Biological Forum – An International Journal **11(1): 95-100(2019)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Assessment of Impact of *Eupatorium adenophorum* Spren. on the Plant Diversity in Tanakpur Range, Champawat Forest Division, Uttarakhand

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(Received 28 October 2018, Accepted 05 February, 2019)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Impact study of *Eupatorium adenophorum* Spren. on the indigenous flora in the Tanakpur Range of Champawat district, Uttarakhand was carried out. Species richness, IVI and plant diversity indices of Eupatorium impacted and non Eupatorium impacted (Control) sites were studied. Tree density in the present study was reported to be 4.7 and 4.4 for control and infested sites respectively. TBA (cm^2 $100m^{-2}$) and density (P $100m^{-2}$) values are reported 241 and 29 for the Shrubby layer respectively and 1.56 and 13.3 for the herbaceous layer respectively. In both shrubby and herbaceous layers, biodiversity indices such as species richness, diversity index and evenness was recorded higher in control site than infested site. Concentration of dominance was higher in the herbaceous layer. It reveals study that Eupatorium is causing tremendous impact on the indigenous plant diversity. Hence, spread of invasive species can be checked by adopting suitable conservation measures. Local people can be educated through awareness programme on invasive species spread and their impact on indigenous flora and fauna.

Keywords: Invasive Alien Species, Species richness, Diversity index, Concentration of dominance

How to cite this article: A. Chandra, A.K. Dhakad, P.K. Verma, J. Saxena and A.K. Raut (2019). Assessment of impact of *Eupatorium adenophorum* Spren. on the plant diversity in Tanakpur Range, Champawat Forest Division, Uttarakhand. *Biological Forum – An International Journal*, **11**(1): 95-100.

INTRODUCTION

Alien species are non-native or exotic organisms that occur outside their natural adapted ranges and dispersal potential (McGeoch *et al.,* 2010). Many alien species support our farming and forestry systems in a big way. However, some of the alien species become invasive when they are introduced deliberately or unintentionally outside their natural habitats into new areas where they express the capability to establish, invade and out-compete native species (Raghubanshi *et al.,* 2005). The Millennium Ecosystem Assessment (2005) listed Invasive Alien Species (IAS) as one of the five primary drivers of change in ecosystem composition, structure and function. Moreover, global climate change may well accelerate the rate of introduction and spread of IAS into areas where they were previously absent, or increase their performance relative to indigenous species (Raizada *et al.,* 2009). Invasive alien species can have large detrimental economic impacts on human enterprises such as fisheries, agriculture, grazing and forestry. Overall, examination of the IUCN database on species extinctions implicated a negative role of IAS in 50% of those extinctions where a cause could be identified or inferred, second only to habitat transformation (Ervin, 2003).

India is also facing negative impact of the invasive species. Khuroo *et al.,* (2012) reported that the alien flora of India amounts to 1599 species, belonging to 842 genera in 161 families and constituting 8.5% of the total vascular flora found in the country. Kerala Forest Research Institute and CAB International (2009) collaboratively compiled a manual on *Chromolaena odorata*, *Lantana camara*, *Mikania micrantha*, *Mimosa diplotricha* and *Parthenium hysterophorus* as major IAS in India. Various studies have been underlined the detrimental effects of spread of Invasive species (Saxena, 1991; Crawley, 1997; Prasad, 2012; Ramaswami and Sukumar, 2011; Aravind *et al.,* 2010; Keane and Crawley, 2002; Byers, 2002; Levine *et al.* 2003; Ehrenfeld, 2006; Lau, 2008; Prashanth, 2009; Sharma and Raghubanshi, 2011; Bhagwat *et al*., 2012). In the present study efforts have been made to assess the impact of *Eupatorium adenophorum*, a inavasive species on the indigenous flora of the Champawat district of the Uttarakhand.

A. Study Area

The state of Uttarakhand is endowed with high plant diversity. Total forest area is about 38,000 sq. km. (63.42%) of total geographical area (53483 sq. km) of the states (Anon, 2017). The state has cover of forest cover of 24.295 sq. km. which is 45.43% of the geographical area of the state. The Champawat district has total geographical area of 1766 sq. km. and has forest cover of 1224 sq km. is 3269 sq. km. It is about 69% of the total geographical area of the state. Forest cover is distributed on the basis of canopy as VDF (367 sq. km), MDF (593 sq. km) and OF (264sq. km).

Study area is located at Tanakpur Forest area. It is situated in Champawat district of the Uttarakhand (Fig.1). It lies between latitude 30° and longitude 78°, Alt 1768m. Area is affected by invasive species. Sites with invasive infestation and without infestation were identified for the study.

Fig. 1. Map of study area.

MATERIALS AND METHODS

Phytosociological studies were conducted during 2014 using quadrat method (size of the quadrat: 10 × 10m for trees; 3 × 3 m for shrubs and 1 × 1 m for herbs). Plant specimens were collected and identified with help of DD Herbarium and relevant floras (Gaur, 1999; Kanjilal, 1928). Ten quadrats were laid down randomly in each location. 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 case of herb and shrub, diameter was measured 2.5 cm above ground level. Quantitative analysis of vegetation for frequency, density and dominance was calculated following Mishra (1968). Values of Relative fervency, density and dominance were summed to get Importance Value Index (IVI).

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

$$H = - \sum pi \ln pi$$

Where pi is the proportional of individuals of $\mathbf{i}^{th}$ species.

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

$$Cd = \sum(pi)^2$$

Pielou's evenness index (Pielou, 1966) was calculated using formula:

$$J = H'/\ln(S)$$

where *H'* is Shannon Weiner diversity and ***S*** is the total number of species.

RESULTS AND DISCUSSION

Mean density, frequency and total basal area of tree, shrubby and herbaceous layers of Control site and *Eupatorium* infested of Tanakpur Range, Champawat Forest Division, Uttarakhand is presented in Table 1. Total density (P $100m^{-2}$) of different tree species at Control site and *Eupatorium* infested were 4.7 and 4.4 respectively. Total basal area ($cm^2\ 100^{-2}$) of *Eupatorium* infested sites was 3575 and of control sites was 4505. Highest IVI reported for *Shorea robusta* for both control (204.12) and infested (247.0).

In the shrubby layer, 9 species were reported for control site and 3 were from the infested site. Total density (P 100^{-2}) of different species at Control and infested sites were 29.1 and 13.3 respectively. Total basal area ($cm^2\ 100^{-2}$) was estimated 249.1 for control and 1.57 for the infested site. The most dominant shrub species on the basis of IVI in control site was *Holarrhena pubescens* (90.62), followed by *Tectona grandis* (58.41), *Mallotus philippensis* (43.03) etc. In *Eupatorium* infested site, most dominant shrub species was *Cestrum parqui* (131.4) followed by *Clerodendrum viscosa* (86.73) and *Mallotus philippensis* (81.84).

Total density (P $100m^{-2}$) of different herbaceous species in control and infested site were 1600 and 6480 respectively. *Eupatorium adenophorum* had maximum density of 5550 in infested site. Total basal area ($cm^2\ 100^{-2}$) of 648 was recorded at control site while it was 11.81 for the infested site. Highest IVI was estimated for *Clerodendrum viscosa* (78.54) in the control site. In *Eupatorium* infested site, most dominant herb species was *Eupatorium adenophorum* with IVI value of 211.18 followed by *Ageratum conyzoides* (42.51), *Desmodium cephalotes* (19.55) etc.

Table 1: Quantitative analysis of trees, shrubs and herb layers in control site of Tanakpur range, Champawat Forest Division, Uttarakhand.

S. No.	Species	Density (P $100m^{-2}$)	Frequency (%)	TBA (cm^2 $100m^{-2}$)	IVI
Tree Layer					
1.	*Shorea robusta* Roxb. ex Gaertn. f.	3.0	100	4067.7	204.12
2.	*Mallotus philippensis* (Lam..) Muell.-Arg.	1.1	60	187.3	57.56
3.	*Syzygium cumini* (L.) Skeels	4.0	30	210.2	28.18
4.	*Tectona grandis* L. f.	2.0	10	39.8	10.14
	Total	**4.70**		**4505.0**	**300.00**
Shrubby Layer					
1.	*Holarrhena pubescens* (Buch.-Ham.) Wallich ex. G. Don	6.7	40.0	114.0	90.62
2.	*Tectona grandis* L. f.	6.7	30.0	47.1	58.41
3.	*Mallotus philipensis* (Lam..) Muell.-Arg.	5.6	30.0	17.4	43.03
4.	*Murraya koenigii* (L.) Spreng.	5.6	20.0	22.2	41.01
5.	*Lannea coromandelica* (Houtt.) Merr.	0.1	10.0	14.0	15.08
6.	*Syzygium cumini* (L.) Skeels	1.1	10.0	10.7	13.79
7.	*Casearia tomentosa* Roxb.	1.1	10.0	7.9	12.68
8.	*Justicia adhatoda* L.	1.1	10.0	7.9	12.68
9.	*Cassia fistula* L.	1.1	10.0	7.9	12.68
	Total	**29.1**	**170.0**	**249.1**	**300.00**
Herbaceous Layer					
1.	*Cledodendrum viscosum* Vent.	510	100	196.2	78.54
2.	*Mallotus philippensis* (Lam..) Muell.-Arg.	120	80	212.0	53.32
3.	*Pogostemon bengalenses* (Burm.f.) Kuntze	330	60	64.8	40.45
4.	*Ichnocarpus frutescens* (L.) R. Br.	220	80	27.6	31.13
5.	*Holarrhena pubescens* (Buch.-Ham.) Wallich ex. G. Don	110	60	31.1	21.51
6.	*Dioscorea belophylla* (Prain) Haines	90	40	11.3	13.93
7.	*Syzygium cumini* (L.) Skeels	30	20	23.6	8.79
8.	*Tectona grandis* L. f.	20	20	15.7	6.95
9.	*Cissampelos pereira* L. var. hirsute (Buch.-Ham. ex. DC.) Forman	30	20	8.5	6.46
10.	*Murraya koenigii* (L.) Spreng.	20	10	15.7	5.31
11.	*Cassia fistula* L.	20	20	3.9	5.13
12.	*Desmodium cephalotes* (Roxb.) Wallich ex. Wight & Arn.	20	20	2.5	4.92
13.	*Oplismenus burmannii* (Retz.) P. Beauv.	10	10	7.9	3.48
14.	*Sida acuta* Burm. f.	10	10	7.9	3.48
15.	*Solanum indicum* L.	10	10	5.0	3.04
16.	*Coffea benghalensis* Heyne ex Roem.	10	10	5.0	3.04
17.	*Reinwardtia indica* (Roxb.) Planch	10	10	2.8	2.70
18.	*Adiantum spp*	10	10	2.8	2.70
19.	*Ageratum conyzoides* L.	10	10	2.0	2.57
20.	*Rungia pectinata* (L.) Nees	10	10	2.0	2.57
	Total	**1600**		**648.1**	**300.00**

Diversity indices for different growth forms of Champawat Forest Division, Uttarakhand are presented in Table 3. In tree layer, species richness diversity index (H), species richness and evenness were higher in control than *Eupatorium* infested site. Similarly, in shrubby and herbaceous layer, diversity index, species richness and evenness was estimated higher in the control site than Eupatorium infested site.

Several workers (Dabel and Day, 1977; Killingbeck and Wali, 1978; Sexena and Singh, 1980; Pande *et al.* 1996; Bhandari *et al.* (1997) have reported the value of TBC and density of tree species varying from 1561 to 5930 cm^2 $100m^{-2}$ and 3.5 to 20.8 tree $100m^{-2}$ respectively. Ralhan *et al.* (1982) reported the value of TBC and density varying from 2686 to 6045 cm^{-2} and 3.8 to 16.33 trees 100 m^{-2} for temperate forests of Kumaon Himalaya. Singhal *et al.* (1986) reported TBC and density varying from 1455 to 5672 cm^{-2} and 0.7 to 3.7 trees $100m^{-2}$ respectively.

Table 2: Quantitative analysis of trees, shrubs and herb layers in infested site of Tanakpur Range, Champawat Forest Division, Uttarakhand.

S. No.	Species	Density (P $100m^{-2}$)	Frequency (%)	TBA (cm^2 $100m^{-2}$)	IVI
Tree Layer					
1.	*Shorea robusta* Roxb. ex Gaertn. f.	3.7	130	3240.1	247.0
2.	*Terminalia bellirica* (Gaertn.) Roxb.	0.6	40	3055.0	44.4
3.	*Syzygium cumini* (L.) Skeels	0.1	10	28.6	8.6
	Total	**4.4**		**3574.2**	**300.0**
Shrubby Layer					
1.	*Cestrum parqui* L'Herit	5.6	30	0.88	131.5
2.	*Cledodendrum viscosum* Vent.	4.4	30	0.31	86.7
3.	*Mallotus philippensis* (Lam..) Muell.-Arg.	3.3	30	0.37	81.8
	Total	**13.3**		**1.56**	**300.0**
Herbaceous Layer					
1.	*Eupatorium adenophorum* Spreng.	5550	100.00	10.9	211.18
2.	*Ageratum conyzoides* L.	740	80.00	0.52	42.51
3.	*Desmodium cephalotes* (Roxb.) Wallich ex. Wight & Arn.	90	50.00	0.18	19.55
4.	*Pinus roxburghii* Sarg.	20	20.00	0.01	7.09
5.	*Mallotus philippensis* (Lam..) Muell.-Arg.	40	10.00	0.11	4.91
6..	*Jasminum pubescens* (Retz.) Willd.	10	10.00	0.05	3.91
7.	*Reinwardtia indica* (Roxb.) Planch	10	10.00	0.02	3.65
8.	*Solanum indicum* L.	10	10.00	0.01	3.59
9.	*Oplismenus burmannii* (Retz.) P. Beauv.	10	10.00	0.01	3.59
	Total	**6480**		**11.81**	**300.00**

Table 3: Biodiversity indices of Champawat Forest Division, Uttarakhand.

Site	Trees				Shrubs				Herbs			
	SR	**H**	**cd**	**E**	**SR**	**H**	**cd**	**E**	**SR**	**H**	**cd**	**E**
Control	**4**	0.970	0.471	0.700	9	0.174	0.174	0.866	20	2.125	0.178	0.709
Eupatorium infested	3	0.503	0.726	0.458	3	1.077	0.347	0.981	9	0.529	0.747	0.241

(SR= Species richness; H=Diversity index; cd=Concentration of dominance; E= Evenness)

In the present study, tree TBA of Champawat forest in control and infested sites was reported to be 4505 and 3574cm^2 $100m^{-2}$ respectively. Values are of TBA for the present study fall in this range. Tree density in the present study was reported to be 4.7 and 4.4 for control and infested sites respectively. Value of density also falls in the above range. TBA (cm^2 $100m^{-2}$) and density (P $100m^{-2}$) values are reported 241 and 29 for the Shrubby layer respectively and 1.56 and 13.3 for the herbaceous layer respectively. Density in control and infested sites were recorded to be 1600 and 6480 respectively. Higher the density in the herbaceous layer is the presence of heavy infestation of Eupatorium at the site. Inspite of high density in Eupatorium infested site, total basal area is low, it indicates the presence of young plants in the site.

Various workers reported diversity index values between 1.16 to 3.14 for temperate forests (Monk, 1967; Risser and Rice, 1971; Saxena and Singh, 1982; Singh and Singh, 1984; Pande *et al.* 1996; Verma, 2016; Verma, 2017). In the present study, significant difference in the species richness in the shrubby and herbaceous layer is observed. Species richness was recorded higher in control site in both shrubby and herbaceous layers. Concentration of dominance was higher in the herbaceous layer indicates the higher number of individual of the Eupatorium in the area.

It is concluded from the present study that Eupatorium is causing tremendous pressure on the indigenous plant diversity. Diversity parameters such as tree diversity index, concentration of dominance and species richness showed higher in control site than infested site. Shrub and herb species diversity index (H) also showed the similar kind of trend. A lower value of diversity index indicates that there is impact of invasive species on the indigenous flora of the area.

Therefore, declining plant diversity of the infested sites may be restored by adopting suitable conservation measures. Local people can be educated through training programmes on invasive species spread and their impact on indigenous flora and fauna.

ACKNOWLEDGEMENT

Authors are thankful to the Director, Forest Research Institute, Dehradun for constant encouragement and support.

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