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Factors Responsible for Global Decline of Reptilian Population: A Review

Choudhary Narayan Lal and Chishty Nadim*

Wildlife, Limnology and Toxicology Research Laboratory, Department of Zoology, Government Meera Girl's College (Mohanlal Sukhadia University), Udaipur 313001, Rajasthan, India

*Corresponding Author

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Abstract: Reptiles are now categorized as threatened group due to dramatic decline in population both at local and global level. They are currently facing extinction risks in future due to habitat loss and fragmentation, landscape modification, vanishing of natural ecosystem, global warming and climate changes, pressure of parasitism and other disease and invasion of floral and faunal species, unsustainable use and illegal trading in poaching market. Reptile's population is mainly affected due to excessive anthropogenic pressures like expansion of urbanization, deforestation, road killing, handling by recreationists, habitat fragmentation due to human settlement and mining activities. Biological factors like low level of genetic diversity, natural disasters, extreme environmental conditions like temperature, humidity, rainfall and day light perception also influence reptile population and behavioral biology. Systematic studies related to reptile taxonomy, ecology, behavior and molecular biology at species level, might be helpful for better conservation and also understanding pattern and trends of genetic variability among reptile populations at regional and global level will also be beneficial for elucidating gene pool of reptiles.

Keywords: Reptiles, Threatened group, Habitat loss, Extinction risk, Population, Conservation

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Introduction

Several animal and plant species are facing risk of extinction (Pimm *et al.*, 1995; Woodruff, 2001) and now it's widely accepted fact that anthropogenic influence is the ultimate factor for the biodiversity crisis (Caballeros and Ehrlich, 2002; Davis *et al.*, 2006; Ehrlich and Pringle, 2008). International Union for Conservation of Nature (IUCN) Red list described that almost about 38% reptile species facing extinction risk in near future (Vie *et al.*, 2009). Habitat loss is major threat to species extinction at global levels (Baillie *et al.*,

2004) and frequently at national scale (Wilcove *et al.*, 1998; Venter *et al.*, 2006). Reptiles and amphibians are an integral and key part of natural ecosystem and act as an indicator for quality and status of habitat (Gibbons and Stangel, 1999). Natural variation among population and regional extinction are very common in both the groups-- reptiles and amphibians (Pechmann *et al.*, 1991; Blaustein *et al.*, 1994). Reptile's population had dramatically declined due to habitat alteration and degradation, introduction of exotic species,

environmental pollution, habitat fragmentation, expansion of urbanization, parasitism and other disease, road killing, unsustainable use and climate changes and some other unknown additional factors responsible for rapid population decline at global level (Nilson *et al.*, 1999). Few reports state that many reptile species population declined in particular and specific geographic regions like Asp viper (*Vipera aspis*) in Swiss Jura Mountains (Moser *et al.*, 1984; Jaggi and Baur, 1999), Milos viper (*Microvipera schweizeri*) in Greece (Nilson *et al.*, 1999). Several reptile species have been used by various people in different parts of the world for food, trading, leather and eggs, skin, meat and traditional medicinal purpose every year at large scale (Fitzgeorald, 1994b; Schlaepfer *et al.*, 2005). Almost 70% of total illegal reptile trading originated from south eastern Asia regions (Natusch *et al.*, 2016).

Present review describes about current threats of survival and factors responsible for population decline of reptiles at global level. Following major factors have been reported which are responsible for global population decline of various reptiles.

Habitat Destruction and Degradation:

Several researchers reported habitat destruction as a single largest factor for declined amphibian and reptile population (Alfor and Richards, 1999). Destruction and pollution of water bodies also altered the habitat of semi-aquatic reptiles and amphibians. Habitat alteration and modification may also influence the population of territorial reptiles like salamanders (Hunter, 1995). Habitat destruction largely contributed decline of reptile population at global level. Many scientists documented population decline of many reptile species in different geographic regions of various countries like population of flat woods salamander (*Ambystoma cingulatum*) declined due to reduction of south eastern long leaf pine habitat (Wave *et al.*, 1993; Means *et al.*, 1996), gopher tortoise (*Gopherus polyphemus*), eastern indigo snake (*Drymarchon corais*) and eastern

diamondback rattle snake (*Crotalus adamantusi*) in Columbia and its surrounding regions (Guyer and Bailey, 1993). Due to over exploitation of natural resources, forest landscapes are converted into semi-natural landscapes that reduced the habitat quality which results into loss of connectivity between suitable habitat patches and reduced the size of natural habitat ranges and edge effect (Saunders *et al.*, 1991; Murcia, 1995; Fahring, 2003; Urbina *et al.*, 2006; Fischer and Linder Mayer, 2007). Floods, drought and other natural disasters in terrestrial landscape have also caused higher mortality rate in lizards and snakes due to slow moving ability.

Introduction of Exotic Species:

Introduction of non-native or invasive reptile species disrupts native reptile communities and habitat for example- Losos *et al.* (1993) observed invasion of Grand Cayman by exotic brown anoles (*Anolis sagrei*) caused behavioral changes and habitat shifting of native species *Anolis conspersus*. Introduction of the brown tree snake (*Boiga irregularis*) at island of Guam and Tinian caused negative impact on native species gecko (*Nactus pelagicus*); brown tree snake was also responsible for dramatic declination of native lizard population at Mariana Island (Rodda, 1992). Not only exotic animal species influences reptile community but invasion of plant species also altered native habitat where reptiles were living for example Desert tortoise- *Gopherus agassizii* and Gopher tortoise- *Gopherus polyphemus* (Stewart *et al.*, 1993; Lovich, 1995).

Environmental Pollutants:

Many environmental pollutants and contamination of heavy metals, plastic wastes, pesticides and herbicides, radioactive wastes, petrochemical wastes causes direct and indirect effects on both amphibians and reptiles and their survival (Hinton and Scott, 1990; Hall and Hennry, 1992; Srivastav *et al.*, 2017, 2020). Numerous toxic compounds adversely affected the semi-aquatic and terrestrial life at global level (Hall, 1980; Fontenot *et al.*, 1994). Environmental

pollutants also disturbed the male and female sex-ratio in many reptiles including turtles and crocodiles due to concentrations of endocrine disrupting chemicals which were associated with normal development and growth of body (Guillette and Crain, 1996).

Illegal Trading and Unsustainable Harvesting:

The key driver of the biodiversity crisis is wildlife trade (Marshall *et al.*, 2020). The commercial trade, overharvesting for food, illegal poaching and trading, destruction of eggs during breeding season declined reptile populations drastically at global level especially in the cases of turtles and tortoise (Berger *et al.*, 1998; Lips, 1999). Over exploitation of reptiles for food, meat, eggs, skin, pet trade, supply to biological houses have been also responsible for declined reptilian and amphibian population (Pough *et al.*, 1998; Spotila *et al.*, 1996). In India, the frog-leg trade has resulted dramatic population decline of many frog species namely bull frog (*Rana tigrina*) and green pond frog (*Rana hexadactyla*); and an approximate 70 million frogs are exported illegally every year in international trade market (Oza, 1999). International trade of turtles and tortoise for consumption as food, medicinal value and recreational domestic activities have declined their population enormously (Sharma, 1999). Not only turtle's population due to overexploitation for various purposes but also lizards were also facing the same problems of its survival and existence and their abundance declined in several parts of the world including tropical region of America (e.g. spiny tailed lizard- *Ctenosaura similis*, Green iguanas-*Iguana iguana*) (Fitch *et al.*, 1982). Egg collection of several turtle species leads to reduction in breeding rates and hatchling success and population of young individuals are at primary threats for its survival (Copeyon, 1997). Snake is also facing threats of survival due to over collection for specimen trade, traditional medicinal purposes and obtaining snake venom from venomous snake species (Nilson *et al.*, 1990; Pough *et al.*, 1998).

Global Warming and Climate Change:

One of the greatest threats to global biodiversity is Climate change (Evans, 2019; Kellogg, 2019; Dayananda *et al.*, 2021). Global warming and climate change is also responsible for dramatic decline of reptile's population due to changes in behavioral activity pattern, habitat, thermoregulation time, breeding season, hormone regulation and developmental activities (Greene and Campbell, 1993; Brerenton *et al.*, 1994; Halpin, 1997; Guertin *et al.*, 1997; Ross, 1998; Still *et al.*, 1999; Vinikow *et al.*, 1999). Global warming and temperature influences the breeding activities and time, developmental process due to changes in production and secretion of various important hormones, juvenile growth rate, and early age maturity shifted functional ratio and also influenced the male and female sex ratio among several reptile species (Frazer *et al.*, 1993). Global warming and fluctuations in temperature largely influenced population and sex ratio in temperature dependent development of sex in reptile species like crocodiles and some species of turtles (Janzen, 1994). Climatic changes were also responsible for altering ecosystem and created unfavorable habitat for species survival at global level (Hughes, 2000; Penuelas and Filella, 2001; Root *et al.*, 2003). Alteration in native habitat or ecosystems caused adverse effect on species survival and created more complexities for its conservation and enhanced the degree of extinction risk (Mac Nally *et al.*, 2009). Amphibians and reptiles are very sensitive towards environmental changes like temperature, humidity, rainfall, seasons, day light perceptions and exposure of UV radiations due to which they are more vulnerable to extension risk as compared to the birds with additional factors like slow mobility and dispersal rate.

Parasitism and Diseases:

Past decades have seen the increase in infectious disease in several animal taxa or groups including reptiles, which becomes limiting factor for survival of reptiles in various regions of the world

(Sutherland *et al.*, 2010; Fisher *et al.*, 2012). Changes in climatic conditions and modifications in ecosystem due to human disturbance are potential factors for causing diseases in reptiles (Fisher *et al.*, 2012). Obligate strains of fungal pathogens badly influenced the reptile population both wild and captive (Mitchell and Walden, 2013). Most potent fungal species *Ophidiomyces ophiodiicola* causing severe dermatitis in reptiles particularly snake fungal diseases. At present snake fungal disease is a common disease in them and is frequently observed in multiple free ranging snake species including timber rattle snake (*Crotalus horridus*), Massasangas (*Sistrurus catenatus*) and many other species of viperidae and colubridae snakes (Lorch *et al.*, 2016). *Metarhizium viride* another fungal species observed in Chameleon species *Chamaeleo calyptratus* and *Furcifer pardalis* (Schmidt *et al.*, 2017), similarly *Nannizziopsis guarroi* in bearded dragons (*Pogona vitticeps*), green iguanas *Iguana iguana* (Schmidt, 2015) and *Fasarium solani* in longer headed sea turtle *Caretta caretta* (Fisher *et al.*, 2012) were some of the infectious fungal species in reptiles.

Current Trends of Reptilian Population and Other Threats:

At present 6437 species of amphibians and 8863 reptiles species had been identified and reported at global level (Frost, 2008; Uetz, 2008). Out of them 32.5% species of amphibians and 22% of reptiles are listed in endangered category and 122 amphibian and 22 reptile species are currently facing high risk of extinction from wild (Dizzo and Raven, 2004; Baillie *et al.*, 2004; Stuart *et al.*, 2004; Gascon *et al.*, 2007). Not only habitat changes are responsible for global population decline of amphibians and reptiles but also some other associated invisible threats like fluctuation in the duration of breeding periods, lack of breeding site or egg laying sites, loss of genetic diversity within the species due to habitat fragmentation, changes and shifting of home ranges, population isolation due to anthropogenic activities such as construction activities of roads

and highways, water canals etc. These changes affect individual growth rate, activity pattern and increased sensitivity towards changes in microclimatic conditions (Gibbon *et al.*, 2000; Crump, 2003; Hedges, 2006). Additionally bushfires in summer season and anthropogenic forest fires also declined reptilian populations. Geyle *et al.* (2021) have reported that at least 17 squamata species have been substantially affected by wildfires that devastated eastern and southern Australia in 2019 and early 2020. Landscape modification adversely affected both biotic and abiotic characteristic features of ecosystem and hence reptilian life (Saunders *et al.*, 1991). Human reptile conflict is also responsible for declined reptile population in human dominated habitat and urban areas.

Conservation Remedies for Saving Reptiles from Immediate Extinction:

Several studies were conducted on systematic and taxonomy of reptiles but very few have been conducted about their behavioral biology and ecology. Indeed immediate actions are required toward identification of threats, conservation problems, quality of population size, phylo-genetic relationship, home range, geographical distribution patterns, understanding population trends of endemic and rare species of reptiles can also be helpful in achieving better conservation of reptiles and saving them from immediate extinction both at regional and global level. Further scientific studies are required at population and community levels at different temporal and spatial parameters which are necessary to understand biology of reptiles, threats of survival in relation to anthropogenic disturbance, habitat fragmentation and alteration, edge effect, effect of climatic conditions and level of genetic variation among particular species. Arrangement of translocation programs also minimizes human wildlife conflict with reptiles and establishment of reptile conserving protected areas or snake parks can also become helpful for conserving reptiles and its population. Translocations are used to mitigate more direct

conflicts between human and wildlife. Organization of workshop and conferences in local community of villages, farmers, schools and colleges would also be helpful in increasing awareness towards reptilian conservation and enhances rescue rate of reptiles. Establishments of reptile parks, zoo and captive breeding programs, snake rescue actions would also increase reptilian population.

Conclusion

Habitat alteration, landscape modifications and various anthropogenic activities such as urbanization, industrialization, extension of water canals in desert areas, changes in composition and structure of vegetation, environment pollutants and toxicants adversely affected reptiles' diversity and populations. Short-term studies is restricted to assess population status, cause of decline; hence long-term scientific efforts, advance techniques and methods are required for assessing the population status and trends of reptiles in present and future scenario. Lack of long-term monitoring and scientific studies on reptilian population has limited the status and knowledge of threats and conservation problems for its survival at global level. Long-term scientific studies and monitoring of reptilian population is essential and must be aided by the establishment of standard methods and techniques.

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