



Chapter

[8]

Impacts of invasive alien plant species on biodiversity in the regions of Western Himalayas, India: An overview

Sugam Gupta^{1*}, Naresh Kumar², Devvret Verma³,
Archana Bachheti⁴, Ashish Kumar Arya⁴,
Kamal Kant Joshi⁵ and Rakesh Kumar Bachheti⁶

¹Department of Applied Science, JB Institute of Technology, Dehradun, Uttarakhand, India

²Department of Environmental Science, Sharda University, Greater Noida, Uttar Pradesh, India

³Department of Biotechnology, Graphic Era Deemed to Be University, Dehradun, Uttarakhand, India

⁴Department of Environmental Science, Graphic Era Deemed to Be University, Dehradun, Uttarakhand, India

⁵Department of Environmental Science, Graphic Era Hill University, Dehradun, Uttarakhand, India

⁶Department of Industrial Chemistry, Addis Ababa Science and Technology University, Addis Ababa, Ethiopia

Abstract

The Western Himalayas regions are one of the richest repositories of the plant diversity in India. The spread of invasive alien plant species across Himalayan range causes loss of biodiversity including species extinction and change in the ecosystem functioning. These exotic plant species differ from their native area, based on their requirements, mode of resource asset and consumption may lead to the change in the structure, profile of the soil as well as the nutrient content. This results in adverse impacts on the biodiversity and ecosystem. However, various studies have been performed in documenting the ecological impacts of invasive species but there is a lack of understanding in regards of their economic importance, medicinal values, and livelihood considerations and in assessment the risk on human health. Present paper showcased some invasive alien species which are common and becoming threat for the forest zones and alpine regions in the Western Himalayan states of India.

Keywords

Biodiversity, Himalayas, Invasive Alien Plant Species, Western Himalayas

✉ Sugam Gupta, Email: sugam2606@gmail.com (*Corresponding author)

Introduction

The alien plant is also denoted as foreign, introduced, exotic, non-native and non-indigenous. These plants are those which had been introduced by humans deliberately or else through human activity or unintentionally from one area to another. This alien plant gets slip away from its environmental habitat and starts its development and reproduction on its own in the regional flora which is considered as naturalized species. The invasive alien species are naturalized alien which has been successful that it can scatter and spread with the regional flora as well as relocate the native biota by threatening the valued environmental, agricultural or personal resources by the damage it causes are considered invasive. Biological interference has been identified as a significant contributor to global environmental change and is a major cause of degradation or depletion of native biodiversity and ecological services. The invasive alien species are plants, animals, or other organisms which come up to places outside their natural area giving a negative impact. It has been seen for the past few years that invasive alien plant species have caused several menaces to the native biodiversity, ecosystem services and also deteriorated the environmental quality as well as human health (Kueffer, 2017; Jones and McDermott, 2018; Bartz and Kowarik, 2019). The rate of biological colonization has increased in all habitats and environments as human migration and foreign trade have increased. The detrimental effect of invasive species is compounded further by ongoing climate change, which is expected to increase both the extent and severity of biological invasion (Simberloff, 2000).

Biological invasion could also be thought-about as a variety of biological pollution and major factor on international amendment and one in every of the foremost causes of species extinction (Mooney and Drake, 1987). However, notably, in this respect Global Assessment Report on Biodiversity and Ecosystem Services of United Nations and human health (Pyšek and Richardson, 2010; Stone *et al.*, 2018; Jones and McDermott, 2018; Jones, 2019). In this present scenario United Nations an Inter-governmental stage for biodiversity as well as ecosystem services predicted that about nearly, 1/5th of the Earth's surface and even total biodiversity hotspots present around the world are in danger due to foreign aggressors (IPBES, 2019). Invasion issue can be more often noticed in developed countries as compared with low income nations. Therefore, the hotspots of invasive alien plant species in developed nations includes Australasia, European Union and North America, Asia Pacific and African regions too. Currently, invasive alien plant species professed as main motorist for the biodiversity loss (Seebens *et al.*, 2018; IPBES, 2019). But these invaders are not only responsible for loss of biodiversity there are other drivers too including anthropogenic activities, pollution, habitat fragmentation, climate change, over exploitation are some major threats to natural biodiversity.

India is known as unique 17 mega biodiversity nation of the world. The country has a vast phytogeographical area and edaphic conditions that offers the lush growth for countless fauna and flora (Chaudhry *et al.*, 2011). The country poses diverse ecological conditions which provide a platform for arise of a new alien species. The Himalayas is known for its rich biodiversity and forest ecosystem that provides a high value of environmental service. The region has expanded landforms and climatic zones which uphold a wide range of vegetation (Rana *et al.*, 2010; Khanduri *et al.*, 2017). The various

change in the climatic conditions and ecological change lead to the infringement of the area by any other new alien species. Raizada *et al.* (2008) published that CBD known as Convention on Biological Diversity stated that invasive alien plant species is the second largest cause for the loss of biodiversity worldwide and inflicts high prices on forestry, agriculture, and water ecosystems.

The Himalayan mountain range are one of the most endangered and exquisite habitats of the world, consisting of enormous biodiversity that provides significant ecosystem services (Kumar *et al.*, 2020). For last few years' scientists and policymakers has noticed that native diversity is under pressure all over the globe due to foreign invaders which have become greatest threat. In fact, one sixth of the world's ground surface habitat are enormously unsafe due to attack of alien species, which include large part of high income nations and global hotspots diversity (Early *et al.*, 2016). The invasive species are non-indigenous species and they show adverse consequence which can be economically or environmentally especially at those areas where these species are being introduced, either unintentionally or intentionally, outside their distribution pattern (Masters and Norgrove, 2010). Around 0.5–0.7 percent of the world's tree and shrub inhabitants are now a days invasive outside to their native ranges (Richardson and Rejmanek, 2011). Invasive species are regarded as one of the main causes of biodiversity destruction, altering environmental resources and socioeconomic environments through a variety of mechanisms (Rai and Singh, 2020). The Convention on Biological Diversity (1992) identified biological invasion as a major cause of biodiversity loss, ranking second only to habitat depletion and ecosystem degradation.

Status and distribution of invasive plant species in India

India is known as mega diverse country since it covers 2.4 percent of the global geographical area and accounts about 8% of the world's species diversity (Khoshoo, 1996). There are about 90,000 animal species and 45,000 wild floras, with just roughly half of the geographical region investigated so far (MoEF, 2008). Nearly 40% of species considered as alien species are found in India's flora. Due to growing trade and travel via numerous ways, India is a megadiverse country that is rapidly globalizing, putting species at risk of invasion (Saxena, 1991; Singh, 2005). Invasive alien flora and fauna have been identified as a major cause of species extinction and endangerment in freshwater wetlands and aquatic environments. Some of the Indian research revealed that inland environments have a lot of non-native flora and fauna, as well as the ramifications of regional invasion (Arya *et al.*, 2021). Reddy (2008) compiled the first catalogue of invasive alien plant species of India. Khuroo *et al.* (2012a, b) released a list of 1599 alien plant species belonging to 842 genera and 161 families with their native ranges and invasion status from India. About 471 invasive plant species were compiled by Inderjit *et al.* (2018). There are very few studies done from Indian Himalayan region on exotic species (Khuroo *et al.*, 2007; Sekar *et al.*, 2012; Jaryan *et al.*, 2013; Sekar *et al.*, 2015). Debnath and Debnath (2017), provided a comprehensive listing different kinds of foreign plant from Tripura, as well as facts on their intrusive life form, status, pattern, habitat, and source of introduction. This type of research, which provides updates on the status of the invasion, would be extremely beneficial in effective management.

The data on invasive species distribution is crucial for understanding the range of species shifts and comparing them across different time periods. The states of Western Himalayan region i.e. Himachal Pradesh, Jammu and Kashmir and Uttarakhand account 232,192,181 invasive alien species respectively. The studies done by some of the ecologist and taxonomist in Western Himalayan region are Khuroo *et al.* (2007) compiled the invasive flora of Kashmir valley and Kaur *et al.* (2014) published invasive flora of Jammu. Jaryan *et al.* (2013); Sekar *et al.* (2015) listed various kinds of invasive species for Himachal Pradesh. Invasive alien flora of Doon valley was compiled by Negi and Hajra (2007) and updated listing of invasive alien species was published by Sekar *et al.* (2012).

Proliferation of invasive species in western Himalayan regions

The most proliferative alien plant species present in Western Himalayan region are listed in the (Table 1). The results revealed that *Ageratum conyzoides*, *Lantana camara* and *Parthenium hysterophorous* are the established invasive alien species that have flourished and effecting the biodiversity from Western to eastern Himalayan regions of India. The species including *Argemone Mexicana*, *Ageratina adenophora*, *Cassia tora*, *Rubus neivus* and *Sapium sebiferum* persist and proliferative in a larger area of western Himalayan regions. Therefore, such species should be given more emphasis to the flourished alien species, but also on the such invasive species which till now are not proliferated so that they can be prevented of becoming invasive to the areas. There are few such species which are confined to a certain area or state for example *Anthemis cotula* which only is reported from Kashmir Valley (Khuroo *et al.*, 2008) and on the other hand *S. sebiferum* which has shown its proliferation only in Himachal Pradesh (Jaryan *et al.*, 2013).

Influence of invasive plant species

The above invasive alien species cause a wide range of impact on different classes of diversity, richness, crop fields, loss of nutrient component and environmental services to larger extent (Bhatt *et al.*, 1994; Wilcove *et al.*, 1998; McKee *et al.*, 2004; Reshi *et al.*, 2008; Vila *et al.*, 2010; Huddle *et al.*, 2011). Some of the studies have also shown that due to growth and development of invasive species can lead to genetic variation in regional populace through hybridization and also often obstructs in plant pollination interaction (Vila *et al.*, 2000; Schweiger *et al.*, 2010). The studies done globally on invasive plants has revealed that there is low richness and diversity of local plants in the invaded occupied sites but on other hand it is also increased the primary production in those localities (Vila *et al.*, 2000). Kosaka *et al.* (2010) reported that previously, the invasive alien plant species proliferate mainly along way side or open forest cover areas or boundaries in the Indian Himalayan region. In the last few decades it has been seen due to fast urbanization through forest range so many of alien species have started occupying woodland and mountainous ecosystems. The investigation and studies done by some of the researches have revealed that these invasive alien plants species pose numerous impacts/ effects on the

Table 1. Dominant invasive alien plant species in Western Himalayan Region of India.

Plant Species	Family	Native country	Life form	Pattern	Utilization	Habitat	Mode of Introduction	State
<i>Argemone conyzoides</i> L.	Asteraceae	Tropical America	H	A	M	AL, WL	O	J&K, HP & UK
<i>Argemone mexicana</i> L.	Papaveraceae	South America	H	A	M	W, RS	Ui	J&K
<i>Ageratina adenophora</i> (Spreng.) R.M. King & H. Rob.	Asteraceae	Mexico and Central America	S	P	M	W, RS	O	UK
<i>Anthemis cotula</i> L.	Asteraceae	Mediterranean region	H	A	M	W	O	J&K
<i>Cassia tora</i> L.	Caesalpiniaceae	South America	H	A		W	Ui	J&K
<i>Lantana camara</i> L.	Verbenaceae	Tropical America	H	P	M	F, RS, AL	O	J&K, HP and UK H.P.
<i>Sapium sebiferum</i> (L.) Roxb.	Euphorbiaceae	China	T	A	M, Ag, Sb	DS, RS, AL	O	J&K and UK
<i>Rubus niveus</i> Thunb.	Rosaceae	India, China & South Asia	S	P	M, FP		O	J&K, HP and UK
<i>Parthenium hysterophorus</i> L.	Asteraceae	North America	H	A	Not known	W, RS, AL	Ui	J&K, HP and UK

Table 2. Studies on impact or effects of invasive alien species.

Impact/effects	References
• Replacing medicinal plants and fodder grass	Bughani and Rajwar (2005)
• Constraint of seed growth and development	Bhardwaj <i>et al.</i> (2014)
• Preferring other invasive species over endemicspecies	Dobhal <i>et al.</i> (2011)
• Adapt of natural habitats	Dar and Reshi (2015)
• Some of the studies showed the effects on natural environment, but others mainly concentrated on agricultural ecosystems	Batish <i>et al.</i> (2007, 2009); Katoch <i>et al.</i> (2012)
• Dropping in nutrient level of the soil	Bhatt <i>et al.</i> (1994)
• Depletion various ecological parameters of native species like frequency, density and abundance	Tripathi <i>et al.</i> (1981);Kandwal <i>et al.</i> (2009)

native diversity and ecosystem which are as follows in the Table 2. In Indian mainland is mainly occupied by *Parthenium hysterophorous* and pest-ridden areas by species which is assessed as nearly 5 million acres (Kohli *et al.*, 2006). Dobhal *et al.* (2011) reported that Amongst many invasive alien species present in Indian Himalayas viz. *A. adenophora*, *A. conyzoides*, *L. camara* and *P. hysterophorus* are causing the negative impact on the floral diversity to a higher extent due to wider spread over Indian Himalayan regions. The studies have shown that *P. hysterophorus* is the one of the toxic or poisonous weed which is supplanting the native population and causing major health related problems in humans in this region. In the same way, the region is also effected by another species.

Lantana camara is stated to infringe upon vast area of lands, particularly in the lower part of Himalayan foothill forests, where it effectively replaces the underground layer of forest vegetation as well as also decrease the growth and development of trees (Kohli *et al.*, 2006; Negi *et al.*, 2013). This toxic wild plant is also responsible for the decrease species richness to 28.4% of invaded regions and approximately 63% damage to basal area of vegetation in invaded regions as related to non-invaded whereas, there is negative effect of structural growth and function of plant vegetation (love *et al.*, 2009; Dobhal *et al.*, 2010). *Ageratina adenophora* species mainly present in the moist areas, along roadside and forests of Garhwal Himalayas and other Himalayan region giving a negative impact on the plant diversity and crop land by increasing advantage through allelopathic affects and to some extent it also changes the soil microbial populations (Dhyani, 1978). Tripathi and Yadav (1982) stated that this invasive species is abundantly found growing in the Eastern Himalayan states. *A. adenophora*is also reduces the crop production by falling the seed germination of the vegetation, it has also observed that this species is also responsible for the replacement of local grasses from the grassland ecosystems (Kosaka *et al.*, 2010; Katoch *et al.*, 2012; Datta *et al.*, 2017).

Ageratum conyzoides alien species is known to invaded agricultural and crop fields and causing decrease the production of major crops yields by effecting the seed germination; varying soil properties and also responsible in the species reduction in terms of richness in the overspread areas (Kohli *et al.*, 2004;

Batish *et al.*, 2009, Dogra *et al.*, 2009; Katoch *et al.*, 2012; Sekar *et al.*, 2012). The Kashmir valley known to be one of the biodiversity hotspot of Himalayan region (Allaie *et al.*, 2005), where invasive alien *Anthemis cotula* is spreading at a faster rate and becoming one of the major threat for the native diversity and environment. The invasion of ruderal habitat by this alien species has made extended conscription pattern abetted by disturbed habitat, favourable physical factors like temperature, moisture, light and nutrient level, high populace size that can be observed even afterward of seedling mortality and allelopathic action of its aqueous foliage percolate (Allaie *et al.*, 2006; Shah and Reshi, 2007). *Argemone mexicana* is a common alien species found growing everywhere along the roadside in India. The seeds of the plant bear a resemblance to the seeds of mustard (*Brassica nigra*) it can be adulterated by argemone seeds, rather it is poisonous. There are many important examples of katkar poisoning which have been reported from India as well other countries of the world. There was one such instance with occurred as a major outbreak in India in 1998 where 1% adulteration of mustard oil was mixed with argemone oil and caused clinical disease (WHO, 2006). *Cassia tora* is innate to tropical South America and its was introduced in India nearly in initially 1960's (Singh, 1979; Raghavan, 1980; Reddy, 2008). It has been observed in some of the studies that *Cassia Spp.* usually found growing in scattered clumps, in the interim water logged areas as well as along roadside in pasture land and frequently this species is found growing with the diverse vegetation (Bolde and Dhulap, 2019). *Rubus niveus* the most dominant alien woody tree species in different regions of India. This species spread speedily and grow faster, utilized accessible resources and influenced larger ecological flexibility than native species in the area (Singh *et al.*, 2006). *Sapium sebiferum* it is commonly recognized as tallow tree and is also known to be as most trouble invasive tree species in the world. In the Western Himalayan region especially Himachal Pradesh is found growing abundantly and in few areas it can be seen influencing the wetland as well as mesic habitat. As *S. sebiferum* favours moister areas to increase dominance against innate vegetation (Jubinsky, 1993).

Management outlook of invasive alien species

In the fifth IUCN World Park Congress (2003) mentioned that management of invasive alien plant species could be a precedence matter and its necessity to be standard into all the aspects that management of the forests additionally as all protected areas. The matter in context of managements of the protected areas was highlighted throughout IUCN World Conservation Congress of 2012 and IUCN World Parks Congress control throughout 2014. The management of invasive species is considered to be expansive and high labour cost which have been an interruption in management of these invasive species. Eradication and biological control studies have shown that eradication methods for invasive species are effective only if they are completed at initial stage of propagation (Zanden *et al.*, 2010). To some extent eradication process of well-established invasive species may be reason for the release of one more earlier suppressed non- invasive species to invade a particular area. Hence, eradication process needs a lot of monitoring of the specific areas where these invasive alien species are proliferating so, further invasion can be prevented (Caut *et al.*, 2009). Whether, invasive alien plant

species have positive or negative ecosystem services however it ought to be clearly recognized to clarify its cost-benefit which can be useful for the policy makers and stakeholders (Zengeya *et al.*, 2017; Everard *et al.*, 2018; Shackleton *et al.*, 2019). The policy makers need to undergo many aspects of obliteration like price of eradication, likelihood of success and for an instance if failure happens then more what impact can intruder will cause to a selected space that may be regeneration of invasion species, aid different invasive species (Zanden *et al.*, 2010). For eradication of invasive species from Indian Himalaya region a obliteration was done in Jim Corbett National Park, Uttarakhand, with the help of cut root stock methodology beside with manual removal of *L. camara*, which is one of the a well-established invasive alien species in this region (Love *et al.*, 2009). Further, to stop the regeneration of invasive species or any other secondary invasion by different invasive species, restoration of that area with native grass species was done and this experiment was beneficial (Babu *et al.*, 2009).

Biological control measures are taken in several components of the globe, however not in India aside from toxic *Lantana camara*. The tries to manage infestation of toxic plant *L. camara* biologically by introduction of pest of the species was initiated in India in 1916 (Muniappan and Viraktamath, 1986). Ever since varied studies/ investigation are directed to manage the species by diverse pests for instance *Ophiomyia lantanae*, *Lantanophaga pusillidactyla*, *Teleonemia scrupulosa* etc., and for these pest the host plant is *L. camara* (Khan, 1944; Muniappan and Viraktamath, 1986). Invasive alien plants have a plus over the natives as a result of the run off their natural enemies from their native ranges. Thus, biological control of invasive species mistreatment co-evolved natural enemies has long been thought-about a secure, environmentally sound and price effective management tool it's one technique that's used either alone or together with alternative management choices. Moreover, it's usually extraordinarily successful and extremely value effective method (Moran *et al.*, 2005; Messing and Wright, 2006). The systematic study on ecological role of invasive species should be conducted before the eradication process. On the other hand, biological control studies of invasive species cab be beneficial for improved control as well as management of invasive wild plants. Therefore, it requires proper monitoring for an enduring time for better management of the disturbed sites with well-established invasive species since long time with an effective management sustainable approach.

Conclusion

Among several invasive species including *L. camara*, *A. adenophora*, *P. hysterophorus* and *A. conyzoides*, *R. niveus*, *S. sebiferm*, *C. tora*, *A. mexicana* and *A. cotula* have been reported from Indian Himalayan states. These above species proliferated over large areas of India. The printed studies have shown the evidences that fast urbanization in the forms of construction of roads passing though forest and high-altitude ecosystem and extensive tourism in such areas have lead the increase growth rate of these invasive species. The Himalayan regions have rich and unique biodiversity, still it faces sever intimidations due to proliferation of invasive alien species and this evidence shows that these alien species are moving upwards in the higher altitudes of the Himalayan states. Widely distributions and fast proliferation of these species is menace for native biodiversity and ecosystems to the greater extent

in near future. So, more emphasize must be given on these invasive species and some appropriate management strategies can be made for relating to plant invasion over Indian Himalayan regions. Recent advancement in the technologies like GIS and Remote sensing can help in the study and management of the invasive species. The impact of climate change can also be studied through these techniques.

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