www.nesa-india.org • E-mail: nesapublications@gmail.com
International Journal on Environmental Sciences

International Journal on Environmental Sciences 11 (1) : 11-17, ***January-June 2020***
ISSN No.: 0976-4534; NAAS Rating **3.06**

IMPACT OF INVASIVE ALIEN SPECIES ON BIODIVERSITY AND POPULATION STRUCTURE IN MORNI HILLS OF WESTERN HIMALAYA

Anup Chandra[1] and Ashok Kumar Dhakad[1,2]

[1]Systematic Botany Discipline, Forest Research Institute, Dehradun (India)
[2]Department of Forestry and Natural Resources, Punjab Agricultural University, Ludhiana (India)

Research Article

Received: **19.04.2020** Accepted: **31.05.2020** Published: **16.06.2020**

ABSTRACT

Species diversity, especially in forests, is one of the most important indices used to evaluate forest productivity, sustainability of forest communities and its ecological functioning and stand structure. Invasive alien species (IAS) are usually considered to be the second greatest threat to biodiversity after habitat destruction. The present study aims to characterize estimate the species richness, dominance of certain species distribution and population structure of major species in the study areas i.e. Kalka, Morni and Pinjore forest range of Panchkula Forest Division, Haryana lies under the Shiwalik mountain range of Western Himalaya. To achieve this, phytosociological study was carried out using quadrat method to assess the impact of IAS on plant diversity. We took twenty quardrats laid down in each site (10×10m for tree layer; 3×3m for shrubby layer and 1×1m for herbaceous flora) in both, invaded sites and control sites (without any IAS). In the study sites, *Lantana camara* was the major threat to the native flora. In general, diversity index (H) was higher at control site, however, species richness was found to be more in *Lantana* infested sites for trees and more or less equal for herbs and shrubs in control sites. This indicates the invasion of *L. camara* after the establishment of tree species in study sites. In all sites, the seedlings have significant more number than saplings and trees. But the conversion of saplings into trees was poor as well as the production of seedlings and their survival rate was very less or drastically reduced. Thus, there is an urgent need of conservation and management of alien invasive species in Himalayas and other parts of Indian forests. *Lantana camara* infestation can be managed if we utilize it for making handmade papers, handicrafts, baskets, toys, etc. by involving the self help groups and village forest communities.

Keywords: Invasive Alien Species, *Lantana camara*, Morni Hills, Haryana, Population Structure.

INTRODUCTION

A forest has its own composition and diversity pattern which is important ecological attributes significantly correlated with the factors of locality *i.e.* climatic (light, temperature, precipitation and wind), topographic (aspect, exposure, microclimate and bioclimate), edaphic (physical and chemical properties of soil, soil organic matter and soil organism) and biotic factors (Plants, animals, insect-pest, invasive alien species, parasites, epiphytes, climbers, obnoxious weeds, etc.). The species diversity, floristic composition and vegetation structure are important parameters to judge the state of natural forests in the region and to suggest conservation strategies thereof. Normally, forest diversity varies with place to place just because of variability in biogeography, habitat and disturbance (Whitmore, 1998). The regeneration behaviour and distribution pattern of different tree species is portrayed by their community structure which thusly relies on the presence of sufficient number of seedlings, saplings and tree with various girth classes. The impact of biotic and abiotic components of any locality influences the survival

*Corresponding author: *ashokdhakad@pau.edu*

and development of seedlings into tree (Mullar-Dombios *et al.*, 1980).

Invasion of exotic species is the important global scale problems experienced by natural ecosystems. Although the biological invasion is a natural process, the recent enhanced rate of invasion is clearly a human caused phenomenon with commercial interests (Heywood, 1989). Reddy (2008) reported 173 Invasive Alien Species in India, 80% introduced from the neotropics. The most prominent invasive species are *Ageratum conyzoides* L., *Chromolaena odorata* L., *Eupatorium adenophorum* Spreng, *Lantana camara* L., *Mikania micrantha* Kunth, *Mimosa invisa* (Mart.) Solms, *Parthenium hysterophorus* L. and *Prosopis juliflora* (Sw.) DC. among terrestrial plants, and *Eichhornia crassipes* (Mart.) Solms and *Pistia stratiotes* L., among aquatic IAS. All these species are principal threats to the native flora (Sharma *et al.*, 2005; Hajra and Negi, 2007). Specifically in the North-Western Himalayas, invasive plants such as *L. camara, P. hysterophorus, A. conyzoides* and *Eupatorium adenophorum* are the most problematic weeds (Kohli *et al.*, 2004; Dogra *et al.*, 2009a).

Amongst these *L. camara* is considered as one of world's top 100 invasive species and top 10 worst weeds of the world (Sharma *et al.*, 2005a; IUCN, 2009). In North-Western Himalayan region, *L. camara* was introduced during 1905 in Kathgodam, Uttarakhand (Hakimuddin, 1929). Now after a century, this invasive species is a major ecological problem in this area (Rajwar, 2007) and covers a vast area along horizontal and vertical geographical coordinates. *L. camara* is naturalized up to 1900 m altitude or somewhere beyond that also. The point of worry is that this area under *L. camara* invasion possesses highest forest cover in North-Western Himalaya and North India (ISFR, 2009). *Lantana camara* generally forms dense monospecific thickets (Palmer and Pullen, 1995), grows well on nutrient deficient barren soils (Bhatt et al., 1994) and suppression of seed germination of other flora nearby due to releasing allelochemicals (Bais et al., 2004). Equipped with these features, *L. camara* has potential to prevent natural regeneration of some tree species, block succession and replace native species (Ambika et al., 2003). Thus ultimately change the vegetation and ecosystem structure. Keeping in view above these facts, the present study has been taken to estimate the impact of *Lantana camara* on plant diversity and population structure in western Himalayas.

MATERIALS AND METHODS

Shiwalik hills, also known as Churia Hills and as Manak Parbat in ancient times, are a mountain range of the outer Himalayas that stretches from the Indus River eastwards close to the Brahmaputra River, spanning across the northern parts of the Indian subcontinent. Shivalik literally means 'tresses of the Shiva'. In Indus river area, it covers the lower hills of districts of Himachal Pradesh, Punjab, Haryana and Uttarakhand state. The study area i.e. Morni Hills are offshoots of the Shivalik mountain range of the Himalaya situated in Haryana state, which run in two parallel ranges. The climate in the area is subtropical to mild warm temperate. The average rainfall in this area is about 1500-1800 mm. The minimum temperature in the Shivalik hills is 5°C in January (winter) and maximum in June up to 40°C (summer). A total three different forest ranges, namely, Kalka, Morni and Pinjore range in Panchkula Forest Division were selected for phytosociological studies.

Vegetation analysis was done by random-systematic design and gradsect methods (Barbour *et al.*, 1999). Twenty infested sites were selected at random of study site. Parallel control (non-invaded) sites were also selected to compare the species richness, diversity and composition of vegetation in the invaded and non-invaded areas. Twenty quardrats were laid down in each site (10×10m for tree layer; 3×3m for shrubby layer and 1×1m for herbaceous flora). In each quadrat, g.b.h. (girth at breast height at 1.37m above ground level) of each tree was measured and recoded individually. In each quadrat, plants with dbh more than 10 cm were considered in tree layer, those with diameter with 3-10 cm were considered in shrubby layer, and individuals with less than 3 cm were considered as herbaceous flora (Bhandari *et al.*, 1997). The plants were identified with the help of herbaria of the FRI, Dehradun and other flora like "*Floristic diversity of Shiwalik hills Haryana*" (Negi *et al.*, 2010).

Species richness, diversity, index of dominance, similarity, dissimilarity index and evenness of invaded and non invaded sites was calculated and compared to find out the loss of biodiversity due to invasion of *L. camara*. Concentration of dominance (cd) was measured by Simpson's Index (Simpson, 1949) and

Shannon Wiener information function (Shannon and Wiener, 1963) was also calculated.

Shannon-Wiener information function (Shannon and Wiener, 1963) was using the formula:

$$H = \Sigma\, pi \ln pi$$

Where pi is the proportional of individuals of **i**th species and number of individuals of all the species.

Concentration of dominance (cd) was measured by Simpson Index (Simpson, 1949).

$$Cd = \Sigma\, (pi)^2$$

To estimate the population structure, all tree species grouped under different gbh (girth at breast height) classes. The total number of individuals belonging to each gbh class was calculated for each species for the each site.

RESULTS AND DISCUSSION

Biodiversity plays a key role in regulating ecosystem function and stability and hence, is essential for human survival and economic well being. Trees form the major structural and functional basis of tropical forest ecosystems and can serve as robust indicators of changes and stress at the landscape scale. Plant diversity at local scale has been studied by using various indices, such as number of species per unit area (species richness) or the Shannon index. These are used as indicators of the degree of complexity of a community and provide information on the homeostatic capacity of the system to unforeseen environmental changes (Magurran, 1988). Invasive species i.e. *Lantana camara* was severely invaded in the study sites and affect the under storey as well as middle storey species abundance and composition including tree seedlings. Thus, Invasive species appear to be altering vegetation community structure and composition in forests. This severely affects the germination of seeds or development of seedlings into sapling or trees.

Diversity indices for different growth forms of Kalka Range, Morni and Pinjore range, Panchkula forest division are presented in Table 1. In Kalka range, diversity index (H) was higher at control site, however, species richness was found to be more in *lantana* infested site for trees and herbs but for shrubs it is more in control sites. Concentration of dominance (Cd) was higher in *lantana* infested site for trees and evenness was higher at control site. It may be due to the more regeneration potential and availability of more suitable germination and establishment condition for the sprouts. In Morni range, diversity index (H) was higher at control site for shrubs and herbs but for trees it was higher at lantana infested site, however, species richness was found to be more in *lantana* infested site for herbs and trees but for shrubs it was equal in both control site and infested sites. Concentration of dominance (cd) were higher in lantana infested site for shrubs and herbs but for trees it was more at control site as compare to lantana infested site and evenness were higher at control site for all. In Pinjore range, diversity index (H) was higher at control site for shrubs and herbs but for trees it was higher at lantana infested site (1.222), however, species richness was found to be more in *Lantana* infested site for shrubs and trees but for herbs it was equal in both control site and infested sites (22). Concentration of dominance (cd) were higher in *lantana* infested site for shrubs and herbs but for trees it was more at control site as compare to *lantana* infested site (0.103) and evenness were higher at control site for all.

Table 1: Biodiversity indices of Panchkula Forest Division, Haryana.

Site	Trees				Shrubs				Herbs			
	SR	**H**	**cd**	**E**	**SR**	**H**	**cd**	**E**	**SR**	**H**	**cd**	**E**
Kalka Range												
Control	13	1.068	0.093	0.959	18	1.114	0.107	0.887	18	1.190	0.072	0.948
Invaded	15	1.044	0.121	0.887	15	0.687	0.410	0.584	21	1.088	0.155	0.823
Morni Range												
Control	12	1.000	0.118	0.922	19	1.217	0.068	0.952	30	1.398	0.045	0.946
Invaded	18	1.135	0.096	0.904	19	0.870	0.296	0.680	28	1.154	0.147	0.798
Pinjore Range												
Control	12	1.027	0.103	0.952	12	1.041	0.097	0.965	22	1.245	0.069	0.928
Invaded	20	1.222	0.071	0.939	15	0.794	0.314	0.675	22	1.089	0.156	0.811

Distribution of selected tree species (tree/ha) by different girth classes of Kalka range Haryana is presented in Table 2. It reveals from the data, good number of seedlings and saplings of *Mimosa himalayana*, *Acacia catechu*, *Lannea coromandalica and Bamboo* spp. represent good regeneration. Seedlings and saplings of *M. himalayana and L. coromandalica* were absent and indicated poor regeneration at infested site. It is clear from the Table 2 that total density of all species was higher at control site than infested site. In infested site, total density of *A. catechu* and *Bamboo* spp. was quite high than other species found.

Table 2: Distribution of selected tree species by girth class at Kalka range, Haryana.

Species	Seedlings	Saplings	Girth class (cm)			Total
			30-49	50-69	> 69	
Control site of Kalka range						
Mimosa himalayana	1000	222	400	0	0	1622
Acacia catechu	6000	222	300	0	0	6522
Lannea coromandalica	4000	111	200	100	100	4511
Bamboo spp.	3000	1222	300	0	0	4522
Lantana Invaded site						
Mimosa himalayana	0	0	200	0	0	200
Acacia catechu	2000	111	700	0	0	2811
Lannea coromandalica	0	0	0	0	200	200
Bamboo spp.	3000	222	700	0	100	4022

Distribution of different tree species (tree/ha) by different girth classes (cm) of Morni range, Haryana is presented in Table 3. It reveals from the data at the control site, good regeneration of *Pinus roxburghii*, *Eucalyptus* spp., *M. himalayana and Bamboo* spp. was present. Good number of seedlings and saplings

Table 3: Distribution of selected tree species by girth class at Morni range, Haryana.

Species	Seedlings	Saplings	Girth class (cm)			Total
			30-49	50-69	> 69	
Control site of Morni range						
Pinus roxburghii	9000	445	300	0	300	10045
Eucalyptus spp.	1000	222	600	0	0	1822
Mimosa himalayana	4000	556	500	0	0	5056
Bamboo spp.	6000	111	300	0	0	6411
Lantana Invaded site						
Pinus roxburghii	1000	111	300	100	300	1811
Eucalyptus spp.	0	0	700	100	0	800
Mimosa himalayana	2000	111	200	0	0	2311
Bamboo spp.	1000	0	200	0	0	1200

indicated that there was regeneration of *P. roxburghii*, *Eucalyptus* spp., *M. himalayana and Bamboo* spp. in the area. Seedlings and saplings of *Eucalyptus* spp. was absent and indicated poor regeneration at infested site. It is clear from the Table 3 that total density of all species was higher at control site than infested site.

Distribution of different tree species (tree/ha) by different girth classes (cm of Pinjore range, Haryana is presented in Table 4. It reveals at the control site, good regeneration *A. catechu*, *Flacortia indica*, *Cassia fistula and Bamboo* spp. was present. Good number of seedlings and saplings indicated that there was regeneration of *A. catechu*, *F. indica*., *C. fistula and Bamboo* spp. in the area. Seedlings and saplings of *F. indica* and *Cassia fistula* were absent and indicated poor regeneration at infested site. It is clear from the Table 4 that total density of all species was higher at control site than infested site. In infested site, total density of *A. catechu* and *Bamboo* spp. *w*as observed sufficiently.

Table 4: Distribution of selected tree species by girth class at Pinjore range, Haryana.

Species	Seedlings	Saplings	Girth class (cm)			Total
			30-49	50-69	> 69	
Control site of Pinjore range						
Acacia catechu	8000	445	400	0	0	8845
Flacortia indica	2000	445	200	0	0	2645
Cassia fistula	1000	0	300	0	0	1300
Bamboo spp.	4000	222	200	0	0	4422
Lantana Invaded site						
Acacia catechu	2000	0	700	0	0	2700
Flacortia indica	0	0	400	0	0	400
Cassia fistula	0	0	200	0	0	200
Bamboo spp.	2000	0	300	100	0	2400

The decrease in species evenness, and consequently diversity, is mostly driven by the cover and height of invading species, independently of species identity. However, the species richness is more in at all three invaded sites for tree while less for shrubs. The results indicated that *lantana* invasion does not have any impact on tree species richness. It means *lantana* was invaded after the tree populations have established well. It was also enquired from the local inhabitants that wild animals and forest villagers dig up the tender seedlings from the clear and non-invaded sites than *lantana* invaded sites, however, in later stage it is difficult to dig out roots. It may be the probable reason for the lower sapling populations. The immense pressure on the area from the forest dwellers or tribal's may be the probable reason for the disturbances.

The comparison of population structure and densities of all sites revealed that the highest percentage of seedlings were observed at Morni hill range, highest number of saplings were present at Kalka range and highest percentage of trees was present at Morni range. In all three sites, the seedlings have significant more number than saplings and trees. But the conversion of saplings into trees was poor as well as the production of seedlings and their survival rate was drastically reduced. The population structure indicated poor regeneration of trees in the studied sites. The space, light and root competition and disturbance gradients increased up to that level where the seedlings of few species were totally absent in all sites due to heavy invasion of *L. camara*.

Increased *L. camara* population may lead to ecological disturbance that can change foraging behavior of native pollinators and phenological behavior of plant species, which consequently may result in reduced reproductive output of some native species (Ghazoul, 2004). There were not just decreased population but with large patches of *L. camara* monocultures, the populations of native shrubs in invaded localities were becoming discontinuous. These populations were either having weak plants (with lesser basal area) or small patches of healthy individuals. It is known that isolated plants or fragmented populations suffer reduced fecundity due to declining pollination efficiency. Further, loss of plants can trigger chained extinction throughout the community (Wilcock and Neiland, 2002; Ghazoul and Shaanker, 2004).

ACKNOWLEDGEMENT

The authors would like to express their gratitude to Director, FRI Dehradun for providing the necessary facilities and Indian Council of Forestry Research and Education (ICFRE) for allocation of funds to conduct the study smoothly and successful completion.

REFERENCES

1. **Ambika SR, Poornima S, Palaniraj R, Sati SC and Narwal SS** (2003) Allelopathic plants. 10. *Lantana camara* L. *Allelopathy J.* 12(2): 147-162.
2. **Bais HP, Park SW, Weir TL, Callaway RM and Vivanco JM** (2004) How plants communicate using the underground information superhighway. *Trends in Plant Sci*. 9(1): 26-32.
3. **Barbour MG, Burk JH, Pitts WD, Gilliam FS and Schwartz MW** (1999) *Terrestrial Plant Ecology*. 3rd Edition. Addison Wesely Longman Inc., Menlo Park, California, USA.
4. **Bhandari BS, Mehta JP, Nautiyal BP and Tiwari SC** (1997) Structure of a Chir pine (*Pinus roxburghii* Sarg.) community along an altitudinal gradient in Garhwal Himalaya. *Int. J. Eco. Environ. Sci.* 23(1): 67-74.
5. **Bhatt YD, Rawat YS and Singh SP** (1994) Changes in ecosystem functioning after replacement of forest by *Lantana* shrubland in Kumaun Himalaya. J. Veg. Sci. 5(1): 67-70.
6. **Dogra KS, Kohli RK and Sood SK** (2009) An assessment and impact of three invasive species in the Shivalik hills of Himachal Pradesh, India. *Int. J. Biodivers. Conserv*. 1(1): 4-10.
7. **Ghazoul J.** (2004) Alien abduction: disruption of native plant-pollinator interactions by invasive species. *Biotropica*. 36(2): 156-164.
8. **Ghazoul J and Shaanker RU** (2004) Sex in space: pollination among spatially isolated plants. *Biotropica* 36(2): 128-130.
9. **Hajra PK and Negi PS** (2007) Alien flora of Doon Valley, Northwest Himalaya. *Curr. Sci.* 92(7): 968-978.
10. **Hakimuddin M** (1929) Lantana in Northern India as a pest and its probable utility in solving the cowdung problem. *Indian Forester*. 56: 405-410.
11. **Heywood VH** (1989) In *Biological Invasions: A Global Perspective*: Drake, J.A. *et al.* (eds) John Wiley and Sons, New York. Pp 31-60.
12. **ISFR** (2009) India State of Forest Report 2009, http://www.fsi.org.in/, Cited 10 Dec. 2009.
13. **IUCN** (2009) Invasive Species Specialist Group, 100 World's Worst Invasive Alien Species. www.issg.org/booklet.
14. **Kohli RK, Dogra KS, Batish DR and Singh HP** (2004) Impact of invasive plants on the structure and composition of natural vegetation of north western Indian Himalayas. *Weed Technol.* 18: 1296-1300.
15. **Magurran AE** (1988) Ecological diversity and measurment. Princeton University Press, Princeton 354.
16. **Mullar-Dombios DJ, Jucobi D, Cooray RG and Balakrishnan N** (1980) Ohio rain forest study: ecological investigation of the Ohio diback problem in Huwaii. Miscellaneous Pub. 183. Huwaii Institute of tropical Agricultural and Human Resource, Honolulu HI.
17. **Negi SS, Naithani HB, Chandra A and Kamboj SK** (2010) *Floristic diversity of Shiwalik hills Haryana*. Forest Research Institute, Dehradun, Uttarakhand, India.
18. **Palmer WA and Pullen KR** (1995) The phytophagous arthropods associated with *Lantana camara*, *L. hirsuta*, *L. urticifolia*, and *L. urticoides* (Verbenaceae) in North America. Biological Control 5: 54-72.

19. **Rajwar GS** (2007) Invasive effects of *Lantana camara* in the forests of Southern Garhwal Himalaya. In: Yajun W, Shengcai L, Ping H, Yuzhong Y, Ying A, Xiuyun S (Eds.) Progress in Environmental Science and Technology, Vol. I: Proceedings of the 2007.

20. **Reddy CS** (2008) Catalogue of invasive alien flora of India. *Life Sci. J*. 5(2): 84-89.

21. **Shannon CE and Weaver W** (1963) The Mathematical Theory of Communication. Urbana, IL, University of Illinois Press, USA. 31-35 pp.

22. **Sharma GP, Raghubanshi AS and Singh JS** (2005a) *Lantana* invasion: An overview. *Weed Biol. Mgmt*. 5: 157-165.

23. **Sharma GP, Singh JS and Raghubanshi AS** (2005) Plant invasions: Emerging trends and future implications. *Curr. Sci*. 88(4): 726-734.

24. **Simpson EH** (1949) Measurement of diversity. *Nature* 163: 688.

25. **Whitmore TC** (1998) An introduction to tropical rain forests. Oxford University Press, New York.

26. **Wilcock C and Neiland R** (2002) Pollination failure in plants: Why it happens and when it matters. *Trends in Plant Sci*. 7(6): 270-277.