinx* (Vahl, 1797)
30. *Pteropus giganteus* (Brunnich, 1782)
31. *Rousettus leschenaulti* (Desmarest, 1820)
32. *Eonycteris spelaea* (Dobson, 1871)

Family Rhinolophidae Gray, 1825

33. *Rhinolophus lepidus* Blyth, 1844
34. *Rhinolophus rouxii* Temminck, 1835
35. *Rhinolophus beddomei* Andersen, 1905
36. *Rhinolophus pusillus* Temminck, 1834

Family Hipposideridae Lydekker, 1891

37. *Hipposideros ater* Templeton, 1848
38. *Hipposideros fulvus* Gray, 1838
39. *Hipposideros galeritus* Cantor, 1846
40. *Hipposideros lankadiva* Kelaart, 1850
41. *Hipposideros speoris* (Schneider, 1800)

Family Megadermatidae Allen, 1864

42. *Megaderma lyra* E. Geoffroy, 1810
43. *Megaderma spasma* (Linnaeus, 1758)

Family Rhinopomatidae Bonaparte, 1838

44. *Rhinopoma hardwickii* Gray, 1831
45. *Rhinopoma microphyllum* (Brunnich, 1782)

Family Emballonuridae Gervais, 1855

46. *Saccolaimus saccolaimus* (Temminck, 1838)
47. *Taphozous longimanus* Hardwicke, 1825
48. *Taphozous melanopogon* Temminck, 1841
49. *Taphozous nudiventris*
50. *Taphozous perforatus*

Family Vespertilionidae Gray, 1821

51. *Hesperoptenus tickelli* (Blyth, 1851)
52. *Pipistrellus ceylonicus* (Kelaart, 1852)
53. *Pipistrellus coromandra* (Gray, 1838)
54. *Pipistrellus dormer* (Dobson, 1875)
55. *Pipistrellus tenuis* (Temminck, 1840)
56. *Scotophilus heathii* (Horsfield, 1831)
57. *Scotophilus kuhlii* Leach, 1821
58. *Kerivoula picta* (Pallas, 1767)
59. *Miniopterus schreibersii* (Kuhl, 1817)
60. *Myotis montivagus* (Dobson, 1874)
61. *Murina cyclotis* Dobson, 1872

Family Molossidae

62. Tadarida aegyptiaca (É. Geoffroy, 1818)

Order Pholidota

Family Manidae Gray, 1821

63. *Manis crassicaudata* Gray, 1827

Order Carnivora Bowdich, 1821

Suborder Feliformia Kretzoi, 1945

Family Felidae Fischer, 1817

64. *Felis chaus* Schreber, 1777
65. *Felis silvestris* Schreber, 1777
66. *Prionailurus bengalensis* (Kerr, 1792)
67. *Prionailurus rubiginosus* (I. Geoffroy S-H, 1831)
68. *Prionailurus viverrinus* (Bennett, 1833)
69. *Panthera pardus* (Linnaeus, 1758)
70. *Panthera tigris* (Linnaeus, 1758)

Family Viverridae Gray, 1821
71. *Paradoxurus hermaphrodites* (Pallas, 1777)
72. *Viverra zibetha* Linnaeus, 1758
73. *Viverricula indica* (Desmarest, 1804)

Family Hyaenidae Gray, 1821
74. *Hyaena hyaena* (Linnaeus, 1758)

Family Herpestidae Bonaparte, 1845
75. *Herpestes edwardsii* (I. Geoffroy S-H, 1818)
76. *Herpestes auropunctatus*
77. *Herpestes smithii* Gray, 1837
78. *Herpestes vitticollis* Bennet, 1835

Suborder Caniformia Kretzoi, 1938

Family Canidae Fischer, 1817
79. *Canis aureus* Linnaeus, 1758
80. *Canis lupus* Linnaeus, 1758
81. *Canis alpines* (Pallas, 1811)
82. *Vulpes bengalensis* (Shaw, 1800)

Family Ursidae Fischer, 1817
83. *Melursus ursinus* (Shaw, 1791)

Family Mustelidae Fischer, 1817
84. *Millivora capensis* (Schreber, 1776)
85. *Aonyx cinereus* (Illiger, 1815)
86. *Lutrogale perspicillata* (I. Geoffroy S-H, 1826)

Order Artiodactyla Owen, 1848

Family Suidae Gray, 1821
87. *Sus scrofa* Linnaeus, 1758

Family Tragulidae Milne-Edwards, 1864
88. *Moschiola indica*

Family Cervidae Goldfuss, 1820
89. *Axis axis* (Erxleben, 1777)
90. *Rusa unicolor* Kerr, 1792
91. *Muntiacus muntjak*

Family Bovidae Gray, 1821
92. *Bos gaurus* Smith, 1827
93. *Bubalus arnee* (Kerr, 1792)
94. *Boselaphus tragocalamus* (Pallas, 1766)
95. *Tetracerus quadricornis* (Blainville, 1816)

Family Antilocapridae Gray, 1866
96. *Antilope cervicapra* (Linnaeus, 1758)
97. *Gazella bennettii* (Sykes, 1831)

Avifauna

Order Anseriformes

Family Anatidae
1. Greylag Goose *Anser anser*
2. Greater White-fronted Goose *Anser albifrons*
3. Lesser White-fronted Goose *Anser erythropus*
4. Bar-headed Goose *Anser indicus*
5. Knob-billed Duck (Comb Duck) *Sarkidiornis melanotos*
6. Common Shelduck *Tadorna tadorna*
7. Ruddy Shelduck *Tadorna ferruginea*
8. Cotton Pygmy-goose *Nettapus coromandelianus*
9. Gadwall *Anas strepera*
10. Eurasian Wigeon *Anas penelope*
11. Mallard *Anas platyrhynchos*
12. Indian Spot-billed Duck *Anas poecilorhyncha*
13. Northern Shoveler *Anas clypeata*
14. Northern Pintail *Anas acuta*
15. Garganey *Anas querquedula*
16. Common Teal *Anas crecca*
17. Pink-headed Duck *Rhodonessa caryophyllacea*

18. Red-crested Pochard *Netta rufina*
19. Common Pochard *Aythya ferina*
20. Ferruginous Duck *Aythya nyroca*
21. Tufted Duck (Tufted Pochard) *Aythya fuligula*
22. Fulvous Whistling-duck *Dendrocygna bicolor*
23. Lesser Whistling-duck *Dendrocygna javanica*

Galliformes

Phasianidae (partridges, pheasants, grouse)

24. Black Francolin *Francolinus francolinus*
25. Painted Francolin *Francolinus pictus*
26. Grey Francolin *Francolinus pondicerianus*
27. Common Quail *Coturnix coturnix*
28. Rain Quail *Coturnix coromandelica*
29. King Quail *Coturnix chinensis*
30. Painted Bush Quail *Perdicula erythrorhyncha*
31. Red Spurfowl *Galloperdix spadicea*
32. Painted Spurfowl *Galloperdix lunulata*
33. Red Junglefowl *Gallus gallus*
34. Grey Junglefowl *Gallus sonneratii*
35. Indian Peafowl *Pavo cristatus*

Phoenicopteriformes

Phoenicopteridae

36. Greater Flamingo *Phoenicopterus roseus*
37. Lesser Flamingo *Phoenicopterus minor*

Podicipedidae (Grebes)

38. Little Grebe *Tachybaptus ruficollis*
39. Great Crested Grebe *Podiceps cristatus*

Columbiformes

Columbidae (pigeons)

40. Common Pigeon (Rock Pigeon) *Columba livia*
41. Pale-capped Pigeon *Columba punicea*
42. Oriental Turtle Dove *Streptopelia orientalis*
43. Eurasian Collared Dove *Streptopelia decaocto*
44. Red Collared Dove *Streptopelia tranquebarica*
45. Spotted Dove *Stigmatopelia chinensis*
46. Laughing Dove *Stigmatopelia senegalensis*
47. Emerald Dove *Chalcophaps indica*
48. Orange-breasted Green Pigeon *Treron bicinctus*
49. Thick-billed Green Pigeon *Treron curvirostra*
50. Yellow-footed Green Pigeon *Treron phoenicopterus*
51. Green Imperial Pigeon *Ducula aenea*

Pterocliformes

Pteroclidae (sandgrouse)

52. Chestnut-bellied Sandgrouse *Pterocles exustus*
53. Painted Sandgrouse *Pterocles indicus*

Caprimulgiformes

Caprimulgidae

54. Indian Jungle Nightjar *Caprimulgus indicus*
55. Grey Nightjar *Caprimulgus* (*indicus*) *jotaka*
56. Jerdon's Nightjar *Caprimulgus atripennis*
57. Large-tailed Nightjar *Caprimulgus macrurus*
58. Indian Nightjar *Caprimulgus asiaticus*
59. Savanna Nightjar *Caprimulgus affinis*
60. Great eared Nightjar

Apodidae (swifts)

61. White-rumped Spinetail *Zoonavena sylvatica*
62. Asian Palm Swift *Cypsiurus balasiensis*
63. Alpine Swift *Tachymarptis melba*
64. House (Little) Swift *Apus affinis*
65. Crested Treeswift *Hemiprocne coronata*

Cuculiformes
Cuculidae

66. Asian Koel *Eudynamys scolopaceus*
67. Green-billed Malkoha *Rhopodytes tristis*
68. Blue-faced Malkoha *Rhopodytes viridirostris*
69. Sirkeer Malkoha *Taccocua leschenaultii*
70. Southern (Greater) Coucal *Centropus* (*sinensis*) *parroti*
71. Lesser Coucal *Centropus bengalensis*
72. Jacobin Cuckoo (Pied Crested Cuckoo) *Clamator jacobinus*
73. Chestnut-winged Cuckoo *Clamator coromandus*
74. Large Hawk Cuckoo *Hierococcyx sparverioides*
75. Common Hawk Cuckoo *Hierococcyx varius*
76. Indian Cuckoo *Cuculus micropterus*
77. Eurasian Cuckoo *Cuculus canorus*
78. Lesser Cuckoo *Cuculus poliocephalus*
79. Banded Bay Cuckoo *Cacomantis sonneratii*
80. Grey-bellied Cuckoo *Cacomantis passerinus*
81. Plaintive Cuckoo *Cacomantis merulinus*
82. Drongo Cuckoo *Surniculus lugubris*

Gruiformes
Rallidae

83. Slaty-legged Crake *Rallina eurizonoides*
84. Slaty-breasted Rail *Gallirallus striatus*
85. Water Rail *Rallus aquaticus*
86. Brown Crake *Amaurornis akool*
87. White-breasted Waterhen *Amaurornis phoenicurus*
88. Baillon's Crake *Porzana pusilla*
89. Ruddy-breasted Crake *Porzana fusca*
90. Watercock *Gallicrex cinerea*
91. Purple Swamphen (Purple Moorhen) *Porphyrio porphyrio*
92. Common Moorhen *Gallinula chloropus*
93. Common Coot (Eurasian Coot) *Fulica atra*

Gruidae

94. Demoiselle Crane *Grus virgo*
95. Sarus Crane *Grus antigone*
96. Common Crane *Grus grus*

Otidiformes
Otidiae

97. Great Indian Bustard *Ardeotis nigriceps*
98. Lesser Florican *Sypheotides indicus*

Pelecaniformes
Pelecanidae (pelicans)

99. Great White Pelican *Pelecanus onocrotalus*
100. Spot-billed Pelican (Grey Pelican) *Pelecanus philippensis*

Ciconiidae (storks)

101. Painted Stork *Mycteria leucocephala*
102. Asian Openbill *Anastomus oscitans*
103. Black Stork *Ciconia nigra*
104. Woolly-necked Stork *Ciconia episcopus*
105. White Stork *Ciconia ciconia*
106. Black-necked Stork *Ephippiorhynchus asiaticus*
107. Lesser Adjutant *Leptoptilos javanicus*

Ardeidae

108. Yellow Bittern *Ixobrychus sinensis*
109. Cinnamon Bittern *Ixobrychus cinnamomeus*
110. Black Bittern *Dupetor flavicollis*
111. Black-crowned Night Heron *Nycticorax nycticorax*
112. Indian Pond Heron *Ardeola grayii*
113. Cattle Egret *Bubulcus ibis*
114. Grey Heron *Ardea cinerea*
115. Goliath Heron *Ardea goliath*

116. Purple Heron *Ardea purpurea*
117. Great Egret *Casmerodius albus*
118. Intermediate Egret *Mesophoyx intermedia*
119. Little Egret *Egretta garzetta*

Threskiornithidae

120. Black-headed Ibis (Oriental White Ibis) *Threskiornis melanocephalus*
121. Red-naped Ibis (Black Ibis) *Pseudibis papillosa*
122. Glossy Ibis *Plegadis falcinellus*
123. Eurasian Spoonbill *Platalea leucorodia*

Phalacrocoracidae

124. Little Cormorant *Phalacrocorax niger*
125. Indian Cormorant *Phalacrocorax fuscicollis*
126. Great Cormorant *Phalacrocorax carbo*

Anhingidae

127. Darter *Anhinga melanogaster*

Charadriiformes

Burhinidae

128. Eurasian Thick-knee *Burhinus* (*oedicnemus*) *indicus*
129. Great Thick-knee *Esacus recurvirostris*
130. Eurasian Oystercatcher *Haematopus ostralegus*

Recurvirostridae

131. Black-winged Stilt *Himantopus himantopus*
132. Pied Avocet *Recurvirostra avosetta*

Charadriidae

133. Pacific Golden Plover *Pluvialis fulva*
134. Grey Plover *Pluvialis squatarola*
135. Common Ringed Plover *Charadrius hiaticula*
136. Little Ringed Plover *Charadrius dubius*
137. Kentish Plover *Charadrius alexandrinus*
138. Lesser Sand Plover *Charadrius mongolus*
139. Greater Sand Plover *Charadrius leschenaultii*
140. River Lapwing *Vanellus duvaucelii*
141. Yellow-wattled Lapwing *Vanellus malabaricus*
142. Grey-headed Lapwing *Vanellus cinereus*
143. Red-wattled Lapwing *Vanellus indicus*
144. White-tailed Lapwing *Vanellus leucurus*

Rostratulidae (painted-snipe)

145. Greater Painted-snipe Rostratula benghalensis

Jacanidae

146. Pheasant-tailed Jacana *Hydrophasianus chirurgus*
147. Bronze-winged Jacana *Metopidius indicus*

Scolopacidae

148. Whimbrel *Numenius phaeopus*
149. Eurasian Curlew *Numenius arquata*
150. Jack Snipe *Lymnocryptes minimus*
151. Solitary Snipe *Gallinago solitaria*
152. Wood Snipe *Gallinago nemoricola*
153. Pintail Snipe *Gallinago stenura*
154. Common Snipe *Gallinago gallinago*
155. Asian Dowitcher *Limnodromus semipalmatus*
156. (Western) Black-tailed Godwit *Limosa limosa*
157. Eastern Black-tailed Godwit *Limosa* (*limosa*) *melanuroides*
158. Bar-tailed Godwit *Limosa lapponica*
159. Spotted Redshank *Tringa erythropus*
160. Common Redshank *Tringa totanus*
161. Marsh Sandpiper *Tringa stagnatilis*
162. Common Greenshank *Tringa nebularia*
163. Green Sandpiper *Tringa ochropus*
164. Wood Sandpiper *Tringa glareola*
165. Terek Sandpiper *Xenus cinereus*
166. Common Sandpiper *Actitis hypoleucos*

167. Ruddy Turnstone *Arenaria interpres*
168. Great Knot *Calidris tenuirostris*
169. Red Knot *Calidris canutus*
170. Sanderling *Calidris alba*
171. Red-necked Stint *Calidris ruficollis*
172. Little Stint *Calidris minuta*
173. Temminck's Stint *Calidris temminckii*
174. Long-toed Stint *Calidris subminuta*
175. Curlew Sandpiper *Calidris ferruginea*
176. Dunlin *Calidris alpina*
177. Spoon-billed Sandpiper *Eurynorhynchus pygmeus*
178. Broad-billed Sandpiper *Limicola falcinellus*
179. Ruff *Philomachus pugnax*

Turnicidae

180. Small Buttonquail *Turnix sylvaticus*
181. Yellow-legged Buttonquail *Turnix tanki*
182. Barred Buttonquail *Turnix suscitator*

Dromadidae

183. Crab-plover *Dromas ardeola*

Glareolidae

184. Indian Courser *Cursorius coromandelicus*
185. Jerdon's courser *Rhinoptilus bitorquatus*
186. Collared Pratincole *Glareola pratincola*
187. Oriental Pratincole *Glareola maldivarum*
188. Small Pratincole *Glareola lactea*

Laridae

189. Heuglin's Gull *Larus heuglini*
190. Steppe Gull *Larus* (*heuglini*) *barabensis*
191. Pallas's Gull *Ichthyaetus ichthyaetus*
192. Brown-headed Gull *Chroicocephalus brunnicephalus*
193. Black-headed Gull *Chroicocephalus ridibundus*
194. Gull-billed Tern *Gelochelidon nilotica*
195. Caspian Tern *Hydroprogne caspia*
196. Lesser Crested Tern *Thalasseus bengalensis*
197. Greater Crested Tern *Thalasseus bergii*
198. River Tern *Sterna aurantia*
199. Common Tern *Sterna hirundo*
200. Black-bellied Tern *Sterna acuticauda*
201. Little Tern *Sternula albifrons*
202. Whiskered Tern *Chlidonias hybrida*
203. White-winged Tern *Chlidonias leucopterus*
204. Indian Skimmer *Rynchops albicollis*

Accipitriformes

Pandionidae (osprey)

205. Osprey *Pandion haliaetus*

Accipitridae (kites, hawks and eagles)

206. Jerdon's Baza *Aviceda jerdoni*
207. Black Baza *Aviceda leuphotes*
208. Oriental Honey-buzzard *Pernis ptilorhynchus*
209. Black-winged Kite *Elanus caeruleus*
210. Black Kite *Milvus migrans*
211. Black-eared Kite *Milvus* (*migrans*) *lineatus*
212. Brahminy Kite *Haliastur indus*
213. White-bellied Sea Eagle *Haliaeetus leucogaster*
214. Pallas's Fish Eagle *Haliaeetus leucoryphus*
215. White-tailed Eagle *Haliaeetus albicilla*
216. Egyptian Vulture *Neophron percnopterus*
217. White-rumped Vulture *Gyps bengalensis*
218. Indian Vulture *Gyps indicus*
219. [Slender-billed Vulture *Gyps tenuirostris*]
220. Red-headed Vulture *Sarcogyps calvus*

221. Short-toed Snake Eagle *Circaetus gallicus*
222. Crested Serpent Eagle *Spilornis cheela*
223. Eurasian Marsh Harrier *Circus aeruginosus*
224. Crested Goshawk *Accipiter trivirgatus*
225. Shikra *Accipiter badius*
226. Besra *Accipiter virgatus*
227. Northern Goshawk *Accipiter gentilis*
228. White-eyed Buzzard *Butastur teesa*
229. Black Eagle *Ictinaetus malayensis*
230. Indian Spotted Eagle *Aquila hastata*
231. Greater Spotted Eagle *Aquila clanga*
232. Pied Harrier *Circus melanoleucos*
233. Tawny Eagle *Aquila rapax*
234. Steppe Eagle *Aquila nipalensis*
235. Bonelli's Eagle *Aquila fasciata*
236. Booted Eagle *Hieraaetus pennatus*
237. Changeable Hawk Eagle (Crested Hawk Eagle) *Nisaetus cirrhatus*

Strigiformes

Tytonidae (barn owls)

238. Barn Owl *Tyto alba*
239. Eastern Grass Owl *Tyto longimembris*

Strigidae (owls)

240. Collared (Indian) Scops Owl *Otus bakkamoena*
241. Oriental Scops Owl *Otus sunia*
242. Indian Eagle Owl *Bubo (bubo) bengalensis*
243. Spot-bellied Eagle Owl *Bubo nipalensis*
244. Dusky Eagle Owl *Bubo coromandus*
245. Brown Fish Owl *Ketupa zeylonensis*
246. Mottled Wood Owl *Strix ocellata*
247. Brown Wood Owl *Strix leptogrammica*
248. Jungle Owlet *Glaucidium radiatum*
249. Spotted Owlet *Athene brama*
250. Brown Hawk Owl *Ninox scutulata*
251. Short-eared Owl *Asio flammeus*

Trogoniformes

Trogonidae (trogons)

252. Malabar Trogon *Harpactes fasciatus*

Bucerotiformes

Bucerotidae (hornbills)

253. Indian Grey Hornbill *Ocyceros birostris*
254. Malabar Pied Hornbill *Anthracoceros coronatus*
255. Oriental Pied Hornbill *Anthracoceros albirostris*
256. Great Hornbill *Buceros bicornis*

Upupidae (hoopoes)

257. Common Hoopoe *Upupa epops*

Piciformes

Picidae (woodpeckers)

258. Eurasian Wryneck *Jynx torquilla*
259. Speckled Piculet *Picumnus innominatus*
260. Brown-capped Pygmy Woodpecker *Dendrocopos nanus*
261. Fulvous-breasted Woodpecker *Dendrocopos macei*
262. Yellow-crowned Woodpecker *Dendrocopos mahrattensis*
263. Rufous Woodpecker *Micropternus brachyurus*
264. White-bellied Woodpecker *Dryocopus javensis*
265. Lesser Yellownape *Picus chlorolophus*
266. Greater Yellownape *Picus flavinucha*
267. Streak-throated Woodpecker *Picus xanthopygaeus*
268. Grey-headed Woodpecker *Picus canus*
269. Himalayan Goldenback *Dinopium shorii*
270. Lesser Goldenback (Black-rumped Flameback, Lesser Flameback) *Dinopium benghalense*

271. Greater Goldenback *Chrysocolaptes lucidus*
272. White-naped Woodpecker *Chrysocolaptes festivus*
273. Heart-spotted Woodpecker *Hemicircus canente*

Ramphastidae (toucans and barbets)

274. Brown-headed Barbet *Megalaima zeylanica*
275. Lineated Barbet *Megalaima lineata*
276. Blue-throated Barbet *Megalaima asiatica*
277. Coppersmith Barbet *Megalaima haemacephala*

Coraciiformes

Meropidae

278. Blue-bearded Bee-eater *Nyctyornis athertoni*
279. Green Bee-eater *Merops orientalis*
280. Blue-tailed Bee-eater *Merops philippinus*
281. Chestnut-headed Bee-eater *Merops leschenaulti*

Coraciidae (rollers)

282. Indian Roller *Coracias benghalensis*
283. Dollarbird *Eurystomus orientalis*

Alcidinidae (Kingfishers)

284. Stork-billed Kingfisher *Pelargopsis capensis*
285. Brown-winged Kingfisher *Pelargopsis amauroptera*
286. White-throated Kingfisher (White-breasted Kingfisher) *Halcyon smyrnensis*
287. Black-capped Kingfisher *Halcyon pileata*
288. Collared Kingfisher *Todiramphus chloris*
289. Blue-eared Kingfisher *Alcedo meninting*
290. Common Kingfisher *Alcedo atthis*
291. Pied Kingfisher *Ceryle rudis*

Falconiformes

Falconidae (falcons and caracaras)

292. Lesser Kestrel *Falco naumanni*
293. Common Kestrel *Falco tinnunculus*
294. Red-necked Falcon *Falco chicquera*
295. Amur Falcon *Falco amurensis*
296. Eurasian Hobby *Falco subbuteo*
297. *Laggar Falcon Falco jugger*
298. Peregrine Falcon *Falco peregrinus*

Psittaciformes

Psittaculidae (Old World parrots)

299. Alexandrine Parakeet *Psittacula eupatria*
300. Rose-ringed Parakeet *Psittacula krameri*
301. Plum-headed Parakeet *Psittacula cyanocephala*
302. Vernal Hanging Parrot *Loriculus vernalis*

Passeriformes

Pittidae (pittas)

303. Indian Pitta *Pitta brachyura*

Campephagidae (minivets and cuckooshrikes)

304. Large Cuckooshrike *Coracina macei*
305. Black-winged Cuckooshrike *Coracina melaschistos*
306. Black-headed Cuckooshrike *Coracina melanoptera*
307. Rosy Minivet *Pericrocotus roseus*
308. Small Minivet *Pericrocotus cinnamomeus*
309. White-bellied Minivet *Pericrocotus erythropygius*
310. Long-tailed Minivet *Pericrocotus ethologus*
311. Scarlet Minivet *Pericrocotus (flammeus) speciosus*

Oriolidae

312. Indian Golden Oriole *Oriolus (oriolus) kundoo*
313. Black-naped Oriole *Oriolus chinensis*
314. Black-hooded Oriole *Oriolus xanthornus*

Artamidae (woodswallows)

315. Ashy Woodswallow *Artamus fuscus*

Vangidae

316. Large Woodshrike *Tephrodornis virgatus*

317. Common Woodshrike *Tephrodornis pondicerianus*
318. Bar-winged Flycatcher-shrike *Hemipus picatus*

Aegithinidae (ioras)

319. Common Iora *Aegithina tiphia*
320. Marshall's Iora *Aegithina nigrolutea*

Dicruridae (drongos)

321. Black Drongo *Dicrurus macrocercus*
322. Ashy Drongo *Dicrurus leucophaeus*
323. White-bellied Drongo *Dicrurus caerulescens*
324. Bronzed Drongo *Dicrurus aeneus*
325. Spangled Drongo *Dicrurus hottentottus*
326. Greater Racket-tailed Drongo *Dicrurus paradiseus*

Rhipiduridae (fantails)

327. White-throated Fantail *Rhipidura albicollis*
328. White-browed Fantail *Rhipidura aureola*

Laniidae (shrikes)

329. Brown Shrike *Lanius cristatus*
330. Red-tailed Shrike *Lanius phoenicuroides*
331. Bay-backed Shrike *Lanius vittatus*
332. Long-tailed Shrike *Lanius schach*
333. Grey-backed Shrike *Lanius tephronotus*
334. Southern Grey Shrike *Lanius meridionalis*

Corvidae (crows and jays)

335. Rufous Treepie *Dendrocitta vagabunda*
336. Grey Treepie *Dendrocitta formosae*
337. House Crow *Corvus splendens*
338. Indian Jungle Crow *Corvus* (*macrorhynchos*) *culminatus*

Monarchidae

339. Black-naped Monarch *Hypothymis azurea*
340. Asian Paradise-flycatcher *Terpsiphone paradisi*

Dicaeidae (flowerpeckers)

341. Thick-billed Flowerpecker *Dicaeum agile*
342. Pale-billed Flowerpecker *Dicaeum erythrorhynchos*

Nectariniidae (sunbirds)

343. Ruby-cheeked Sunbird *Chalcoparia singalensis*
344. Purple-rumped Sunbird *Leptocoma zeylonica*
345. Purple Sunbird *Cinnyris asiaticus*
346. Loten's Sunbird *Cinnyris lotenia*
347. Crimson Sunbird *Aethopyga siparaja*
348. Little Spiderhunter *Arachnothera longirostra*

Irenidae (fairy-bluebirds and leafbirds)

349. Asian Fairy Bluebird *Irena puella*
350. Jerdon's Leafbird *Chloropsis jerdoni*
351. Golden-fronted Leafbird *Chloropsis aurifrons*

Ploceidae (weavers)

352. Black-breasted Weaver *Ploceus benghalensis*
353. Streaked Weaver *Ploceus manyar*
354. Baya Weaver *Ploceus philippinus*

Estrildidae (waxbills)

355. Red Avadavat *Amandava amandava*
356. Green Avadavat *Amandava formosa*
357. Indian Silverbill *Euodice malabarica*
358. White-rumped Munia *Lonchura striata*
359. Scaly-breasted Munia *Lonchura punctulata*
360. Black-throated Munia *Lonchura kelaarti*
361. Black-headed Munia *Lonchura malacca*
362. Chestnut Munia *Lonchura* (*malacca*) *atricapilla*

Passeridae (sparrows)

363. House Sparrow *Passer domesticus*
364. Eurasian Tree Sparrow *Passer montanus*
365. Chestnut-shouldered Petronia *Gymnoris xanthocollis*

Motacillidae (wagtails and pipits)

366. Forest Wagtail *Dendronanthus indicus*
367. Western Yellow Wagtail *Motacilla flava*
368. Citrine Wagtail *Motacilla citreola*
369. Grey Wagtail *Motacilla cinerea*
370. White Wagtail *Motacilla alba*
371. White-browed Wagtail *Motacilla maderaspatensis*
372. Richard's Pipit *Anthus richardi*
373. Paddyfield Pipit *Anthus rufulus*
374. Tawny Pipit *Anthus campestris*
375. Blyth's Pipit *Anthus godlewskii*
376. Tree Pipit *Anthus trivialis*
377. Olive-backed Pipit *Anthus hodgsoni*
378. Red-throated Pipit *Anthus cervinus*

Fringillidae (finches)

379. Common Rosefinch *Carpodacus erythrinus*

Emberizidae (Old World buntings)

380. Crested Bunting *Melophus lathami*
381. Red-headed Bunting *Emberiza bruniceps*

Stenostiridae

382. Grey-headed Canary Flycatcher *Culicicapa ceylonensis*

Paridae (tits)

383. Great Tit *Parus major*
384. Indian Yellow Tit *Parus* (*xanthogenys*) *aplonotus*
385. White-naped tit *Machlophus nuchalis*

Alaudidae (larks)

386. Singing Bushlark *Mirafra cantillans*
387. Jerdon's Bushlark *Mirafra affinis*
388. Bengal Bushlark *Mirafra assamica*
389. Indian Bushlark *Mirafra erythroptera*
390. Rufous-tailed (Finch) Lark *Ammomanes phoenicura*
391. Greater Short-toed Lark *Calandrella brachydactyla*
392. Crested Lark *Galerida cristata*
393. Oriental Skylark *Alauda gulgula*
394. Ashy-crowned Sparrow Lark *Eremopterix griseus*

Cisticolidae (cisticolas)

395. Zitting Cisticola *Cisticola juncidis*
396. Rufous-fronted Prinia *Prinia buchanani*
397. Rufescent Prinia *Prinia rufescens*
398. Grey-breasted Prinia *Prinia hodgsonii*
399. Jungle Prinia *Prinia sylvatica*
400. Yellow-bellied Prinia *Prinia flaviventris*
401. Ashy Prinia *Prinia socialis*
402. Plain Prinia *Prinia inornata*

Locustellidae (bush warblers)

403. Grasshopper Warbler *Locustella naevia*
404. Striated Grassbird *Megalurus palustris*
405. Bristled Grassbird *Chaetornis striata*

Acrocephalidae (brush, reed and swamp warblers)

406. Booted Warbler *Iduna caligata*
407. Sykes's Warbler *Iduna rama*
408. Blyth's Reed Warbler *Acrocephalus dumetorum*
409. Thick-billed Warbler *Phragamaticola aedon*
410. Clamorous Reed Warbler *Acrocephalus stentoreus*
411. Paddyfield Warbler *Acrocephalus agricola*

Hirundinidae (swallows)

412. Barn Swallow *Hirundo rustica*
413. Wire-tailed Swallow *Hirundo smithii*
414. Eurasian Crag Martin *Ptyonoprogne rupestris*
415. Dusky Crag Martin *Ptyonoprogne concolor*
416. Red-rumped Swallow *Cecropis daurica*

417. Streak-throated Swallow *Petrochelidon fluvicola*
418. Asian House Martin *Delichon dasypus*

Pycnonotidae (bulbuls)

419. Black-crested Bulbul *Pycnonotus* (*melanicterus*) *flaviventris*
420. Red-whiskered Bulbul *Pycnonotus jocosus*
421. Red-vented Bulbul *Pycnonotus cafer*
422. White-browed Bulbul *Pycnonotus luteolus*
423. Yellow-throated bulbul *Pycnonotus xantholaemus*

Phylloscopidae (Old World leaf warblers)

424. Common Chiffchaff *Phylloscopus collybita*
425. Dusky Warbler *Phylloscopus fuscatus*
426. Tickell's Leaf Warbler *Phylloscopus affinis*
427. Sulphur-bellied Warbler *Phylloscopus griseolus*
428. Yellow-browed Warbler *Phylloscopus inornatus*
429. Hume's Leaf Warbler *Phylloscopus humei*
430. Greenish Warbler *Phylloscopus trochiloides*
431. Green Warbler *Phylloscopus* (*trochiloides*) *nitidus*
432. Large-billed Leaf Warbler *Phylloscopus magnirostris*
433. Western Crowned Warbler *Phylloscopus occipitalis*
434. Blyth's Leaf Warbler *Phylloscopus reguloides*
435. Green-crowned Warbler *Seicercus burkii*

Sylviidae

436. Lesser Whitethroat *Curruca curruca*

Zosteropidae (white-eyes)

437. Oriental White-eye *Zosterops palpebrosus*

Timaliidae (scimitar babblers)

438. Indian Scimitar Babbler *Pomatorhinus horsfieldii*
439. Rufous-fronted Babbler *Stachyridopsis rufifrons*
440. Tawny-bellied Babbler *Dumetia hyperythra*
441. Pin-striped Tit Babbler *Macronus gularis*
442. Chestnut-capped Babbler *Timalia pileata*

Pellorneidae (Smaller babblers)

443. Puff-throated Babbler *Pellorneum ruficeps*
444. Abbott's Babbler *Malacocincla abbotti*

Leiothrichidae (babblers, laughingthrushes)

445. Large Grey Babbler *Turdoides malcolmi*
446. Jungle Babbler *Turdoides striata*
447. Yellow-billed Babbler *Turdoides affinis*
448. Common Babbler *Turdoides caudata*
449. Striated Babbler *Turdoides earlei*

Sittidae (nuthatches, spotted creepers and wallcreeper)

450. Chestnut-bellied (Indian) Nuthatch *Sitta castanea*
451. Velvet-fronted Nuthatch *Sitta frontalis*
452. Spotted Creeper *Salpornis spilonotus*

Sturnidae (starlings)

453. Common Hill Myna *Gracula religiosa*
454. Jungle Myna *Acridotheres fuscus*
455. Bank Myna *Acridotheres ginginianus*
456. Common Myna *Acridotheres tristis*
457. Asian Pied Starling (Pied Myna) *Gracupica contra*
458. Chestnut-tailed Starling *Sturnia malabarica*
459. Brahminy Starling *Sturnia pagodarum*
460. Rosy Starling *Pastor roseus*
461. Common Starling *Sturnus vulgaris*

Muscicapidae (Chats and Flycatchers)

462. Malabar Whistling Thrush *Myophonus horsfieldii*
463. Indian Blue Robin *Luscinia brunnea*
464. Oriental Magpie Robin *Copsychus saularis*
465. White-rumped Shama *Copsychus malabaricus*
466. Indian Robin *Saxicoloides fulicatus*

467. Black Redstart *Phoenicurus ochruros*
468. Common Stonechat *Saxicola torquatus*
469. White-tailed Stonechat *Saxicola leucurus*
470. Pied Bushchat *Saxicola caprata*
471. Brown Rock Chat *Cercomela fusca*
472. Blue Rock Thrush *Monticola solitarius*
473. Blue-capped Rock Thrush *Monticola cinclorhynchus*
474. Dark-sided Flycatcher *Muscicapa sibirica*
475. Asian Brown Flycatcher *Muscicapa dauurica*
476. Brown-breasted Flycatcher *Muscicapa muttui*
477. Rusty-tailed Flycatcher *Muscicapa ruficauda*
478. Red-breasted Flycatcher *Ficedula parva*
479. Taiga Flycatcher *Ficedula albicilla*
480. Little Pied Flycatcher *Ficedula westermanni*
481. Ultramarine Flycatcher *Ficedula superciliaris*
482. Verditer Flycatcher *Eumyias thalassinus*
483. Pale-chinned Flycatcher *Cyornis poliogenys*
484. Tickell's Blue Flycatcher *Cyornis tickelliae*
485. Blue-throated Blue Flycatcher *Cyornis rubeculoides*
486. Bluethroat *Luscinia svecica*

Turdidae (thrushes)

487. Pied Thrush *Zoothera wardii*
488. Orange-headed (Ground) Thrush *Zoothera citrina*
489. Scaly Thrush *Zoothera dauma*
490. Tickell's Thrush *Turdus unicolor*
491. Indian Blackbird *Turdus* (*merula*) *simillimus*
492. Eyebrowed Thrush *Turdus obscurus*
493. Black-throated Thrush *Turdus atrogularis*

Reptiles

Order: Crocodylia

Family: Crocodylidae

1. *Crocodylus palustris*

Family: Gavialidae

2. Gavialis gangeticus

Order: Chelonia

Family: Bataguridae

3. *Pangshura tentoria*
4. *Melanochelys tricarinata*
5. *Melanochelys trijuga*

Family: Testudinidae

6. *Indotestudo elongata*
7. *Geochelon elegans*

Family: Trionychidae

8. *Lissemys punctata*
9. *Nilssonia gangeticus*
10. *Nilssonia hurum*
11. *Nilssonia leithii*
12. *Chitra indica*

Order: Squamata

Family: Agamidae Gray, 1825

13. *Calotes versicolor*
14. *Calotes rouxii*
15. *Psammophilus blanfordanus*
16. *Psammophilus dorsalis*
17. *Draco dussumieri*
18. *Sitana ponticeriana*

Family: Chamaeleonidae Gray, 1825

19. *Chamaeleo zeylanicus*

Family: Eublepharidae Boulenger, 1883

20. Eublepharis hardwickii

Family: Gekkonidae Gray, 1825

21. *Calodactyloides aureus*
22. *Cnemaspis otai*
23. *Cnemaspis yercaudensis*
24. *Cyrtodactylus nebulosus*
25. *Geckoella jeyporensis*
26. *Hemidactylus brookii*
27. *Hemidactylus bowringii*
28. *Hemidactylus treutleri*
29. *Hemidactylus flaviviridis*
30. *Hemidactylus frenatus*
31. *Hemidactylus leschenaultii*
32. *Hemidactylus* sp.
33. *Hemidactylus gigantius*
34. *Hemidactylus reticulates*
35. *Hemidactylus triedrus*
36. *Hemidactylus subtriedrus*
37. *Hemidactylus yajurvedii*
38. *Hemiphyllodactylus aurantiacus*

Family: Lacertidae Cope, 1864

39. *Ophisops jerdoni*
40. *Ophisops leschenaultii*
41. *Ophisops minor*
42. *Ophisops beddomei* (Jerdon, 1870)

Family: Scincidae Gray, 1825

43. *Lygosoma albopunctata*
44. *Lygosoma ashwamedhi*
45. *Lygosoma punctata*
46. *Lygosoma guentheri*
47. *Lygosoma vosmaerii*
48. *Eutropis beddomei*
49. *Eutropis carinata*
50. *Eutropis macularia*
51. *Eutropis bibronii*
52. *Eutropis trivittata*
53. *Eutropis innotata*
54. *Eutropis nagarjunii*
55. *Eutropis allapallensis*
56. *Eutropis dissimilis*
57. *Barkudia insularis*
58. *Barkudia melanosticta*
59. *Sepsophis punctatus*
60. *Sphenomorphus dussumieri*

Family: Varanidae

61. *Varanus bengalensis*
62. *Varanus flavescens*

Snakes

Family Boidae

Subfamily Pythoninae

63. *Python molurus*

Subfamily Erycinae

64. *Gongylophis conicus*
65. *Eryx johnii*

Family Ahaetullidae

66. *Ahaetulla nasuta*
67. *Ahaetulla nasuta isabellina*

Family Colubridae

68. *Amphiesma stolatum*
69. *Argyrogena fasciolata*
70. *Atretium schistosum*
71. *Boiga forsteni*
72. *Boiga flaviviridis*
73. *Boiga trigonata*
74. *Chrysopelea ornata*
75. *Coelognathus helena*
76. *Coelognathus helena nigriangularis*
77. *Coelognathus radiates*
78. *Coluber bholanathii*
79. *Dendrelaphis tristis*
80. *Dendrelaphis* cf. *pictus*
81. *Dryocalamus gracilis*
82. *Dryocalamus nympha*
83. *Enhydris enhydris*
84. *Lycodon aulicus*
85. *Lycodon jara*
86. *Lycodon striatus*
87. *Lycodon travancoricus*
88. *Liopeltis calamaria*
89. *Macropisthodon plumbicolor*
90. *Oligodon arnensis*
91. *Oligodon taeniolatus*
92. *Oligodon travancoricus*
93. *Psammodynastes pulverulentus*
94. *Ptyas mucosus*
95. *Xenochrophis piscator*

Family Psammophidae

96. *Psammophis condanarus*

Family Sibynophidae

97. *Sibynophis sagittaria*
98. *Sibynophis subpunctatus*

Family Elapidae Boie, 1827

99. *Bungarus caeruleus*
100. *Bungarus fasciatus*
101. *Calliophis melanurus*
102. *Calliophis beddomei*
103. *Calliophis nigriscens*
104. *Naja kaouthia*
105. *Naja naja*
106. *Ophiophagus hannah*

Family Typhlopidae

107. *Gryptotyphlops acutus*
108. *Ramphotyphlops braminus*
109. *Typhlops diardii*
110. *Typhlops porrectus*
111. *Gerrhopilus beddomii* (Boulenger, 1890)

Family Uropeltidae

112. *Uropeltis ellioti*
113. *Uropeltis dindigalensis* (Beddome, 1877)
114. *Uropeltis shorttii* (Beddome, 1863)
115. *Uropeltis ceylanicus* Cocteau, 1833 Cuvier's Sheildtail
116. *Rhinophis gower*

Family Viperidae

117. *Daboia russelii*
118. *Echis carinatus*
119. *Trimeresurus gramineus*

Amphibians
Order: Anura
Family Bufonidae

1. *Duttaphrunus hololius*
2. *Duttaphrynus scaber*
3. *Duttaphrynus stomaticus*
4. *Duttaphrynus melanostictus*

Family: Dicroglossidae

5. *Euphlyctis cyanophlyctis*
6. *Euphlyctis hexadactylus*
7. *Euphlyctis aloysii**
8. *Fejervarya orissaensis*
9. *Fejervarya sybadrensis*
10. *Fejervarya moodei*
11. *Fejervarya* sp.
12. *Fejervarya cf. keralensis**
13. *Hoplobatrachus crassus*
14. *Hoplobatrachus tigerinus*
15. *Spaerotheca breviceps*
16. *Spaerotheca dobsonii*
17. *Spaerotheca rolandae*

Family: Microhylidae

18. *Uperodon taprobanica*
19. *Microhyla ornata*
20. *Microhyla rubra*
21. *Uperodon variegata*
22. *Uperodon globulosus*
23. *Uperodon systoma*

Family: Ranidae

24. *Hylarana bahuvistara*
25. *Hylarana tytleri*
26. *Hylarana temporalis*
27. *Indosylvirana sreeni* Biju et al. 2014

Family: Rhacophoridae

28. *Chiromantis simus*
29. *Philautus similipalensis*
30. *Philautus sanctisilvaticus*
31. *Philautus terebrans*
32. *Polypedates maculatus*
33. *Polypedates teraiensis*

Order: Gymnophiona
Family: Indotyphlidae

34. *Gegeneophis orientalis*

*** Doubtful species**

Defaunation and Conservation

Suman Pratihar, M.Sc. Zoology (Gold Medalist) and Ph.D. from Vidyasagar University, presently working as an Assistant Professor in Zoology at Sukumar Sengupta Mahavidalaya. Interested in molecular aspects of metabolic depression in hibernating anurans and global distribution of *Duttaphrynus* sp. He has completed the prestigious DST (Government of India) Post Doctoral Research fellowship. Published 30 research articles in peer-reviewed journals and 8 review articles (genome evolution). Editorial board member of the *Sonoran Herpetologist*, Arizona, USA.

Howard O. Clark, Jr., is a Certified Wildlife Biologist® with 20 years of professional wildlife and research experience. His work as a researcher focuses on the ecosystems of Northern and Central California, USA, the Mojave Desert, the Bay Area, and includes extensive baseline mammalian inventories, surveys focused on rare animals, habitat assessment, radio telemetry, and long-term ecological studies on several endangered species. He regularly works with the western burrowing owl (*Athene cunicularia hypugea*), San Joaquin kit fox (*Vulpes macrotis mutica*), giant kangaroo rat (*Dipodomys ingens*), and the Mohave ground squirrel (*Xerospermophilus mohavensis*). He serves in an editorial capacity with the following scientific journals: *Herpetological Conservation & Biology*, *Western Wildlife*, *Sonoran Herpetologist*, and *Amphibian & Reptile Conservation*.

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