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A Status of Invasive Alien Species Plant diversity in Tehri District Forest Ecosystem of Garhwal Himalayan Region

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Abstract

Invasive alien species that is non-indigenous to an area, and which may have harmful effect on human, animal, plant health as habitat destruction, degradation and fragmentation of ecosystems. During the study observed the present status of plant diversity of invasive alien species (IAS) in Tehri District of Garhwal Himalaya, Uttarakhand. Data were collected through extensive field survey and quadrat method. Result observed that 75 Forest Invasive Species (FIS) and 47 weed species documented from the area. Among the 75 FIS, 12 species belonging from Asteraceae, 7 species from Poaceae, 7 species of Solanaceae, 5 species of Lamiaceae, followed by four species of each Ranunculaceae and Polygonaceae while the other belongs to Papilionaceae, Cyperacea, Euphorbiaceae and various other angiospermic families were recorded. Weed Species from 5 different angiospermic families were recorded. The highest diversity was reported for Asteraceae family. Species diversity of IAS indicated that study area was distinctly dissimilar or unlike in diversity and unhealthy. An investigation of the habitat depicts that herbs prevail (11 species) followed by shrubs (8 species) and trees (2 species). However, major impact of these species on the indigenous flora, change in hydrology and function of ecosystems is yet to be studied. There is an urgent need to develop regional data, information on their ecology, morphology, reproductive biology, phenology and physiology for effective management and control of IAS. Present Study will helpful in further study on developing effective management and control protocol of IAS on spreading outside their natural habitat and most prominent menaces to biodiversity.

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Introduction

The Himalaya mountain region is one of the richest and most unusual ecosystems on Earth[1]. Indian Himalayan region covers about an area of 4,19,873 Km^2. The unique physiography, climatic conditions, soil features of the area have resulted in a mixture of habitats and a substantial biological diversity. The Himalayan region affirms approximately 8000 plant species (47.06% of the total flowering plants of India) of which 30% are endemics among natives, 10.2% trees, 8.44% wild edibles and over 15% medicinal. The dependence of human and livestock on this rich plant diversity is long-familiar physical process since time immemorial[2,3]. The Tehri Dam is tallest dam in India. Tehri Dam provides common services such as food mitigation, water supply for agricultural crop cultivation, drinking water, electricity production, employment opportunity, recreational and tourisms facility in surrounding area. The utilization and subsequent changes in hydrological water body has a significantly influencing on river flow and their linked biotic and abiotic organisms. Dams are grant credentials to as having fairly large negative effects on the closely encircling natural ecosystems divesity[4]. In many developing countries tourism was act as revenue generate, employment opportunity to local people, improved living standards and sustainable livihood development with buildup good relationship between people and nature from conservation point of view[5, 6,7a]. The global trade and tourism are key factors concerned with the ecological effects of altering the environment in developing regions[8b, 9]. In the last decades tourisms has rapidly originated worldwide in mountain regions.[10, 11]. The mountain tourisms in new emerging area had negative results on wetlands, protected areas and natural area indicated by previous examines concerned to recreation ecology[12, 13]. In past 25 years, Nepal has rapidly increased in tourism growth, the positive or negative effect of tourism ontogenesis on forest resource and alpine vegetation plant diversity has been well recorded[14].

Human actions have significant determines on the dispersal of exotic plants[15, 16, 17, 18]. In Central Europe, an invasion has been often outcome of interaction between biological and anthropogenic factors[19]. Human interruptions enhance alien extend in general[20]. They are determined that the parameters in a most excellent way to justify the density of alien plants were the human growth index and imports[21]. Some outcomes guided that numbers of individuals per unit area of human population and human action have crucial consequences on the plants invasions[22, 23]. Biological plant invasion have charming effect on ecologist due to their substantial ecological and economical importance from the conservation threat of plant diversity point of view worldwide[24]. India is the 7th largest country and one of the mega-diversity countries on globe out of 17 most biodiversity-rich countries. With a various types of habitats and different environmental conditions, India is particularly susceptible to attack of invasive species of foreign origin. The sketch of invasive plants in India is now obligating immediate action in practice and also helpful for invasion plant ecology.

The biological invasion involving the entire earth threatens biodiversity, resource availability, ecosystem dynamics, and people health and country economy[25].The analyses of the apportioning of invasive alien species and the kinship with existing factors furnish the chances to explore the possible factors that lead to their spatial distribution at a prominent scale[26, 27a]. However, seldom observe the spatial distribution analysis revolve about species with prominent consequence separately from those with miserable effects [28, 29b].The scrimpy native diversity privileges to introduce invasion proposed by Elton's[30].Some data-based and model based studies reports support that diversity decreased invisibility[31, 32,33,34,35]. Investigate on the features of invasive species and the recipient spatial location is indispensable for recognizing the action of invasion[36].Therefore, insufficiency of data point concerning forest invasivesis a subject of associate as this creats an off-key of complacency. Devoted research antecedence taken to be conceded to buildup detailed database in perspective of forest resources in the state and nation on scientific lines and to updating datum. If so, for this conclusion, periodical assemblage, Identification and collection of such species are needed, thus one can find out and could consider management options to prevent, or at least reduce the damaging effects of biological invasions. And this only can be possible if we have the proper knowledge about their presence in the area, thus need the base line data, and this could gather only through inventory. The objectives of the present study accomplish this research need and provide the basic information for further research in the same field.

Materials and Methods

The present investigation was accomplished in the District Tehri Garhwal of the Garhwal Himalayan region of Uttarakhand which lies at 30^0 55' to 31^0 18' N latitude and 78^0 to 79^0 25' E longitude in Western Himalaya covering 36000 sq. km. The greatest extent of the region is 180 km N to S and 200 km E to W. The region is highly mountainous, ranging in altitude from 300-7000m, therefore by considering the diverse forms of the area the widely renowned Tehri Dam site was considered as a reference point and further study was carried out at different elevations. Specifically four different sites were marked based on their regional importance showed in Fig.1, i.e. site I (Jardhar VFE), known for its luxuriant forest area, and indigenous agricultural practices, site II (Dikhol VFE), became central hub for all the social activities, followed by site III (Kuttha VFE), this site became central point for the dam site seeing and tourism purposes and site IV (Saundkoti VFE) valuable natural site, as no any human induced pressure is assumed in this site.The concept of village forest exist in the study area, i.e., Tehri, from time immemorial as the forest were aligned to certain villages upto a certain radial distance to meet the bonafied needs and requirements of the village people. The geo-coordinates of each sites has been also recorded by using Global Positioning System (GPS) that are following:

Sites	Latitude (N)	Longitude (E)	Altitude (m asl)
Site I	30^0 20' 23"	78^0 20' 05"	1650 m
Site II	30^0 20' 21"	78^0 20' 21"	1570 m
Site III	30^0 23' 16"	78^0 27' 23"	1220 m
Site IV	30^0 20' 26"	78^0 25' 02"	1630 m

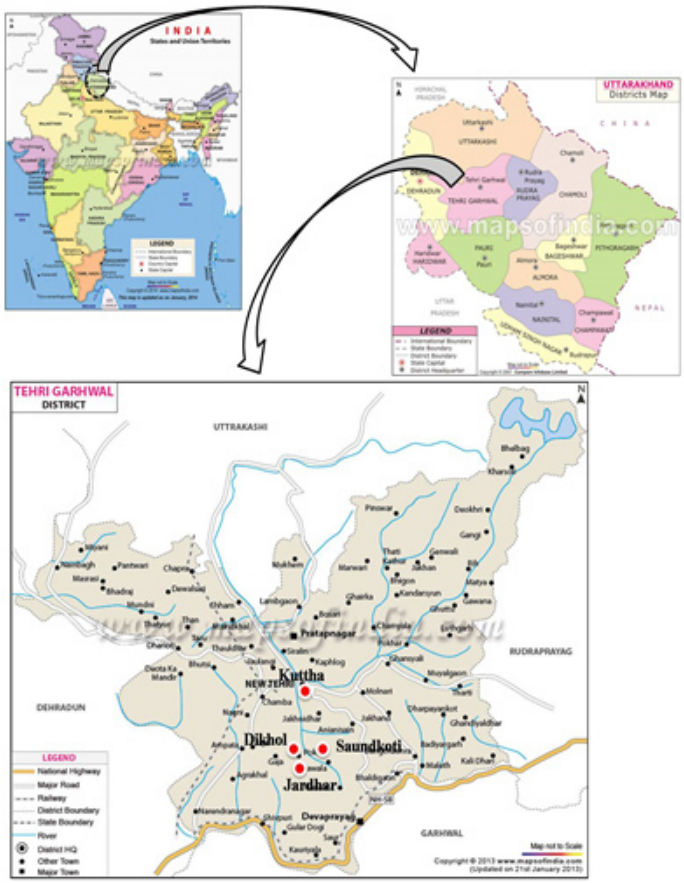

Fig. 1: Study Sites

Methods

A List Of Weed / Exotic / Invasives Of The Country

Before starting inventory for FIS in the site, secondary data was collected by preparing literature survey, list of weeds/ exotics/ invasives of the country have been prepared as per GIS database www.issg.org/global 2007[37], Negi and Hajra 2007[38], Reddy 2008[39], Biswas and Jain 2003[40], Sankaran and Sreenivasan 2001[41], Plant Quarantine report and Plant Quarantine list[42]. The data related to existing invasives of the sites was further gathered by critiquing the literature, research papers, working plan of the District, related flora of the site and explore the review of Biswas Sas 1985 and 1994[43,44], Bhattacharya and Goel 1982[45], Badoni and Bhatt 1993[46], Goel and Bhattacharya 1981[47], and Uniyal *et. al.,* 1995[48].

Reconnaissance surveys of the areas were carried out for the occurrence of Forest Invasive species. The available populations were studied using the random quadrate method[49].The field layout of sample plots was indicated in fig.2 along with various size of quadrate A, B, C for trees, shrubs and herbs field data enumeration. The study was carried out by laying out 50 quadrates (Fig.2) on each site. Thus a total 200 sample plot was laid out in all four sites. The herbarium samples along with camera photographs of the various plant species were collected.

The plant species found and recorded in the study sites were identified with the help of the available concerned site specific Floras, Forest flora of the Chakrata, Dehradun and Sahanpur Forest Divisions, Uttar Pradesh by Knajilal, U.P.[50] and Flora of the District Garhwal Northwest Himalaya by Gaur, R.D.[51] etc.).Thoroughly identification of the material was done by consulting the material with authentic specimen sheets at, DD Herbarium of FRI, Botanical Survey of India, Northern Circle, Dehradun. Final checklist of the site was cross-checked with the list of Invasive Alien Species list of IUCN for the country for the recognition of the site specific Forest Invasive Species, resulting in the form of the FIS checklist.

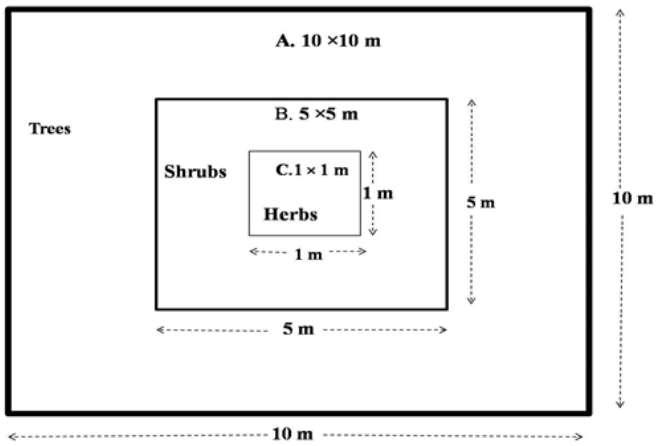

Fig. 2: Field Layout of Sample Plot

Result

The plant diversity of Forest Invasive Species of all three life form (tree, shrub and herb) and the potential weed species which could become invasives in the study area is given in Table-I,II,III,IV; Fig. III & IV.

Seventy five (75) Forest Invasive Species (FIS) and forty seven (47) weed species which could become potential invasives were invantorized from the area (Table-III and IV). Among the 75 FIS, 12 species belonging from Asteraceae, 7 species from Poaceae, 7 species of Solanaceae, 5 species of Lamiaceae, followed by four species of each Ranunculaceae and Polygonaceae while the other belongs to Papilionaceae, Cyperacea, Euphorbiaceae and various other angiospermic families were recorded. Habitat analysis of FIS showed that highest percentage of plant diversity was herbs (81.33 %), shrubs (17.33%) and Tree species (1.34%). Whereas, plant diversity among the weed species observed in study sites was maximum belongs to angiospermic family Poaceae.

Data presented in Table I reveals the maximum

invasion proportion in tree layer is reported in site II (Dikhol VFE) followed by site III (Kuttha VFE), and then site I (Jardhar VFE) (Table I). In site I (Jardhar VFE), the less invasion may be due to higher

Table 1: Forest Invasive Species account of the study sites

Category	I (Jardhar)	II (Dikhol)	III (Kuttha)	IV (Saundkoti)
Invasive tree species	1	1	1	0
Invasive shrub species	11	6	6	6
Invasive herb species	37	38	34	21
Invasives total diversity (No. of species)	49.0	45.0	41.0	27.0

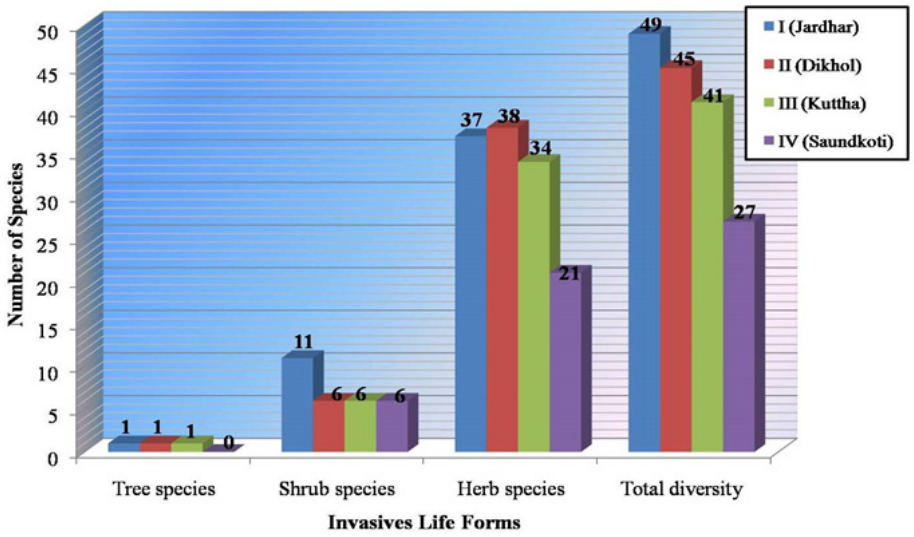

Fig. 3: FSI account of the study sites

diversity of invasives was recorded for site I (49 species), followed by site II (45 species), site III (41 species) and least invaded site was IV (27 species).

The maximum number of FIS belongs to family Asteraceae (16%), followed by Poaceae and Solanaceae (9% each), Lamiaceae (7%), Polygonaceae and Ranunculaceae (5%) whereas other angiospermic families constitute between (4 -1%) respective dominance irrespective to other recorded families as given in Table II.

Discussion

For the present research context Dam site was considered as a reference point, and this have been widely observed that disturbed habitats are more prone to invasion. The present study observed that the cumulative effects of dam construction activities resulted in greater amount of invasion in nearby areas, whether it is forest, agriculture, wasteland, and village common land etc.Similar study was carried out in Arizona, Colorado and eastern Oregon arid area, the permanent water availability has promote the growth invasion of exotic species such as Tamarix that flourish in such considerations [52, 53, 54].The inventorization carried out for the area, resulted that the forest ecosystem of four villages have similar native species in floristic composition except for dominant species while a single invasive, *Euphorbia royleana* is reported from the tree layer of the ecosystem. Site IV (Saundkoti village forest ecosystem) is free from this invasive because less anthropogenic disturbance in site like very few people in village carried out agriculture practices and an area is rich in native species diversity.

Level of invasion varies in all the sites, maximum

Table 2: Dominating FIS families of the study area

Family	No of species	Dominance of family (%)	Family	No of species	Dominance of family (%)
Asteraceae	12	16.00	Brassicaceae	1	1.33
Solanaceae	7	9.33	Cannabinaceae	1	1.33
Poaceae	7	9.33	Caryophyllaceae	1	1.33
Lamiaceae	5	6.67	Chenopodiaceae	1	1.33
Polygonaceae	4	5.33	Cleomaceae	1	1.33
Ranunculaceae	4	5.33	Commelinaceae	1	1.33
Cyperaceae	3	4.00	Crassulaceae	1	1.33
Euphorbiaceae	3	4.00	Cuscutaceae	1	1.33
Fabaceae	3	4.00	Fumariaceae	1	1.33
Rosaceae	3	4.00	Nyctaginaceae	1	1.33
Amaranthaceae	2	2.67	Tiliaceae	1	1.33
Apiaceae	2	2.67	Linaceae	1	1.33
Malvaceae	2	2.67	Papavaraceae	1	1.33
Oxalidaceae	2	2.67	Verbenaceae	1	1.33
Rubiaceae	2	2.67			

Table 3: FIS diversity of the study area, Site 1 –Jardhar(I), Site 2 –Dikhol(II), Site 3 – Kuttha(III), Site 4-Saundkoti(IV)

S.No	Species	Family	I	II	III	IV	Habit
1	*Achyranthes asperaL.*	Amaranthaceae	+	+	+	+	H
2	*Anaphalis busua* Buch.Ham ex D.Don DC	Asteraceae	+	_	+	_	H
3	Apludamutica, L.	Poaceae	+	+	+	-	H
4	*Argemone mexicana* L.	Papavaraceae	+	+	+	+	H
5	*Arundinella nepalensis*Trinius	Poaceae	+	_	_	_	H
6	*Ageratum conyzoides* L.	Asteraceae	_	+	+	+	H
7	*Amaranthus spinosus* L	Amaranthaceae	_	_	+	_	H
8	*Blainvilleaa cmella (L.)* Philipson	Asteraceae	+	_	_	_	H
9	*Bupleurum hamiltonii Balakrishnan*	Apiaceae	+	_	_	_	H
10	*Biden spilosa* L.	Asteraceae	-	+	+	+	H
11	*Bistorta amplexicaulis* (D.Don) Greene	Polygonaceae	_	+	_	_	H
12	*Boerhavia diffusa* L.	Nyctaginaceae	_	+	+	+	H
13	*Clematis gouriana* Roxb. ex DC.	Ranunculaceae	+	+	+	+	S
14	*Clematis montana* Buch.-Ham. ex DC	Ranunculaceae	+	_	_	+	S
15	*Cleome viscosa* L.	Cleomaceae	+	_	_	+	H
16	*Cuscuta reflexa* Roxb	Cuscutaceae	+	_	_	_	H
17	*Cymbopogon martinii* (Roxb) W.Watson	Poaceae	+	_	_	_	H
18	*Cynodon dactylon* L. Persoon	Poaceae	+	+	+	+	H
19	*Cyperus niveus* Retz.	Cyperaceae	+	_	_	_	H
20	*Cannabis sativa* L.	Cannabinaceae	_	+	_	_	H
21	*Chenopodium album* L.	Chenopodiaceae	_	+	_	_	H
22	*Commelina benghalensis* L.	Commelinaceae	_	+	+	+	H
23	*Datura metel* L	Solanaceae	_	+	+	_	H
24	*Delphinium denudatum*Wallich ex Hook.f. & Thomson	Ranunculaceae				+	_
_	_	H					

25	*Desmodium triflorum* (L.)DC	Fabaceae	_	_	+	_	H
26	*Eupatorium glandulosum* H.B.K.	Asteraceae	+	+	+	+	H
27	*Euphorbia hirta* L.	Euphorbiaceae	+	+	+	+	H
28	*Euphorbia royleana*Boissier.	Euphorbiaceae	+	+	+	_	T
29	*Echinochloa colona* (L.) Link	Poaceae	+	+	_	_	H
30	*Fimbristylis falcata* (Vahl) Kunth	Cyperaceae	+	_	_	_	H
31	*Fumaria indica* (Haussknecht) Pugsley	Fumariaceae	+	_	_	_	H
32	*Gerbera gossypina* (Royle)G. Beauv.	Asteraceae	+	_	_	+	H
33	*Heteropogon contortus* L. Beauv. ex Roemer & Schultes	Poaceae	+	+	_	_	H
34	*Indigofera heterantha* Wallich ex Brandis, Syn I. gerardiana (Wallich ex Baker) Ali	Fabaceae	+	_	_	_	S
35	*Koenigiadelicatula* (Meisn.) Hara Syn *Polygonum delicatulum* Meisn	Polygonaceae	+	_	_	_	H
36	*Kyllinga brevifolia* Rottboell	Cyperaceae	_	_	+	_	H
37	*Lantana camara* L.	Verbenaceae	+	+	+	+	S
38	*Leucas lanata*Benth	Lamiaceae	+	_	_	+	H
39	*Micromeria biflora* (Buch.-Ham. exD.Don) Benth	Lamiaceae	+	+	_	_	H
40	*Nepeta graciliflora* Benth	Lamiaceae	+	_	_	_	H
41	*Nicotiana plumbaginifolia* Viviani	Solanaceae	_	_	+	_	H
42	*Ocimumbasilicum* L.	Lamiaceae	+	+	_	_	H
43	*Oxalis corniculata* L.	Oxalidaceae	_	+	+	+	H
44	*Oxalis dehradunensis* Raizada	Oxalidaceae	_	+	+	+	H
45	*Origanum vulgare* L.	Lamiaceae	_	_	+	_	H
46	*Parthenium hysterophorus* L.	Asteraceae	+	+	+	+	H
47	*Pavetta indica* L.	Rubiaceae	+	+	_	_	S
48	*Physalis peruviana* L.	Solanaceae	+	+	_	_	H
49	*Polygonum plebeium* R.Br.	Polygonaceae	_	+	+	_	H
50	*Reinwardtia indica* Dumortier	Linaceae	+	+	+	+	H
51	R*osa brunonii* Lindley	Rosaceae	+	+	+	+	S
52	*Rubia cordifolia* L.	Rubiaceae	+	+	+	+	H
53	*Rubus ellipticus* Smith.	Rosaceae	+	+	+	+	S
54	*Rubus niveus* Thunb.	Rosaceae	+	_	_	_	S
55	*Rumex hastatus* D.Don	Polygonaceae	+	+	+	+	H
56	*Ranunculus sceleratus* L.	Ranunculaceae	_	+	_	_	H
57	*Ricinus communis* L	Euphorbiaceae	_	+	+	_	S
58	*Rorippa indica* (L.) Hiern	Brassicaceae	_	+	+	_	H
59	*Saccharum spontaneum* L.	Poaceae	+	+	+	_	H
60	*Sedum multicaule* Wallich ex Lindley	Crassulaceae	+	_	+	_	H
61	*Senecio nudicaulis* Buch.-Ham.exD.Don	Asteraceae	+	_	+	+	H
62	*Solanum anguiviLam*	Solanaceae	+	_	_	_	S
63	*Solanum nigrum* L.	Solanaceae	+	+	+	+	H
64	*Solanum verbascifoliumauct.*pl.	Solanaceae	+	_	_	_	S
65	*Sonchusolearecus* L	Asteraceae	+	+	+	+	H
66	*Selinumcandollii* DC	Apiaceae	_	+	_	_	H
67	*Sida rhombifolia* L.	Malvaceae	_	+	+	_	H
68	*Solanum surattense* Burm.f. *SynS. xanthocarpum*,	Solanaceae	_	+	_	_	H

	Schrader &Wendland						
69	*Stellaria media* (L.) Villars	Caryophyllaceae	_	+	+	_	H
70	*Syndrellaspp*.		_	+	+	_	H
71	*Tridax procumbensL*.	Asteraceae	+	+	+	_	H
72	*Triumfettar homboidea* Jacquin	Tiliaceae	+	_	_	_	H
73	*Trifolium repens* L.	Fabaceae	_	+	_	_	H
74	*Urenal obata* L.	Malvaceae	+	_	_	_	S
75	*Xanthium strumarium* L	Asteraceae	_	+	+	+	S

(+)Present; (-) Absent

Table 4: Check list of weedy species of the study area

S.No.	Species	Family	Habit
1	*Agave wightii*,Drummond & Prain	Agavaceae	S
2	*Ajuga bracteosa*,Wallich ex Benth	Lamiaceae	H
3	*Alloteropsis cimcina* (L.) Stapf	Poaceae	H
4	*Amaranthus* spp.	Amaranthaceae	H
5	*Anagallis arvensis*, L.	Primulaceae	H
6	*Androsace lanuginose*, Wall	Primulaceae	H
7	*Androsace umbellate* (Lour.) Merrill	Primulaceae	H
8	*Apluda mutica*, L.	Poaceae	H
9	*Avena sativa* L.	Poaceae	H
10	*Barleria cristata* L.	Acanthaceae	H
11	*Chenopodium album*, L.	Chenopodiaceae	H
12	*Chenopodium ambrosiodes*, L.	Chenopodiaceae	H
13	*Cichorium intybus*, L.	Asteraceae	H
14	*Commelina benghalensis*, L.	Commelinaceae	H
15	*Crotalaria prostrate*, Rottler ex Willd	Papilionaceae	H
16	*Cynoglossum zeylanicum* (VahlexnbHornem) Thunb.ex Lehmann	Boraginaceae	H
17	*Cyperus rotundus*	Poaceae	H
18	*Desmodium triflorum* (L.) DC	Papilionaceae	H
19	*Dicliptera spp.*	Acanthaceae	H
20	*Digitaria sanguinalis* (L.) Scop	Poaceae	H
21	*Drymaria cordata* (L.) Willd	Caryophyllaceeae	H
22	*Eragrostis spp.*	Poaceae	H
23	*Euphorbia hypericifolia*, L	Euphorbiaceae	H
24	*Fimbristylis falcate* (Vahl) Kunth	Cyperaceae	H
25	*Fumariaindica*, (Haussknecht) Pugsley	Fumariaceae	H
26	*Galinsoga ciliate* (Raf.Schm.)Blake	Asteraceae	H
27	*Geranium nepalense*, Sweet	Geraniaceae	H
28	*Hedyotis corymbosa* (l.) Lam	Rubiaceae	H
29	*Kyllinga spp.*	Cyperaceae	H
30	*Lathyrus sativus*, L.	Papilionaceae	CS
31	*Leucas lanata*,Benth	Lamiaceae	H
32	*Micromeria biflora* Buch.-Ham.ex D Don. Benth	Lamiaceae	H
33	*Nepeta graciliflora*, Benth	Lamiaceae	H
34	*Oplismenus compositus* (L.)P.Beauv	Poaceae	H
35	*Peristrophe speciosa* (Roxb) Nees	Acanthaceae	S
36	*Pogonantherum spp.*	Poaceae	H
37	*Polygala chinensis*, L.	Polygonaceae	H
38	*Rumex hastatus*,D.Don	Polygonaceae	H

39	*Rungia parviflora*, Nees	Acanthaceae	H
40	*Setaria gluca* (L.) P.Beauv	Poaceae	
41	*Sileneconoidea*, L.	Caryophyllaceae	H
42	*Sporobolus diander* (Retz) P. Beauv	Poaceae	H
43	*Stellaria media* (L.) Villars	Caryophyllaceeae	H
44	*Torenia cordifolia*, Roxb.	Scrophulariaceae	H
45	*Triumfetta annua*, L.	Tiliaceae	H
46	*Trium fettapilosa*, Roth	Tiliaceae	S
47	*Vernonia cinerea* (L.) Lessing	Asteraceae	H

*H-Herb, S-Shrub

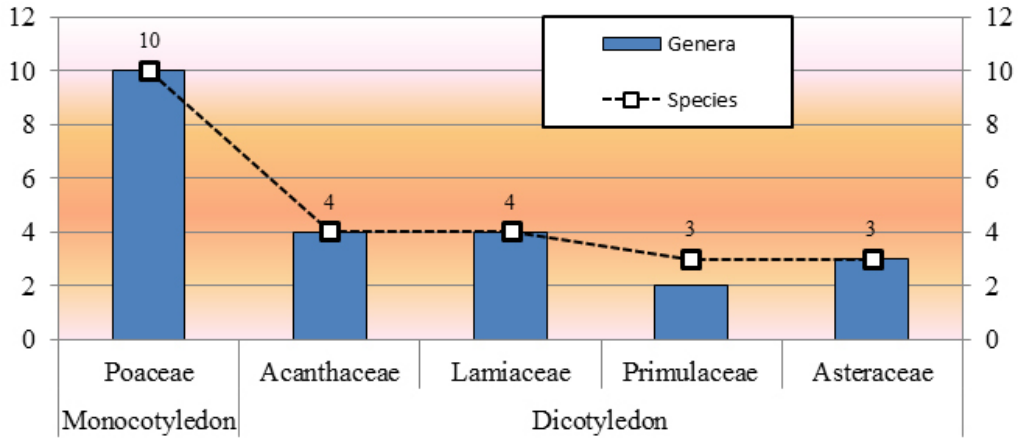

Fig. 4: Dominnent weedy species familyn of the study area

diversity of native species, invasives though present but could not get accommodated or spread their area of occupancy, thus proportion of invasion is least among all three invaded sites II (Dikhol), III (Kutta), I (Jardhar) (Fig I). Our finding agree with the protocol designed to distinguish between species that induce higher, medium, lower, or undistinguished negative affect to indigenous biodiversity within the region, state or nation of interest[55].

While disturbance in site II attributed for developing empty niche which in turn promoted invasion in the area. Similar problem is also attributed in site III, where habitat disturbance is very high due to the close vicinity of Tehri hydroelectric dam. Another important reason of invasion is the association of *Pinus roxburghii* in all the affected sites, as it is associated with the acidity in soil, where invasives like *Euphorbia royleana* can flourish[56] and the present study reveals that site III (Kuttha) is Pinus dominated might be create a favorable condition to growth of invasive species and hence, proportion of invasion this site is maximum in comparison to the other study sites.

Though *Pinus roxburghii* is also reported in site IV (Saundkoti), but as per field observations this place is situated at higher elevation and far from the reference point as a disturbing factor, dominated by *Quercus leucotrichophora*, *Rhododendron arboreum* and *Cedrus deodara*, which likely to be assumed for prohibition of the growth of *Euphorbia royleana* in the forest.

The invaded environment was providing desirable condition to invasion of species from outset, that likewise, the invasive species has the potentiality of obtruding upon that environment without any intrinsic ecological or evolutionary changes being necessitated.Therefore, wherever space is found to be free from the natives,invasives encroached those as revealed from the study and also supported by the empty niche hypothesis proposed by Elton[57].

Site II and III are equally affected by invasion of shrubaceous flora indicating a high disturbances level and invasion proportion. Both the phenomena are related to each other thus supporting the theory that more disturbances will promote more invasions. Invasion by herbaceous invasive species was

almost equal in all the sites as the herbs establish easily irrespective of shrub or tree species and their seedlings. And this is also proven by the inventory that maximum numbers of invasive are from herbs. In a number of cases, intense biotic interference (as in Dikhol, Saundkoti and Kuttha forest) does not permit the native scrub vegetation to progress any further whereas invasive herbs and few of shrubs by virtue of their specific traits gradually make thickets in these threatened areas. Another result of the biotic interference is the occurrences of blank covers over large areas, which eventually become the home of invasive shrubs, annual and perennial herbs.

Studies reveal that Asteraceae was the higher number (12) of species than other families thus it is most dominant family in study area. It is due to the fact that the members of the family are best equipped to the study area, possess best traits among all. The family is followed by invasives belonging to Poaceae and Solanaceae. The representative of the families are of herbaceous life form having short life cycle, few are perennials, thus possessing better opportunities for their survival and better growth and thus encroach the area without any natural hindrance. [58]Kumari *et al* also carried out study on a preliminary survey of invasive alien angiosperms of Rohilkhand region (U.P), India, revealed that maximum species (21) was from the family Asteraceae, Amaranthaceous (7), Euphorbiaceae (5), Papilionaceae (4) and Caesalpiniaceae (4) respectively[56].This conclude that the heightening a number of invasive alien species increased with disturbance and may affect the native diversity threat. This study will help in carrying out further research work on it; and also helpful support to ecologist, agriculturist, forest and concerned stack holder to understand the pattern of distribution of plant in area. Assist as conservation of natural resources against step-down of quality and quantity of resources.

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