

# Invasive Alien Plants of Indian Himalayan Region— Diversity and Implication

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## ABSTRACT

The present study deals with comprehensive list of Invasive alien plants of Indian Himalayan Region with background information on family, habit and nativity. A total of 190 invasive alien species under 112 genera, belonging to 47 families have been recorded. Among these, the dicotyledons represent by 40 families, 95 genera and 170 species; monocotyledons represent by 7 families, 17 genera and 20 species. The analysis of invasive species reveals that 18 species have been introduced intentionally, while the remaining species established unintentionally through trade. In terms of nativity, amongst 13 geographic regions, the majority of invasive plants reported from American continent (73%). While in life form analysis, the herbs (148 species) are dominant, followed by shrubs (19 species), Grass (11 species), Trees (4 species), sedges and climber (3 species each). Most of the invasive species are annual habit (63%). Apart from these, 90 species (47%) are being used by locals for medicinal purposes. A better planning is needed for early detection to control and reporting of infestations of spread of new and naturalized weeds to be monitored.

**Keywords:** Invasive Alien Species; Indian Himalayan Region; Nativity; India

## 1. Introduction

The Himalaya, is an enchantment territory of the nature where the magnificence of the world's highest mountains is mirrored in the rugged beauty and unique culture of the people who live in their shadow. The Indian part of Himalayas covering an area about 5 lakh km<sup>2</sup> (about 16.2% of country's total geographical area) and forms the northern boundary of the country. It extends between latitudes 26°20' and 35°40' North, and between longitudes 74°50' and 95°40' East. The Indian Himalayan Region (IHR) is spreading on 10 states (administrative regions) namely, Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Meghalaya, Nagaland, Manipur, Mizoram, Tripura, and hill regions of 2 states viz., Assam and West Bengal of Indian Republic. Starting from foot-hills in the south (Siwaliks) the region extends to Tibetan plateau in the north (trans-Himalaya) comprising about 95 districts of the country and contributes about 16.2% of India's total geographical area [1]. The most of IHR area is covered by snow-clad peaks, glaciers of higher Himalaya, dense forest cover of mid-Himalaya. A total of 10,000 plant species are estimated in IHR, of which 3160 species are endemic [2]. There is no record about the invasive species found in IHR.

Alien species are exotic organisms that occur outside their natural adapted ranges and dispersal potential [3].

Many alien species supports our farming and forestry systems in bulk. However, a few alien species become invasive when they are introduced intentionally or unintentionally outside from their natural habitats into new areas where they express the capability to establish, invade and out-compete native species [4,5]. International Union for Conservation of Nature and Natural Resources (IUCN) defines alien invasive species as an alien species which becomes established in natural or semi-natural ecosystems or habitat, an agent of change, and threatens to native biological diversity. These invasive are widely distributed among all categories of living organisms as well as all kinds of ecosystems throughout the world.

Invasive species cause loss of biodiversity including species extinctions, changes in hydrology and ecosystem function [6]. The exotic plant species vary from native one, based on their requirements, modes of resource acquisition and more consumption which may cause changes in soil structure, its profile, decomposition, nutrient content, moisture, etc. It results significant undesirable impacts on the biodiversity and ecosystems. Thus, Invasive species are a serious hindrance for conservation and sustainable use of biodiversity. Biological invasions now operated on global level and it will undergo rapid increase due to increasing globalization of markets, rise in global trade, travel and tourism [7]. Therefore, it is very

important to make an effective implication management of invasive species, knowledge about their diversity, life form, habitat, uses, is essential. Considering these reasons, the present study has been selected to enumerate the alien species of Indian Himalayan Region and its diversity with future implication of the region.

## 2. Materials and Methods

Intensive field studies were conducted to record the maximum number of Invasive species in different habitats, *i.e.* agricultural lands, wastelands, protected areas, river banks, reserve forests, etc. in different states of Uttarakhand. The information available in the literature [8-21] were collected and in the locality of species in IHR were confirmed through consulting the herbaria of Botanical Survey of India, Dehradun (BSD), Forest Research Institute, Dehradun (DD) and Central National Herbarium, Kolkata (CAL).

The nativity of the invasive plants was recorded from the published literature [22-35]. The modes of introduction of these species in Indian Himalayan Region (IHR) were recorded from the published literature and categorized as food, fodder, medicinal, ornamental, etc. Plants were categorized by life form (herb, undershrub, shrub, climber and tree) and habit (annual and perennial). Habitat (wasteland, cultivated field, river banks, forest, roadside, aquatic, etc.) where a given species was most abundant also noted and parasitic plants were also recorded. Literature and herbarium were consulted to find out use value, if any, of these species. The invasive species are enumerated alphabetically in tabular form, followed by author's abbreviations, name of the Family, Nativity, Life form, Habit, Uses, Habitat and mode of Introduction.

## 3. Results

A total of 190 species distributed in 112 genera and 47

families recorded as invasive alien in the flora of Indian Himalayan Region (**Table 1**). Among these, the dicotyledons represent by 40 families, 95 genera and 170 species; monocotyledons represent by 7 families, 17 genera and 20 species. Only 18 species namely, *Ageratum conyzoides*, *Cassia alata*, *Catharanthus pusillus*, *Celosia argentea*, *Chenopodium album*, *Eichhornia crassipes*, *Impatiens balsamina*, *Ipomoea eriocarpa*, *I. quamoclit*, *Lantana camera*, *Leucaena latisiliqua*, *L. leucocephala*, *Melilotus alba*, *Mirabilis jalapa*, *Passiflora foetida*, *Penisetum purpureum*, *Portulaca oleracea* and *Prosopis juliflora* are seem to have been introduced deliberately; the rest of them unintentionally through trade exchange including grain import.

A total of 13 different geographic regions in terms of nativity are recorded in the present study. Among these, about 90% are contributed by four major geographical regions, *viz.*, continent of America (140 sp.), Africa (20 sp.), Europe (7 sp.) and Mediterranean (4 sp.). The American continents contributed majority (73%) of noxious invasive plants in IHR. The Africa and Europe contribute 10 and 3 percent respectively. Annuals comprise about 63% (120 sp.) and the remaining are perennials. Herbs constitute 77% (148 plants), whereas trees were represented by only four species *viz.*, *Acacia dealbata*, *A. farnesiana*, *Borassus flabellifer* and *Leucaena latisiliqua*; three climbers namely, *Antigonon leptopus* and *Merremia aegyptia*, *Solanum seafortianum* have been recorded apart from 19 Shrubs (**Table 1** and **Figure 1**). Three sedges recorded as an invasive species namely, *Cyperus difformis*, *C. iria* and *Fuirena ciliaris*. Apart from these, 11 species of grasses are also recorded as an Invasive of IHR (**Table 1**). While analyzing the plant habit, 63% are annuals and 37% are perennials. The genera with the highest number of alien invasive species in IHR are *Ipomoea* (10 species); *Cassia* (9 sp.); *Alternanthera*, *Corchorus* and *Solanum* (5 sp. each); *Cleome*,

**Table 1. Invasive species of Indian Himalayan Region.**

SN	Name of the Species	Family	Nativity	Life Form	Habit	Uses	Habitat	Mode of Introduction
1	<i>Acacia dealbata</i> Link	Mimosaceae	Australia	T	P	Nk	AR	Ui
2	<i>Acacia farnesiana</i> (L.) Willd.	Mimosaceae	S. America	T	P	M	AR	Ui
3	<i>Acacia mearnsii</i> De Wild.	Mimosaceae	Australia	T	P	So	AR	O
4	<i>Acanthospermum hispidum</i> DC.	Asteraceae	Brazil	H	A	M	W	Ui
5	<i>Aerva javanica</i> (Burm. f.) Juss.	Amaranthaceae	Trop. America	H	A	M	W	Ui
6	<i>Aeschynomene americana</i> L.	Fabaceae	Trop. America	H	A	M	AR	Ui
7	<i>Ageratum conyzoides</i> L.	Asteraceae	Trop. America	H	A	M	W	O
8	<i>Ageratum houstonianum</i> Mill.	Asteraceae	Trop. America	H	A	Ch	W	Ui
9	<i>Alternanthera paronychioides</i> St. Hill.	Amaranthaceae	Trop. America	H	P	M	RB	Ui
10	<i>Alternanthera philoxeroides</i> (Mart.) Griseb.	Amaranthaceae	Trop. America	H	P	Nk	RB	Ui
11	<i>Alternanthera pungens</i> Humb., Bonpl. & Kunth	Amaranthaceae	Trop. America	H	P	M, Ch	W	Ui
12	<i>Alternanthera sessilis</i> (L.) DC.	Amaranthaceae	Trop. America	H	P	M, Ch	RB	Ui

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13	<i>Alternanthera tenella</i> Colla	Amaranthaceae	Trop. America	H	A	M	W	Ui
14	<i>Amaranthus spinosus</i> L.	Amaranthaceae	Trop. America	H	A	M, V, Fo	CF	Ui
15	<i>Anagallis arvensis</i> L.	Primulaceae	Europe	H	A	M	CF	Ui
16	<i>Antigonon leptopus</i> Hook. & Arn.	Polygonaceae	Trop. America	C	P	M	AR	Ui
17	<i>Argemone mexicana</i> L.	Papaveraceae	S. America	H	A	M	W	Ui
18	<i>Argemone ochroleuca</i> Sweet	Papaveraceae	S. America	H	A	M	AR, W	Ui
19	<i>Asclepias curassavica</i> L.	Asclepiadaceae	Trop. America	H	P	M	AR	Ui
20	<i>Asphodelus tenuifolius</i> Cav.	Liliaceae	Trop. America	H	A	M	CF	Ui
21	<i>Bidens pilosa</i> L.	Asteraceae	Trop. America	H	A	M, V, Fo	CF	Ui
22	<i>Blainvillea acmella</i> (L.f.) Philipson	Asteraceae	Trop. America	H	A	Ch	W	Ui
23	<i>Blumea eriantha</i> DC.	Asteraceae	Trop. America	H	P	Ch	W	Ui
24	<i>Blumea lacera</i> (Burm. F.) DC.	Asteraceae	Trop. America	H	A	M	W	Ui
25	<i>Blumea obliqua</i> (L.) Druce	Asteraceae	Trop. America	H	A	Ch	W	Ui
26	<i>Borassus flabellifer</i> L.	Arecaceae	Trop. Africa	T	P	Hu, Hf	W	Ui
27	<i>Bromus catharticus</i> Vahl	Poaceae	S. America	G	A	Fo	CF, W	Ui
28	<i>Calotropis gigantea</i> (L.) R. Br.	Asclepiadaceae	Trop. Africa	S	P	M, Sa	W	Ui
29	<i>Calotropis procera</i> (Ait.) R. Br.	Asclepiadaceae	Trop. Africa	S	P	Ne, St, M	W	Ui
30	<i>Cannabis sativa</i> L.	Cannabaceae	Central Asia	H	P	R, C, Sc, M, Cn, Fi	AR, W	Ui
31	<i>Cardamine hirsuta</i> L.	Brassicaceae	Trop. America	H	P	Nk	RB	Ui
32	<i>Cardamine trichocarpa</i> Hochst. ex A. Rich.	Brassicaceae	Trop. America	H	A	Fo, V	W	Ui
33	<i>Cassia absus</i> L.	Caesalpiniaceae	Trop. America	H	A	M	W	Ui
34	<i>Cassia alata</i> L.	Caesalpiniaceae	S. America	S	P	M	CF	O
35	<i>Cassia hirsuta</i> L.	Caesalpiniaceae	Trop. America	H	A	Fo	W	Ui
36	<i>Cassia obtusifolia</i> L.	Caesalpiniaceae	Trop. America	H	P	M	W	Ui
37	<i>Cassia occidentalis</i> L.	Caesalpiniaceae	S. America	H	P	M	W	Ui
38	<i>Cassia pumila</i> Lam.	Caesalpiniaceae	Trop. America	H	A	Ch	W	Ui
39	<i>Cassia rotundifolia</i> Pers.	Caesalpiniaceae	S. America	H	A	Fo	W	Ui
40	<i>Cassia tora</i> L.	Caesalpiniaceae	S. America	H	A	M	W	Ui
41	<i>Cassia uniflora</i> Mill.	Caesalpiniaceae	S. America	H	A	Fo	W	Ui
42	<i>Catharanthus pusillus</i> (Murr.) G. Don	Apocynaceae	Trop. America	H	A	Po	CF	O
43	<i>Celosia argentea</i> L.	Amaranthaceae	Trop. Africa	H	A	M, V	CF	Fd
44	<i>Ceratophyllum demersum</i> L.	Ceratophyllaceae	Trop. America	H	A	M	A	Ui
45	<i>Chenopodium album</i> L.	Chenopodiaceae	Europe	H	A	V	CF	Fd
46	<i>Chenopodium ambrosioides</i> L.	Chenopodiaceae	Trop. America	H	A	Nk	W	Ui
47	<i>Chenopodium murale</i> L.	Chenopodiaceae	Trop. America	H	A	V	CF, W	Ui
48	<i>Chloris barbata</i> (L.) Sw.	Poaceae	Trop. America	G	P	Fo	W	Ui
49	<i>Chrozophora plicata</i> (Vahl) A. Juss. ex Spreng.	Euphorbiaceae	Trop. Africa	H	A	Nk	W	Ui
50	<i>Cleome *iscose</i> L.	Capparaceae	Trop. America	H	A	M, Cn	W	Ui
51	<i>Cleome gynandra</i> L.	Capparaceae	Trop. America	H	A	M, V	W	Ui
52	<i>Cleome monophylla</i> L.	Capparaceae	Trop. Africa	H	A	We	AR	Ui
53	<i>Cleome rutidosperma</i> DC.	Capparaceae	Trop. America	H	A	M	AR	Ui
54	<i>Clidemia hirta</i> (L.) D. Don	Melastomataceae	Trop. America	H	A	Nk	AR	Ui
55	<i>Convolvulus arvensis</i> L.	Convolvulaceae	Europe	H	A	M	F, W	Ui
56	<i>Conyza *anadensis</i> (L.) Cronquist	Asteraceae	S. America	H	A	Ch	F	Ui
57	<i>Corchorus aestuans</i> L.	Tiliaceae	Trop. America	H	A	M	W	Ui
58	<i>Corchorus fascicularis</i> Lam.	Tiliaceae	Trop. America	H	A	M	W	Ui
59	<i>Corchorus olitorius</i> L.	Tiliaceae	Trop. Africa	H	A	M	CF	Ui
60	<i>Corchorus tridens</i> L.	Tiliaceae	Trop. Africa	H	A	V, Fi, Ne	AR, W	Ui
61	<i>Corchorus trilocularis</i> L.	Tiliaceae	Trop. Africa	H	A	Ch	W	Ui
62	<i>Crassocephalum crepidioides</i> (Benth.) S. Moore	Asteraceae	Trop. America	H	A	Ch	F	Ui
63	<i>Crotalaria pallida</i> Ait.	Fabaceae	Trop. America	H	A	Ch	CF	Ui
64	<i>Crotalaria retusa</i> L.	Fabaceae	Trop. America	H	A	Ch	CF	Ui
65	<i>Croton bonplandianum</i> Baill.	Euphorbiaceae	S. America	H	P	Ch	W	Ui
66	<i>Cryptostegia grandiflora</i> R. Br.	Asclepiadaceae	Madagascar	H	P	O	CF	Ui
67	<i>Cuscuta chinensis</i> Lam.	Cusutaceae	Mediterranean	H	P	M	P	Ui
68	<i>Cuscuta reflexa</i> Roxb.	Cusutaceae	Mediterranean	H	A	M	P	Ui
69	<i>Cyperus difformis</i> L.	Cyperaceae	Trop. America	SE	A	Ch	CF	Ui
70	<i>Cyperus iria</i> L.	Cyperaceae	Trop. America	SE	A	Ch	CF	Ui
71	<i>Cytisus scoparius</i> (L.) Link	Papilionaceae	Europe	H	A	M	C	Ui
72	<i>Datura fastuosa</i> L.	Solanaceae	S. America, Mexico	S	P	M	AR, W	Ui
73	<i>Datura innoxia</i> Mill.	Solanaceae	Trop. America	S	P	M	W	Ui
74	<i>Datura metel</i> L.	Solanaceae	Trop. America	S	P	M	W	Ui
75	<i>Datura stramonium</i> L.	Solanaceae	Trop. America	S	P	M	AR, W	Ui
76	<i>Dicoma tomentosa</i> Cass.	Asteraceae	Trop. Africa	H	A	Nk	W	Ui

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77	<i>Digera muricata</i> (L.) Mart.	Amaranthaceae	S. W. Asia	H	A	M	CF	Ui
78	<i>Dinebra retroflexa</i> (Valh) Panz.	Poaceae	Trop. America	G	P	Fo	W	Ui
79	<i>Echinochloa colona</i> (L.) Link	Poaceae	S. America	G	A	Ft, Fo	RB	Ui
80	<i>Echinochloa crus-galli</i> (L.) P. Beauv.	Poaceae	S. America	G	A	Ad	RB	Ui
81	<i>Echinops echinatus</i> Roxb.	Asteraceae	Afghanistan	H	A	Nk	W	Ui
82	<i>Eclipta prostrata</i> (L.) Mant.	Asteraceae	Trop. America	H	A	Nk	AR	Ui
83	<i>Eichhornia crassipes</i> (C. Martius) Solms.	Pontederiaceae	Trop. America	H	P	Co, St	A	O
84	<i>Emilia sonchifolia</i> (L.) DC.	Asteraceae	Trop. America	H	A	M, V	RB	Ui
85	<i>Eupatorium adenophorum</i> Sprengel	Asteraceae	Mexico	US	P	Nk	FE, W	Ui
86	<i>Euphorbia chamaesyce</i> L.	Euphorbiaceae	W. Africa and Mauritius	H	A	M	W	Ui
87	<i>Euphorbia cyathophora</i> Murray	Euphorbiaceae	Trop. America	H	A	Nk	W	Ui
88	<i>Euphorbia heterophylla</i> L.	Euphorbiaceae	Trop. America	H	A	O	CF	Ui
89	<i>Euphorbia hirta</i> L.	Euphorbiaceae	Trop. America	H	A	M	CF	Ui
90	<i>Euphorbia peplus</i> L.	Euphorbiaceae	Europe	H	P	M	AR, FE	Ui
91	<i>Evolvulus nummularius</i> (L.) L.	Convolvulaceae	Trop. America	H	P	Ch	W	Ui
92	<i>Fuirena ciliaris</i> (L.) Roxb.	Cyperaceae	Trop. America	SE	A	Nk	W	Ui
93	<i>Galinsoga parviflora</i> Cav.	Asteraceae	Trop. America	H	A	M, Fo	RB	Ui
94	<i>Galinsoga quadriradiata</i> Ruiz & Pavon	Asteraceae	Mexico	H	A	Nk	W	Ui
95	<i>Glossocardia bosvallea</i> (L.f.) DC.	Asteraceae	East Indies	H	A	Nk	W	Ui
96	<i>Gnaphalium coarctatum</i> Willd.	Asteraceae	Trop. America	H	A	Nk	W	Ui
97	<i>Gnaphalium pensylvanicum</i> Willd.	Asteraceae	Trop. America	H	A	Nk	RB	Ui
98	<i>Gnaphalium polycaulon</i> Pers.	Asteraceae	Trop. America	H	A	Nk	W	Ui
99	<i>Gomphrena celosoides</i> Martius	Amaranthaceae	S. America	H	A	Nk	CF	Ui
100	<i>Gomphrena serrata</i> L.	Amaranthaceae	Trop. America	H	A	V	CF	Ui
101	<i>Grangea maderaspatana</i> (L.) Poir.	Asteraceae	S. America	H	A	M	RB	Ui
102	<i>Hyptis suaveolens</i> (L.) Poit.	Lamiaceae	Trop. America	H	A	M	AR	Ui
103	<i>Impatiens balsamina</i> L.	Balsaminaceae	Trop. America	H	A	Cn	RB	O
104	<i>Imperata cylindrical</i> (L.) Raeusch.	Poaceae	Trop. America	G	P	R	W	Ui
105	<i>Indigofera astragalina</i> DC.	Fabaceae	Trop. America	H	A	Ch	F	Ui
106	<i>Indigofera glandulosa</i> Roxb. ex Willd.	Fabaceae	Trop. America	H	A	M	CF	Ui
107	<i>Indigofera linifolia</i> (L.f.) Retz.	Fabaceae	S. America	H	A	M	AR	Ui
108	<i>Indigofera linnaei</i> Ali	Fabaceae	Trop. Africa	H	A	M, Ma	F	Ui
109	<i>Indigofera trita</i> L.f.	Fabaceae	Trop. Africa	S	P	Ch	F	Ui
110	<i>Ipomoea carnea</i> Jacq. subsp. <i>Fistulosa</i> (Mart. ex Choisy) Austin	Convolvulaceae	Trop. America	S	P	M	W	Ui
111	<i>Ipomoea eriocarpa</i> R.Br.	Convolvulaceae	Trop. Africa	H	A	M	W	O
112	<i>Ipomoea hederifolia</i> L.	Convolvulaceae	Trop. America	H	A	Ch	F	Ui
113	<i>Ipomoea muricata</i> (L.) Jacquin	Convolvulaceae	Trop. America	H	A	M	CF, W	Ui
114	<i>Ipomoea nil</i> (L.) Roth	Convolvulaceae	N. America	H	A	M	FE, W	Ui
115	<i>Ipomoea obscura</i> (L.) Ker.-Gawal.	Convolvulaceae	Trop. Africa	H	P	M	W	Ui
116	<i>Ipomoea pes-tigridis</i> L.	Convolvulaceae	Trop. East Africa	H	A	M	W	Ui
117	<i>Ipomoea purpurea</i> (L.) Roth	Convolvulaceae	S. America	H	A	M, Fo	CF, W	Ui
118	<i>Ipomoea quamoclit</i> L.	Convolvulaceae	Trop. America	H	P	M	W	O
119	<i>Ipomoea staphylina</i> Roem. & Schult.	Convolvulaceae	Trop. Africa	H	A	Nk	W	Ui
120	<i>Lagascea mollis</i> Cav.	Asteraceae	Central America	H	A	Nk	CF	Ui
121	<i>Lantana camara</i> L.	Verbenaceae	Trop. America	H	P	Bf, Sb	F	O
122	<i>Leonotis nepetifolia</i> (L.)R. Br.	Lamiaceae	Trop. Africa	H	A	M	W	Ui
123	<i>Leucaena latisiliqua</i> (L.) Gilli.	Mimosaceae	Trop. America	H	P	M	W	Fo
124	<i>Ludwigia adscendens</i> (L.) Hara	Onagraceae	Trop. America	H	A	Sb	A	Ui
125	<i>Ludwigia octovalvis</i> (Jacq.) Raven	Onagraceae	Trop. Africa	H	A	M	RB	Ui
126	<i>Ludwigia perennis</i> L.	Onagraceae	Trop. Africa	H	A	M	RB	Ui
127	<i>Macroptilium atropurpureum</i> (Mocino & Sesse et DC) Urb.	Fabaceae	Trop. America	H	P	Fo	CF	Ui
128	<i>Macroptilium lathyroides</i> (L.) Urb.	Fabaceae	C. & S. America	H	A	Nk	W	Ui
129	<i>Malachra capitata</i> (L.) L.	Malvaceae	Trop. America	H	P	M	W	Ui
130	<i>Malvastrum coromandelianum</i> (L.) Garcke	Malvaceae	Trop. America	H	A	M, Fi	W	Ui
131	<i>Martynia annua</i> L.	Pedaliaceae	Trop. America	H	P	M	W	Ui
132	<i>Mecardonia procumbens</i> (Mill.) Small	Scrophulariaceae	Trop. North America	H	A	Ch	W	Ui
133	<i>Melilotus alba</i> Medik. ex Desr.	Fabaceae	Europe	H	A	Fo, Br	CF	Fd
134	<i>Melochia corchorifolia</i> L.	Sterculiaceae	Trop. America	H	P	Fi, V	F	Ui
135	<i>Merremia aegyptia</i> (L.) Urb.	Convolvulaceae	Trop. America	C	P	Nk	W	Ui
136	<i>Mimosa pudica</i> L.	Mimosaceae	Brazil	H	P	M	F	Ui
137	<i>Mirabilis jalapa</i> L.	Nyctaginaceae	Peru	H	A	O	W	O
138	<i>Monochoria vaginalis</i> (Burm.f.) C. Presl.	Pontederiaceae	Trop. America	H	P	M, V	RB	Ui
139	<i>Nicotiana plumbaginifolia</i> Viv.	Solanaceae	Trop. America	H	A	Sm	W	Ui

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140	<i>Ocimum americanum</i> L.	Lamiaceae	Trop. America	H	A	In, Cu	W	Ui
141	<i>Opuntia elatior</i> Miller	Cactaceae	S. America	S	P	Ft	AR, W	Ui
142	<i>Opuntia stricta</i> Haw. Var. <i>dillenii</i> (Ker Gawl.) Benson	Cactaceae	Trop. America	S	P	Nk	W	Ui
143	<i>Opuntia vulgaris</i> Miller	Cactaceae	S. America	S	P	Ft	AR, W	Ui
144	<i>Oxalis corniculata</i> L.	Oxalidaceae	Europe	H	P	V	CF	Ui
145	<i>Parthenium hysterophorus</i> L.	Asteraceae	N. America	H	A	Nk	W	Ui
146	<i>Passiflora foetida</i> L.	Passifloraceae	S. America	H	P	M	W	O
147	<i>Pedaliium murex</i> L.	Pedaliaceae	Trop. America	H	P	M	W	Ui
148	<i>Pennisetum purpureum</i> Schum.	Poaceae	Trop. America	G	A	Co	F	Fo
149	<i>Peperomia pellucida</i> (L.) Kunth	Piperaceae	S. America	H	A	Nk	AR	Ui
150	<i>Peristrophe paniculata</i> (Forssk.) Brummit	Acanthaceae	Trop. America	H	A	M	W	Ui
151	<i>Physalis angulata</i> L.	Solanaceae	Trop. America	H	A	Nk	W	Ui
152	<i>Physalis heterophylla</i> Nees	Solanaceae	Peru	H	A	Nk	AR	Ui
153	<i>Physalis minima</i> L.	Solanaceae	Trop. America	H	A	M, Ft	W	Ui
154	<i>Physalis peruviana</i> L.	Solanaceae	Peru	H	A	M	W, CF	Ui
155	<i>Pilea microphylla</i> (L.) Liebm.	Urticaceae	S. America	H	A	Nk	RB	Ui
156	<i>Pistia stratiotes</i> L.	Araceae	Trop. America	H	P	M	A	Ui
157	<i>Portulaca oleracea</i> L.	Portulacaceae	S. America	H	A	M, V	W	Fd
158	<i>Portulaca quadrifida</i> L.	Portulacaceae	Trop. America	H	A	V	W	Ui
159	<i>Prosopis juliflora</i> (Sw.) DC.	Mimosaceae	Mexico	S	P	Sb	W	Af
160	<i>Rhynchelytrum repens</i> (Willd.) C. E. Hubb.	Poaceae	Trop. America	G	A	Nk	W	Ui
161	<i>Rorippa dubia</i> (Pers.) Hara	Brassicaceae	Trop. America	H	A	Nk	CF	Ui
162	<i>Rubus ellipticus</i> Smith	Rosaceae	Trop. America	S	P	We	W	Ui
163	<i>Ruellia tuberosa</i> L.	Acanthaceae	Trop. America	H	A	Ch	RB	Ui
164	<i>Saccharum spontaneum</i> L.	Poaceae	Trop. West Asia	G	P	M	RB	Ui
165	<i>Scoparia dulcis</i> L.	Scrophulariaceae	Trop. America	H	P	M	W	Ui
166	<i>Sesbania bispinosa</i> (Jacq.) W. F. Wight	Fabaceae	Trop. America	S	A	Fi, Ma	RB	Ui
167	<i>Setaria geniculata</i> (Lam.) P. Beauv.	Poaceae	Trop. America	G	P	Fo	AR, WP	Ui
168	<i>Setaria paniculifera</i> (Steudel) Fourm. ex Hemsley	Poaceae	Trop. America	G	P	Fo	AR, WP	Ui
169	<i>Sida acuta</i> Burm.f.	Malvaceae	Trop. America	H	A	M, Fi, Fo	W	Ui
170	<i>Solanum hispidum</i> Persoon	Solanaceae	Peru	S	P	Nk	AR, WP	Ui
171	<i>Solanum nigrum</i> L.	Solanaceae	Trop. America	H	A	M, Ft	CF	Ui
172	<i>Solanum pseudo-capsicum</i> L.	Solanaceae	Trop. America	US	P	O	FE	Ui
173	<i>Solanum seaforthianum</i> Andrews	Solanaceae	Brazil	C	P	Nk	W	Ui
174	<i>Solanum torvum</i> Sw.	Solanaceae	West Indies	S	P	M	F	Ui
175	<i>Solanum viarum</i> Dunal	Solanaceae	Trop. America	H	P	Nk	F	Ui
176	<i>Sonchus asper</i> (L.) Hill	Asteraceae	Mediterranean	H	A	M	AR	Ui
177	<i>Sonchus oleraceus</i> L.	Asteraceae	Mediterranean	H	A	M, V	RB	Ui
178	<i>Spermacoce hispida</i> L.	Rubiaceae	Trop. America	H	P	M	CF	Ui
179	<i>Stachytarpheta urticifolia</i> Sims	Verbenaceae	Trop. America	H	A	Nk	W	Ui
180	<i>Synedrella nodiflora</i> (L.) Gaertn.	Asteraceae	West Indies	H	A	Nk	W, AR	Ui
181	<i>Torenia fourmieri</i> Linden ex E. Fourm.	Scrophulariaceae	Australia	H	P	Nk	W	Ui
182	<i>Tribulus terrestris</i> L.	Zygophyllaceae	Trop. America	H	P	M	W	Ui
183	<i>Tridax procumbens</i> L.	Asteraceae	Central America	H	P	M, V	CF	Ui
184	<i>Triumfetta rhomboidea</i> Jacq.	Tiliaceae	Trop. America	H	A	M	W	Ui
185	<i>Typha angustifolia</i> L.	Typhaceae	Trop. America	H	P	T, Wc, Ne, Hu	RB	Ui
186	<i>Urena lobata</i> L.	Malvaceae	Trop. Africa	S	P	Fi	W	Ui
187	<i>Waltheria indica</i> L.	Sterculiaceae	Trop. America	H	P	M	F	Ui
188	<i>Xanthium indicum</i> Koenig	Asteraceae	Trop. America	S	A	M, Bf	AR	Ui
189	<i>Xanthium strumarium</i> L. P. P.	Asteraceae	Trop. America	H	A	Nk	AR, WP	Ui
190	<i>Youngia japonica</i> (L.) DC.	Asteraceae	S. America	H	A	Nk	AR	Ui

Life form: H—Herb; C—Climber; US—Undershrub; S—Shrub; SE—Sedges; T—Tree; G—Grass.

Habit: A—Annual; P—Perennial.

Uses: Ad—Adulteration; B—Basket making; Bf—Biomass fuel in rural area; Br—Biofertilizer; C—Clothes making; Ch—Presence of bioactive chemicals; Cn—Condiment; Co—Compost; Cu—Culinary; Fi—Fibre; Fo—Fodder; Ft—Fruits edible; Hu—Hut; Hf—Hand-held fan; In—Insecticide; M—Medicinal; Ma—Manure; Ne—Net making; Nk—Not known; O—Ornamental; P—Poisonous plant; R—Rope making; Sa—Sacred Plant; Sb—Soil binder; Sc—Sac making; Sm—Smoking; So—Social forestry, St—Secondary waste water treatment; T—Thatching; V—Vegetable; W—Wood work; Wc—Wicker work; We—Wild edible. Habitat: W—Wastelands; CF—Cultivated fields; F—Forests; AR—Along roadside; A—Aquatic; P—Parasites; CF—Crop fields; RB—River beds.

Mode of introduction: Af—Agroforestry; Fd—Food; Fo—Fodder; O—Ornamental; Ui—Unintentional.

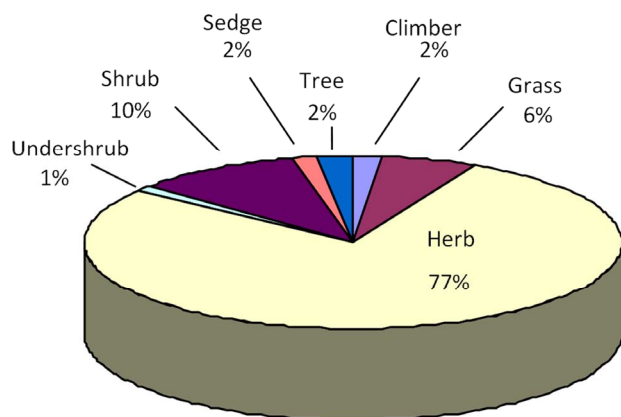


Figure 1. Life forms of invasive species.

*Euphorbia*, *Indigofera* and *Datura* (4 sp. each). These top 9 genera contributed 26% taxa of alien flora of IHR. The family Asteraceae is the most dominant family with 31 species; followed by Solanaceae (15 sp.); Convolvulaceae and Fabaceae (13 sp. each); Amaranthaceae and Poaceae (11 sp. each); Caesalpiniaceae (9 sp.); Euphorbiaceae (7 sp.); Mimosaceae and Tiliaceae (6 sp. each). These ten dominant families contributed 64% of the alien invasive flora of IHR (Figure 2).

About 54% of invasive species were most abundant in wastelands, while cultivated fields, road sides, river beds, forest/forest edges were favored by 17%, 15%, 10% and 9% respectively. A search of literature, herbarium and consultation with local people indicated that several of the invasive species are also being used for different purposes for example, the stem of *Malvastrum coromandelianum*, *Sesbania bispinosa*, *Sida acuta*, and *Cannabis sativa* is being used for fibre, and *Borassus flabellifer* is being used for Hand-held fan. Ninety species listed in Table 1 are reported to be used by locals for medicinal purposes. The species namely, *Leucaena leucocephala* is being effectively used for social forestry. The uses of twenty seven species are not known or even not used by locals. Five plants are reported having high allelopathic potential, namely, *Echinochloa crusgalli*, *Lagascea mollis*, *Lantana camara*, *Parthenium hysterophorus* and *Prosopis juliflora*.

#### 4. Discussion

Alien species are non-native or exotic organisms that occur outside their natural adapted ranges and dispersal potential [6]. 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 [3]. International Union for Conservation of Nature and

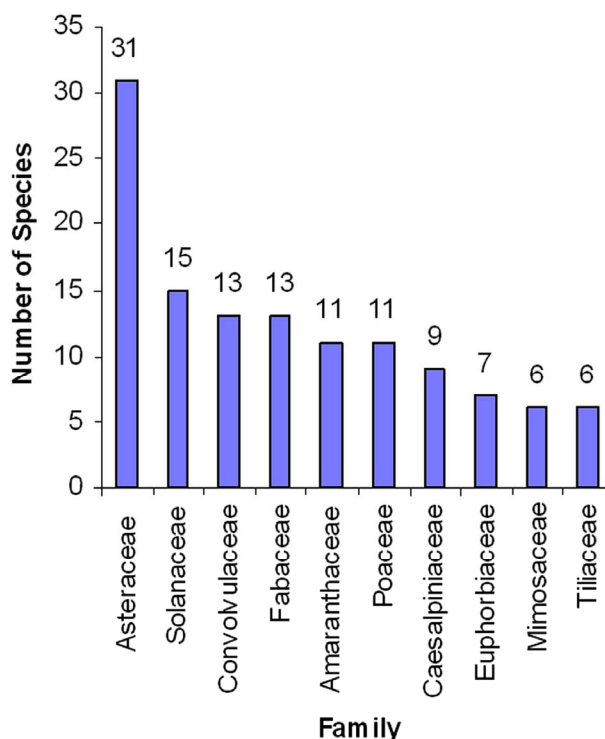


Figure 2. Ten dominant families of invasive species.

Natural Resources (IUCN) defines Alien Invasive Species as an alien species which becomes established in natural or semi-natural ecosystems or habitat, an agent of change, and threatens native biological diversity. These invasive are widely distributed in all kinds of ecosystems throughout the world, and include all categories of living organisms. Nevertheless, plants, mammals and insects comprise the most common types of invasive alien species in terrestrial environments [3]. In Indian Himalayan Region, comprehensive studies on invasive species and plant invasions are still missing. In view of this, the present study attempted to focus on document the invasive alien species in the flora of IHR. This listed invasive exotic species will serve as basic information for future research towards the conservation of endemic and natural forest vegetation of Himalaya.

In IHR, 190 species distributed in 112 genera and 47 families recorded as invasive alien in the flora. Amongst the recorded invasive species, many plants are known invasive of nearby region also. For example, 124 species listed in table 1 are common invasive in the state of Uttar Pradesh [35]. Among these invasive species of IHR, 73% are native to American continent. The invasive flora of India also concerns more than 58% of invasive plants are native to American continent [34,35]. The lesser percentage of American elements in IHR may be due to the presence of high altitudes, as the European flora contributed maximum percentage of invasive species in Kashmir Himalaya [37]. Annuals are recorded the predomi-

nant invasive flora of IHR (63%), so the habit-wise classification of alien invasive shows a preponderance of herbs (77%). Further, greater viability and tolerance to harsh conditions could result this preponderance of herbs in the alien flora. Asteraceae is the dominant invasive family of IHR and contributed most of the exotic weed species in our country [34]. Singh *et al.* [35] also recorded the dominance of Asteraceae in invasive alien flora of Uttar Pradesh and Rao and Murugan [37] also found that the Asteraceae is dominating family in alien flora of India. It is obvious that the family Fabaceae is one among the largest families of alien flora of IHR and having the potential of Nitrogen fixing capacity would be helpful to them in colonizing the empty niches. It is obviously recorded that 47 percent of the invasive species are under the consideration of medicinal purposes. But some of the species like *Echinochloa crus-galli*, *Lagascea mollis*, *Lantana camara* and *Parthenium hysterophorus* are having high allelopathic potential and harmful to natural plant population [35].

The invasive species cause loss of biodiversity including species extinctions, and changes in hydrology and ecosystem function. Differences between native and exotic plant species in their requirements and modes of resource acquisition and consumption may cause a change in soil structure, its profile, decomposition, nutrient content of soil, moisture availability, etc. Invasive species are thus a serious hindrance to conservation and sustainable use of biodiversity, with significant undesirable impacts on the goods and services provided by ecosystems. Biological invasions now operate on a global scale and will undergo rapid increase in this century due to interaction with other changes such as increasing globalization of markets, rise in global trade, travel and tourism. For effective management of invasive species, knowledge about their ecology, morphology, phenology, reproductive biology, physiology and phytochemistry is essential [3]. Monitoring of invasion can be done through qualitative approach like species inventory (seasonally) and quantitative approach using phytosociological methods and mapping using ground-based methods (*via* map overlays or GPS), remotely-sensed images (aerial photos, high resolution multi-spectral digital data). A better planning is needed for early detection and reporting of infestations of spread of new and naturalized weeds by creation of plant detection network in IHR by establishing communication links between taxonomists, ecologists and land managers to monitor and control.

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## REFERENCES

- [1] Anonymous, Indian Himalayan Region, ENVIS Centre on Himalayan Ecology, G. B. Pant Institute of Himalayan Environment & Development, Almora, 2011.
- [2] S. S. Samant, U. Dhar and L. M. S. Palni, "Medicinal Plants of Indian Himalaya: Diversity, Distribution and Potential Value," G. B. Pant Institute of Himalayan Environment & Development, Almora, 1998.
- [3] A. S. Raghubanshi, L. C. Rai, J. P. Gaur and J. S. Singh, "Invasive Alien Species and Biodiversity in India," *Current Science*, Vol. 88, No. 4, 2005, pp. 539-540.
- [4] Y. H. Sujay, H. N. Sattagi and R. K. Patil, "Invasive Alien Insects and Their Impact on Agroecosystem," *Karnataka Journal of Agricultural Sciences*, Vol. 23, No. 1, 2010, pp. 26-34.
- [5] H. M. Pant and N. Sharma, "Inventory of Some Exotic Cultivated Tree Species of Doon Valley and Their Ethnobotanical Uses," *Journal of Medicinal Plants Research*, Vol. 4, No. 20, 2010, pp. 2144-2147.
- [6] M. A. McGeoch, S. H. M. Butchart, D. Spear, E. Marais, E. J. Kleynhans, A. Symes, J. Chanson and M. Hoffmann, "Global Indicators of Biological Invasion: Species Numbers, Biodiversity Impact and Policy Responses," *Diversity and Distributions*, Vol. 16, No. 1, 2010, pp. 95-108. [doi:10.1111/j.1472-4642.2009.00633.x](https://doi.org/10.1111/j.1472-4642.2009.00633.x)
- [7] M. E. Eiswerth, T. D. Darden, W. S. Johnson, J. Agapoff and R. H. Thomas, "Input-Output Modeling, Outdoor Recreation, and the Economic Impacts of Weeds," *Weed Science*, Vol. 53, No. 1, 2005, pp. 130-137. [doi:10.1614/WS-04-022R](https://doi.org/10.1614/WS-04-022R)
- [8] H. Hara, Ed., "Flora of Eastern Himalaya, Second Report," University of Tokyo Press, Tokyo, 1971.
- [9] C. R. Babu, "Herbaceous Flora of Dehradun," Council of Scientific and Industrial Research, New Delhi, 1977.
- [10] H. J. Chowdhery and B. M. Wadhwa, "Flora of Himachal Pradesh—Analysis," Vol. 1-3, Botanical Survey of India, Howrah, 1984.
- [11] R. K. Gupta, "The Living Himalaya," Vol. I, Today and Tomorrow Publication, New Delhi, 1983.
- [12] R. K. Gupta, "The Living Himalaya," Vol. II, Today and Tomorrow Publication, New Delhi, 1989.
- [13] H. J. Chowdhery, G. S. Giri, G. D. Pal, A. Pramanik and S. K. Das, "Materials for the Flora of Arunachal Pradesh," Vol. I, Botanical Survey of India, Calcutta, 1996, pp. 1-693.
- [14] H. J. Chowdhery, G. S. Giri, G. D. Pal, A. Pramanik and S. K. Das, "Materials for the Flora of Arunachal Pradesh," Vol. 2, Botanical Survey of India, Calcutta, 2008, pp. 1-670.
- [15] R. C. Srivastava, "Flora of Sikkim (Ranunculaceae-Morinaceae)," Oriental Enterprises, Delhi, 1998.
- [16] R. D. Gaur, "Flora of the District Garhwal, North West

- Himalaya (with Ethnobotanical Notes),” TransMedia, Srinagar, Garhwal, 1999.
- [17] S. Kumar and V. Singh, “Asteraceae of Sikkim,” Deep Publications, New Delhi, 2001.
- [18] N. P. Singh, D. K. Singh and B. P. Uniyal, Eds., “Flora of Jammu & Kashmir,” Vol. 1, Botanical Survey of India, Kolkata, 2002.
- [19] P. K. Hajra and A. De, “The Indigenous and Exotic Beauties of Dehradun,” Oriental Enterprises, Dehradun, 2007.
- [20] J. D. Hooker, “Flora of British India,” Vol. 1-7, Reeve & Co. Ltd., London, 1872-1897.
- [21] B. P. Uniyal, J. R. Sharma, U. Choudhery and D. K. Singh, “Flowering Plants of Uttarakhand,” Bishen Singh Mahendra Pal Singh, Dehradun, 2007.
- [22] J. K. Maheshwari, “Studies on the Naturalized Flora of India,” *Proceedings of the Summer School of Botany*, New Delhi, 2-15 June 1960, pp. 156-170.
- [23] K. M. Matthew, “Alien flora of Kodai Kanal and Palni Hills,” *Records of Botanical Survey of India*, Vol. 20, No. 1, 1969, pp. 1-241.
- [24] J. K. Maheswari and S. R. Paul, “The Alien Flora of Ranchi,” *Journal of the Bombay Natural History Society*, Vol. 72, No. 1, 1975, pp. 158-188.
- [25] M. P. Nayar, “Changing Patterns of the Indian Flora,” *Bulletin of Botanical Survey of India*, Vol. 19, No. 1-4, 1977, pp. 145-155.
- [26] P. K. Hajra and B. K. Das, “Vegetation of Gangtok with Special Reference to Alien Plants,” *India Forums*, Vol. 107, 1982, pp. 554-566.
- [27] B. D. Sharma, “Exotic Flora of Allahabad,” Botanical Survey of India, Dehra Dun, 1984.
- [28] K. G. Saxena, “Biological Invasion in the Indian Sub-Continent: Review of Invasion by Plants,” In: P. S. Ramkrishnan, Ed., *Ecology of Biological Invasion in the Tropics*, International Scientific Publications, New Delhi, 1991, pp. 53-73.
- [29] R. P. Pandey and P. J. Parmar, “The Exotic Flora of Rajasthan,” *Journal of Economic and Taxonomic Botany*, Vol. 18, No. 1, 1994, pp. 105-121.
- [30] H. A. Mooney and R. J. Hobbs, “Invasive Species in a Changing World,” Island Press, Washington, 2000.
- [31] D. S. Pandey, “Exotics-Introduced and Natural Immigrants, Weeds, Cultivated, etc.,” In: N. P. Singh, D. K. Singh, P. K. Hajra and B. D. Sharma, Eds., *Flora of India: Introductory Volume*, Part II, Botanical Survey of India, Calcutta, 2000, pp. 266-301.
- [32] J. A. McNeely, H. A. Mooney, L. E. Neville, P. Schei and J. K. Waage, “A Global Strategy on Invasive Alien Species,” IUCN Gland, Switzerland, and Cambridge, in Collaboration with the Global Invasive Species Programme, 2001.
- [33] P. S. Negi and P. K. Hajra, “Alien Flora of Doon Valley, North West Himalaya,” *Current Science*, Vol. 92, No. 7, 2007, pp. 968-978.
- [34] C. S. Reddy, “Catalogue of Invasive Alien Flora of India,” *Life Science Journal*, Vol. 5, No. 2, 2008, pp. 84-89.
- [35] K. P. Singh, A. N. Shukla and J. S. Singh, “State-Level Inventory of Invasive Alien Plants, Their Source Regions and Use Potential,” *Current Science*, Vol. 99, No. 1, 2010, pp. 107-114.
- [36] A. A. Khuroo, I. Rashid, Z. Reshi, G. H. Dar and B. A. Wafai, “The Alien Flora of Kashmir Himalaya,” *Biological Invasions*, Vol. 9, No. 3, 2007, pp. 269-292. [doi:10.1007/s10530-006-9032-6](https://doi.org/10.1007/s10530-006-9032-6)
- [37] R. R. Rao and R. Murugan, “Impact of Exotic Adventives Weeds on Native Biodiversity in India: Implications for Conservation,” In: L. C. Rai and J. P. Gaur, Eds., *Invasive Alien Species and Biodiversity in India*, Banaras Hindu University, Varanasi, 2006, pp. 93-109.