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Invasive Herbaceous Floral Elements in Shimla, Himachal Pradesh (India): An Analysis

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ABSTRACT: Presence of invasive alien flora is deemed to be a menace to the native and endemic flora of any region. The impact is more prominent in tourist places like Shimla that lies in the Himalayan range which itself is a biodiversity hotspot. The ecosystem being rickety here makes it even more susceptible to habitat deterioration. An important step for effective and proper management of Invasive flora is the preparation of its baseline data. By means of regular surveys this present abridged study has revealed a total of 99 herbaceous invasive plant species belonging to 27 families and 75 genera. Near about 54 % of these species are native to the American continents, followed by Europe (25%), Eurasian/Mediterranean region (18%), Africa (3%) and China with a mere 1%. Majority of the species belonged to the Asteraceae family. This study reveals the finite information on Invasive alien plants in the region that is currently available. However, there is a need to lay stress towards practical applications of field research, ensuring that such work to be translated or compounded so that the inferences obtained are better understood, for effective management of invasive plants.

Keywords: Invasive, biodiversity hotspot, herbaceous, habitat deterioration, management.

INTRODUCTION

The introduction of alien or non indigenous plants into land and freshwater habitat has been recognized as a predicament since the last century. The plants instituted by humans intentionally or unintentionally from its original habitat into a novel habitat are called alien or exotic species (Sharma *et al*., 2005; Reddy *et al*., 2008). These non native plants invade into the new regions once it gets a hospitable environment. Preston *et al*., 2003 have mentioned that the growth of such invasive plants pose a threat to sustainable development. Once established, these plants become problematic posing a threat to the native plant diversity. Not only do they lead to biodiversity and crop losses but also create health implications like respiratory ailments (Nayak and Satapathy, 2015; Mazza and Tricarico, 2018). The effect of invasive alien species in an ecosystem is continuous and ultimately leads to changes in the structure, function and composition of the native vegetation unless and until there is complete deterioration of the habitat (Maslo, 2016). This group of plants includes species which have an ability to grow in hardy habitats and are resistant in nature. Convention for Biological Diversity (1992) have predicted biological invasion of alien species to be the second worst threat to biodiversity succeeding habitat destruction. Such kinds of biological invasions can be regarded as a type of biological pollution which is amongst the prime causes of species loss.

Globalization is held responsible for the dramatic increase in intentional and accidental introduction of plants from non native regions. Such introductions are mostly unoffending but at times may result in widespread and ecologically damaging invasions (Simberloff *et al.,* 2013). The chances of accidental introductions are liable to shoot up with increase in commercial activities across the globe (Mooney and Drake, 1987; Drake *et al*, 1989; Reddy, 2008). Biological invasion is now one of the principal causes of economic as well as environmental damage in various countries across the world and are also referred to as alien pests or weeds (Pimentel *et al*., 2000, Richardson *et al.*, 2000, Simberloff, 2011; Bellard *et al*., 2012; Reddy, 2008). Its impacts are predicted to increase eventually under the future climatic conditions (Thapa *et al*., 2018).

Naturalization has been identified as the primary phase of biological invasion. A species which is introduced (exotic or alien) to a region where it thrives well and reproduces even without direct human involvement is known as a naturalized species (Richardson *et al*., 2000; Pyšek *et al*., 2002). Many a times the invasion of alien plant species remains silent initially - known as the "lag phase" which may vary from decades to centuries, then followed by an exponential phase where they spread eventually (Ghate, 1991). Once these species are established successfully and start producing viable offspring, they tend to colonize new sites. This is the stage when these naturalized species become invasive and are termed as invasive species (Richardson *et al*., 2000).

Early detection of such species is rather important and the detection should be based on well structured surveys (Mallick *et al*., 2019). Preparation of an inventory of invasive alien species can be considered as a pioneer step towards invasion biology and will be resourceful to study the impact of species on an individual basis (Wu *et al*., 2004). Gudzinskas in 2017 stated that the recorded information is of utmost importance as it helps to predict the existence of these species in the adjoining areas as well. However, the plant inventories created should also be dynamic in nature (Khuroo *et al*., 2012). Broad scale observational studies in combination with experimental studies and predictive modelling may provide the policy makers and the managers with an insight enabling them to make effective plans to combat the effect of plant invasion (Stricker *et al.*, 2015). Native flora and the germplasm of the economically important plants are likely to become rare if such incorporations are not made (Khanna, 2009).

MATERIALS AND METHODS

Site description: Shimla is the capital city of Himachal Pradesh which is located on the last traverse spur of the Central Himalayas, falling to the south of the Sutlej River. The latitudinal extent of Shimla ranges from 31°4' - 31°10' north whereas the longitudinal extent varies from 77°5' – 77°15' east. It rests at an altitude of 2130 metres above mean sea level (Fig. 1). The city comprises of a distinctive conjunction of hills, contours, elevation, spurs and valleys. The town is built over seven hills and ridges, the important ones being Jakhoo Hill, Prospect Hill, Summer Hill, Observatory Hill, Elysium Hill and Bantony Hill. Shimla has cool temperate type of climatic condition; temperature in summer oscillates between 19°C - 33°C in summers and -5°C - 18°C in the winter months. The average annual temperature remains nearly 14°C, whereas the annual rainfall varies between 1400-1500 mm.

Shimla has been a famous tourist destination since the last century or so has always attracted tourists and is a well sought out destination of domestic as well as international tourists. This aspect of tourism has aided the introduction of various plant species from different phyto-geographical zones and their introduction may or may not have been deliberate (Kachroo, 1995).

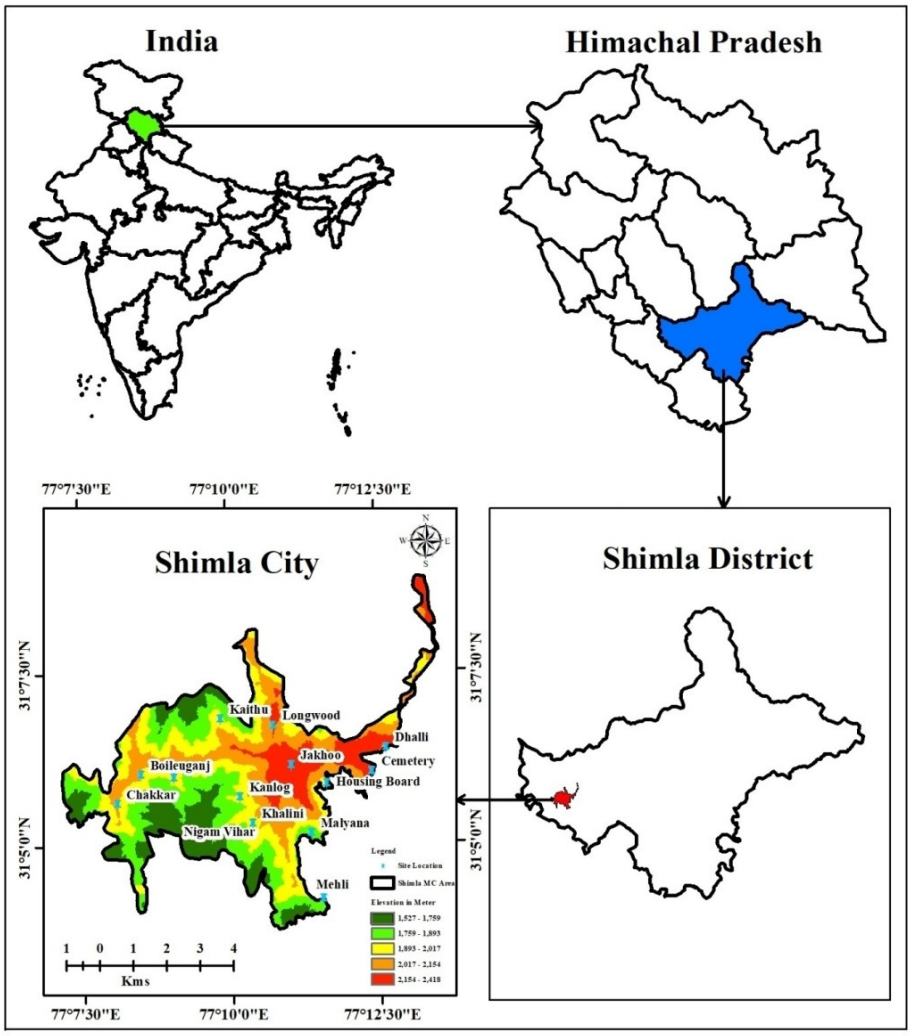

Fig. 1. Map showing the sites surveyed.

Data collection: Regular surveys were carried out from March, 2017 up to May, 2020. Secondary data was summarized from published literature and reports of Municipal Corporation, Tourism, Transport and the Forest Departments of the state. Periodic collection of Invasive Alien Plants was done from the study area followed by identification using the available floras and literature (Hooker, 1872-1897, and Collett, 1902, Buck, 1925). The study area comprised of the Shimla Municipal limits and the entire area was covered by traversing various forest trails, streets and habitations. Sites falling in different altitudinal ranges were also covered (Tutikandi (2206 m) at the lower elevation and Jakhu (2455 m) at the upper limit). Herbarium preparation method as suggested by Jain and Rao, 1993 was followed during collecting and processing of the plant samples during the field surveys. Samples were also identified and authenticated from HFRI Herbarium, DD Herbarium and the BSI Herbarium at Dehradun. To take on the latest and precise nomenclature, The Annual Checklist of World Plants (http://www.sp2000. org), e-Floras (http://www.efloras.org) and the Plant List (www.theplantlist.org) were consulted.

Informal interactivity with the locals and the staff of the State Forest Department, National Bureau of Plant Genetic Resources and Central Potato Research Institute at Shimla was carried out. Information regarding their family, nativity, habitat, history and mode of introduction was consulted from available literatures (Nayar, 1977; Reddy *et al*., 2000; Sekar, 2012). Once the identification process was over, the voucher specimens were deposited with the Herbarium of Himalayan Forest Research Institute, Shimla for future reference.

RESULT AND DISCUSSION

A sum of 99 alien/exotic species was documented from the area under study (Table 1). Out of the total number, 29 species belonged to the Asteraceae family followed by Convolvulaceae (9), Amaranthaceae (7), Poaceae (7), Brassicaceae (5), Leguminaceae (5) and Solanaceae (5). Other families like Malvaceae, Oxalidaceae, Polygonaceae, Geraniaceae, etc, included mere two to three species only (Fig. 2). The species belonged to 75 genera and the major ones being *Erigeron, Ipomea, Oxalis* and *Cuscuta*. As far as their nativity is concerned, bulk of the species are native to American (Neotropical regions) and European region. A majority of 54 plant species are native to the American continent, followed by 25 species from Europe, 18 species from Eurasia and the Mediterranean, 3 species from Africa and only 1 species from China (Fig. 3).

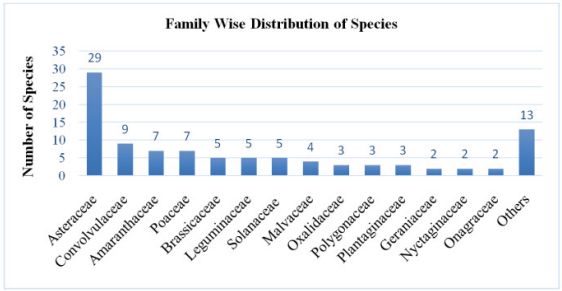

Fig. 2. Family wise representation of the alien flora.

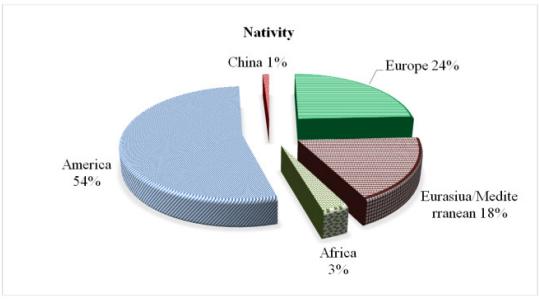

Fig. 3. Nativity of Alien Flora.

Table 1.

S.No.	Name of the plant	Family	Nativity	Introduction Mode	Invasive Status	Habitat
1.	*Aerva javanica* (Burm.f.) Juss.	Amaranthaceae	Trop. America	Ui	Ca	WP
2.	*Ageratum conyzoides* L.	Asteraceae	Trop. America	O	In	WP
3.	*Ageratum houstonianum* Mill.	Asteraceae	Trop. America	Ui	In	WP
4.	*Alliaria petiolata* (M.Bieb.) Cavara & Grande	Brassicaceae	Eurasia	Veg	In	MP
5.	*Alternanthera paronychioides* St. Hill.	Amaranthaceae	Trop. America	Ui	Ca	MP
6.	*Amaranthus hybridus* L.	Amaranthaceae	Eurasia	Veg	Nt	WP
7.	*Amaranthus spinosus* L.	Amaranthaceae	Trop. America	Ui	Ca	CF
8.	*Anagallis arvensis* L.	Primulaceae	Europe	Ui	Nt	CF
9.	*Avena fatua* L.	Poaceae	Eurasia	Fr	In	WP
10.	*Bidens pilosa* L.	Asteraceae	Trop. America	Ui	In	CF
11.	*Bidens tripartita* L.	Asteraceae	Eurasia	Ui	Ca	CF
12.	*Blainvillea acmella* (L.f.) Philipson	Asteraceae	Trop. America	Ui	Ca	WP
13.	*Blumea eriantha* DC.	Asteraceae	Trop. America	Ui	Nt	WP
14.	*Blumea lacera* (Burn.f.) DC.	Asteraceae	Europe	Ui	Nt	WP
15.	*Boerhavia diffusa* L.	Nyctaginaceae	Africa	Ui	Nt	MP
16.	*Bromus catharticus* Vahl	Poaceae	South America	Ui	In	WP
17.	*Cannabis sativa* L.	Cannabaceae	Central Asia	Ui	In	WP
18.	*Capsella bursa-pastoris* L.	Brassicaceae	Europe	Ui	Nt	WP
19.	*Cardamine flexuosa* With.	Brassicaceae	Europe	Veg	In	WP
20.	*Cardamine hirsuta* L.	Brassicaceae	Trop. America	Ui	In	AR
21.	*Carduus acanthoides* L.	Asteraceae	Europe	Ui	Nt	WP
22.	*Celosia argentea* L	Amaranthaceae	Trop. Africa	Fd	Nt	CF
23.	*Chenopodium album* L.	Amaranthaceae	Europe	Fd	In	CF
24.	*Chloris barbata* (L.) Sw.	Poaceae	Trop. America	Ui	Nt	WP
25.	*Chromolaena odorata* (L.) R.M.King & H.Rob.	Asteraceae	America	Ui	In	WP
26.	*Convolvulus arvensis* L.	Convolvulaceae	Europe	Ui	Nt	WP

27.	*Crassocephalum crepidioides* (Benth.) S. Moore	Asteraceae	Trop. America	Ui	Nt	MP
28.	*Cuscuta chinensis* Lam	Convolvulaceae	Mediterranean	Ui	Ca	Parasite
29.	*Cuscuta europea L.*	Convolvulaceae	Europe	Ui	Nt	Parasite
30.	*Cuscuta reflexa* Roxb.	Convolvulaceae	Europe	Ui	In	Parasite
31.	*Cymbalaria muralis* G.Gaertn., B.Mey. & Scherb.	Plantaginaceae	Europe	Ui	In	WF
32.	*Cynodon dactylon* (L.) Pers.	Poaceae	Africa	Ui	In	WP
33.	*Cyperus iria* L.	Cyperaceae	Trop. America	Ui	Nt	CF
34.	*Digitalis purpurea* L.	Plantaginaceae	Europe	O	Ca	WP
35.	*Dysphania ambrosioides* (L.) Mosyakin & Clemants	Amaranthaceae	America/Mexico	O	In	WP
36.	*Echinops echinatus* Roxb.	Asteraceae	Afghanistan	Ui	Nt	WP
37.	*Emilia sonchifolia* (L.) DC.	Asteraceae	Trop. America	Ui	Nt	AR
38.	*Erigeron annuus* (L.) Pers.	Asteraceae	North America	Ui	In	WF
39.	*Erigeron bonariensis* L.	Asteraceae	Americas	Ui	In	WF
40.	*Erigeron canadensis* L.	Asteraceae	Americas	Ui	In	WF
41.	*Erigeron karvanskianus* DC.	Asteraceae	Mexico	O	In	WF
42.	*Euphorbia hirta* L.	Euphorbiaceae	Trop. America	Ui	Nt	WP
43.	*Evolvulus nummularius* (L.) L.	Convolvulaceae	Trop. America	Ui	Nt	WP
44.	*Fagopyrum acutatum* (Lehm.) Mansf. ex K.Hammer	Polygonaceae	China	CE	In	MP
45.	*Galinsoga parviflora* Cav.	Asteraceae	Trop. America	Ui	Nt	MP
46.	*Galinsoga quadriradiata* Ruiz & Pavon	Asteraceae	Mexico	Ui	Nt	WP
47.	*Galium aparine* L.	Rubiaceae	Eurasia	Ui	Nt	CF
48.	*Geranium lucidum* L.	Geraniaceae	Europe	Ui	Nt	MP
49.	*Geranium molle* L.	Geraniaceae	Mediterranean	Ui	Ca	MP
50.	*Hesperis matronalis* L.	Brassicaceae	Eurasia	Ui	Ca	WP
51.	*Hieracium caespitosum* Dumort	Asteraceae	Europe	Ui	Nt	WP
52.	*Hieracium vulgatum* Fries	Asteraceae	Europe	Ui	Nt	MP
53.	*Impatiens balsamina* L.	Balsaminaceae	Trop. America	O	Nt	AR
54.	*Indigofera linifolia* (L.f.) Retz.	Leguminaceae	South America	Ui	Nt	AR
55.	*Ipomoea hederacea* Jacq.	Convolvulaceae	North America	Ui	Nt	MP
56.	*Ipomoea nil* (L.) Roth.	Convolvulaceae	Tropical	O	Nt	MP
57.	*Ipomoea purpurea* (L.) Roth	Convolvulaceae	South America	Ui	Nt	WP
58.	*Ipomoea quamoclit* L.	Convolvulaceae	Trop. America	O	Ca	WP
59.	*Jacobaea vulgaris* Gaertn.	Asteraceae	Eurasia	Ui	Nt	WP
60.	*Leucanthemum vulgare* L.	Asteraceae	Europe	O	In	MP
61.	*Lindenbergia indica* Vatke	Plantaginaceae	Eurasia	Ui	In	WF
62.	*Malva neglecta* Wallr.	Malvaceae	Eurasia	O	Nt	WP
63.	*Matricaria discoides* DC.	Asteraceae	North America	Ui	Ca	MP
64.	*Melilotus alba* Medik. ex Desr.	Leguminaceae	Europe	Fd	Nt	CF
65.	*Mirabilis jalapa* L.	Nyctaginaceae	South America	O	Ca	WP
66.	*Modiola caroliniana* (L.) G.Don	Malvaceae	South America	Ui	In	MP
67.	*Nicandra physalodes* (L.) Gaertn.	Solanaceae	South America	O	Nt	WP
68.	*Nicotiana plumbaginifolia* Viv.	Solanaceae	Tropical America	Nt	Nt	WP
69.	*Oenothera biennis* L.	Onagraceae	North America	O	Ca	MP
70.	*Oenothera rosea* L'Hér. ex Aiton	Onagraceae	South America	Ui	Ca	MP
71.	*Oxalis acetosella* L.	Oxalidaceae	Europe	Ui	Nt	MP
72.	*Oxalis corniculata* L.	Oxalidaceae	Europe	Ui	Nt	CF
73.	*Oxalis latifolia* Kunth.	Oxalidaceae	Mexico	Ui	Nt	CF
74.	*Parthenium hysterophorus* L.	Asteraceae	North America	Ui	In	WP
75.	*Passiflora foetida* L.	Passifloraceae	South America	O	Ca	WP
76.	*Phalaris minor* Retz.	Poaceae	Eurasia	Fd	Nt	WP
77.	*Physalis minima* L.	Solanaceae	Trop. America	Ui	Nt	WP
78.	*Polygonum aviculare* L.	Polygonaceae	Eurasia	Ui	Nt	MP
79.	*Polygonum hydropiper* L.	Polygonaceae	Europe	Ui	Nt	MP
80.	*Polypogon monspeliensis* (L.) Desf.	Poaceae	Europe	Ui	Nt	MP
81.	*Portulaca oleracea* L.	Portulacaceae	South America	Fd	Ca	WP
82.	*Sida acuta* Burm.f.	Malvaceae	Trop. America	Ui	Nt	WP
83.	*Sida rhombifolia* Burm.f	Malvaceae	Tropical America	Ui	Nt	WP
84.	*Solanum chacoense* Bitter	Solanaceae	South America	RE	In	WP
85.	*Solanum nigrum* L.	Solanaceae	Trop. America	Ui	Nt	CF
86.	*Sonchus asper* (L.) Hill	Asteraceae	Mediterranea	Ui	Nt	AR
87.	*Sonchus oleraceus* L.	Asteraceae	Mediterranea	Ui	Nt	AR
88.	*Spartina patens* (Aiton) Muhl	Poaceae	America	Ui	Ca	MP
89.	*Stellaria media* L.	Caryophyllaceae	Europe	Ui	Nt	MP
90.	*Tagetes minuta* L.	Asteraceae	South America	Ui	In	WP
91.	*Tridax procumbens* L.	Asteraceae	Central America	Ui	Ca	CF
92.	*Trifolium pratense* L.	Leguminaceae	Europe	Fd	Nt	MP
93.	*Trifolium repens* L.	Leguminaceae	Europe	Fd	In	MP
94.	*Triumfetta rhomboidea* Jacq.	Tiliaceae	Trop. America	Ui	Nt	WP
95.	*Verbena bonariensis* L.	Verbenaceae	South America	Ui	Ca	WP
96.	*Vicia hirsuta* (L.) Gray	Leguminaceae	Europe	Ui	Nt	MP
97.	*Vinca major* L.	Apocynaceae	Mediterranean	O	In	MP
98.	*Xanthium strumarium* L.	Asteraceae	Trop. America	Ui	Nt	WP
99.	*Zephyranthes minuta* (Kunth) D.Dietr.	Amaryllidaceae	Mexico	O	Ca	MP

[Abbreviations used; Ui =Unintentional; In=Intentional; Nt= Naturalized; Ca= Casual; WP= Wasteplaces; MP= Moist places; Or=Ornamental; AR=Around Roadsides; CF= Cultivated Fields; WF= Wall flora; P = Planted; Nt=Narcotic.

Shimla has a definite colonial impact as many species were introduce by the Britishers to ease their "feel home syndrome". Introduction of 71% of the plant species was unintentional, 16% was for ornamental purpose and to check landslips, 7% came with food, 3% were introduced accidently with vegetables and rest 1% came along with fodder, escaped from research facilities and for narcotic purpose respectively (Fig. 4). *Solanum chacoense* (wild potato) is an example which was introduced for research purpose but later escaped into the wild. As far as the invasive status is concerned, 52% of the species have naturalised and are dominating the region over native flora; 28% are invasive which are negatively impacting the native flora by competing with the natives for habitat and nutrition; 20% are casuals which are not impacting the native flora (Fig. 5). The major invasive alien herbs includes *Bidens pilosa*, *Modiola caroliniana*, *Trifolium pratense*, *Linderbergia indica, Oxalis latifolia*, *Trifolium repens*, *Sonchus oleraceous*, *Leucanthemum vulgare*, and *Impatiens balsamina* (Plate-1). Numerous newly detected species usually occur in natural habitats, construction areas, near human settlements, barren slopes, degraded urban landscape and area with enormous anthropogenic disturbance. A study has revealed the type of vegetation which is prone to degradation as a result of invasion and predicts distribution of invasive plants in near future (Thapa *et al.*, 2018). In similar relation it was observed that 44 plant species occurred in wastelands, 27 in moist places, 13 in cultivated fields, 6 along the roadsides, 6 being predominantly wall flora while 3 plants are parasitic in habit (Fig. 6).

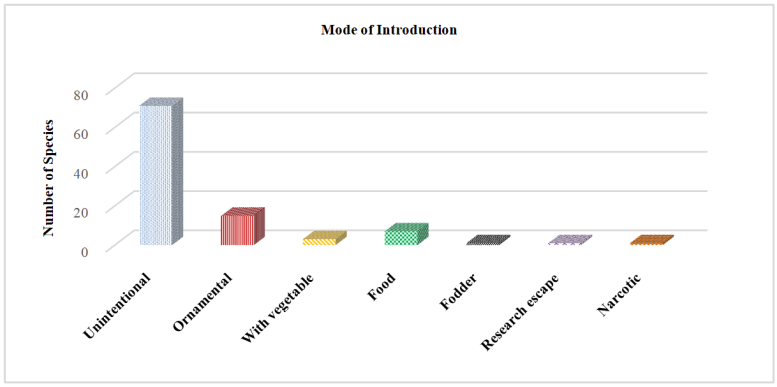

Fig. 4. Mode of Introduction of the Alien Flora.

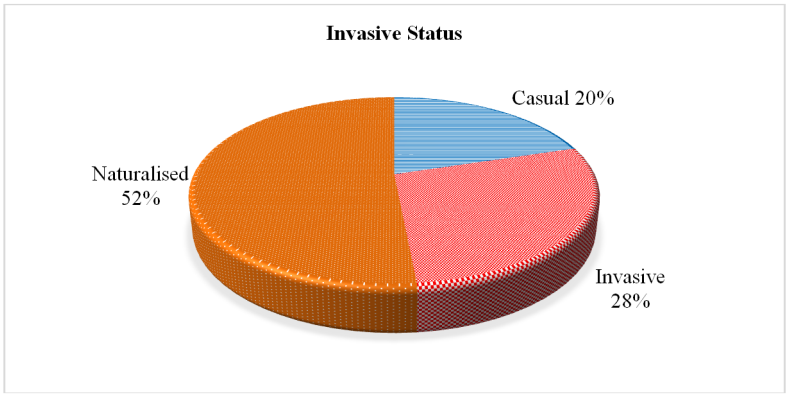

Fig. 5. Invasive Status of the Alien Flora.

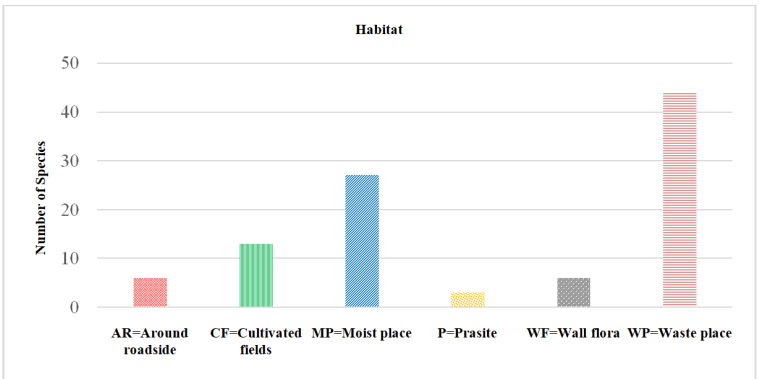

Fig. 6. Habitat of the Alien Flora.

PLATE-1

(1) *Bidens pilosa* (2) *Modiola caroliniana* (3) *Trofolium pretense* (4) *Lindenbergia indica* (5) *Oxalis latifolia* (6) *Trifolium pretense* (7) *Sonchus oleraceous* (8) *Leucanthemum vulgare* (9) *Impatiens balsamina.*

CONCLUSION

By abundant seed and biomass production the alien invasive species are thriving in new areas, thereby altering and threatening the native floral elements. Plant species tend to become invasive when they are ignored for a longer period of time. Documentation after thorough analysis of flora by understanding taxonomic diversity is of prime importance. Besides, monitoring of invasive species is also one of the main step in management by inventory building, phyto-sociological means and mapping. It warrants a strategic planning for early detection and reporting of invasive plants. Also, a sound link needs to be established between taxonomists, ecologists and forests departments, for its better and effective management.

The current study on the 'Invasive Herbaceous Floral Elements in Shimla', will prove to be fruitful and would serve as handy reference for future research, as it inventories a list of herbaceous alien invasive flora of the city. It will also be helpful for the researchers as well as conservationists for their better understanding. This enumeration will certainly help in the assessment and monitoring of alien flora in the region. In turn better management strategies against problematic plant invasions can be chalked out for Shimla.

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Conflict of Interest. No.

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