

## Invasive Alien Species in Khandesh Region (Maharashtra: India): Diversity, Implications and Measures

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### Original Research Article

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#### Article History

Received: 29.11.2017

Accepted: 15.12.2017

Published: 30.12.2017

#### DOI:

10.36347/sajb.2017.v05i12.008



**Abstract:** Invasive alien taxa are serious threat to native biodiversity, besides the global warming and man-engineered activities. The present inventory enlisted them in Khandesh region of Maharashtra State (India) comprehensively. A total of 120 alien angiospermic species belonging to 84 genera and 39 families have been documented. Of these, 111 species and 76 genera of 34 families represent the dicotyledons, whereas 09 species and 08 genera under 05 families are monocotyledons. Analyses of invasive aliens indicate that herbaceous annuals, American floral elements and unintentional introductions share major segment of the alien flora of Khandesh region. It appears desirable to monitor invasion of such species through qualitative and quantitative approaches collaboratively inviting Government Forest Department, NGO's, biodiversity-experts, ecologists and environmentalists in such scientific pursuit.

**Keywords:** Alien species, Khandesh, Maharashtra, Nativity

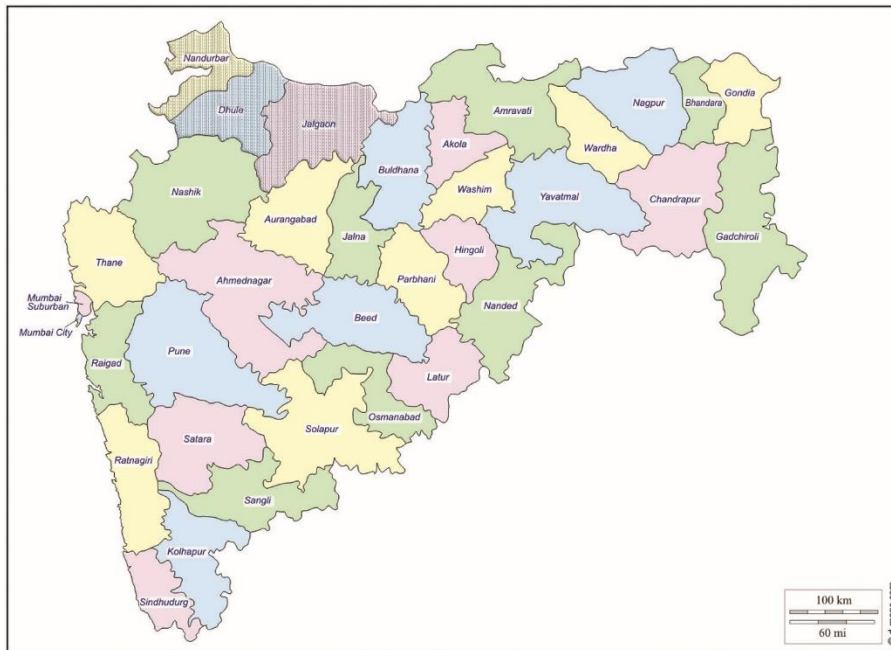
### INTRODUCTION

Apart from man, two major threats to the biodiversity of the world are: (i) global warming and (ii) biological invasions. The former also promotes the latter. Biological invasions, of late, are operating at global level. They will undergo increase because of increasing globalization, rise in global trade, travel and tourism. India is a signatory to all these. It is, therefore, very imperative to make an effective implication management of invasive species. The present study is aimed at inventorising their diversity, life forms, habitat, nativity and mode of introductions with future implications of the region under study.

### METHODOLOGY

Intensive botanization was extended to record maximum number especially of invasive alien plant species paying particular attention to different habits, habitats, life-forms and modes of introductions in Khandesh region. Decipherment of alien species was completed using national, regional, state and district floras [1-8]. The nativity and mode of introductions of invasive species was borrowed from earlier literature [9-24]. They have been enumerated in Table-1 alphabetically with respect to their plant name, family, nativity, life-forms, habit, habitat and mode of introduction.

Khandesh region of Maharashtra presently includes three districts viz., Jalgaon, Dhule and Nandurbar. It lies in the Tapi (Tapti) river basin. Ranges of Western Ghats (Sahyadris) extend in south-western part, whereas Satpura mountain stretches on north-western border of Maharashtra state bordering adjacent states of Gujarat and Madhya Pradesh (Fig-1). The forests are dry deciduous type. Floristic studies are already completed in this region [1, 2]. However, alien taxa are paid cursory attention in such investigations. It is re-investigated with particular emphasis on invasive alien species from ecological point of view. Results of this re-investigation are being presented in this communication.



**Fig-1: Khandesh Region in Maharashtra State (Jalgaon, Dhule and Nandurbar Districts)**

**Table-1: Invasive plant species of Khandesh Region (Maharashtra)**

SN	Plant Species & Family	Native Region/ Country	Life Form	Habit	Habitat	Purpose of Introduction
1.	<i>Acanthospermum hispidum</i> DC. Asteraceae	Brazil	H	A	W	Ui
2.	<i>Ageratum conyzoides</i> L. Asteraceae	Trop. America	H	A	W	Ui
3.	<i>Alternanthera paronychioides</i> St. Hill. Amaranthaceae	Trop. America	H	P	RB	Ui
4.	<i>Alternanthera pungens</i> (Humb.), Bonpl. & Kunth Amaranthaceae	Trop. America	H	P	W	Ui
5.	<i>Alternanthera sessilis</i> (L.) DC. Amaranthaceae	Trop. America	H	P	RB	Ui
6.	<i>Alternanthera tenella</i> Colla Amaranthaceae	Trop. America	H	A	W	Ui
7.	<i>Amaranthus spinosus</i> L. Amaranthaceae	Trop. America	H	A	CF	Ui
8.	<i>Anagallis arvensis</i> L. Primulaceae	Europe	H	A	CF	Ui
9.	<i>Antigonon leptopus</i> Hook. & Arn. Polygonaceae	Trop. America	C	P	AR	O
10.	<i>Argemone mexicana</i> L. Papaveraceae	S. America	H	A	W	Ui
11.	<i>Asclepias curassavica</i> L. Asclepiadaceae	Trop. America	H	P	AR	O
12.	<i>Asphodelus tenuifolius</i> Cav. Liliaceae	Trop. America	H	A	CF	Ui

SN	Plant Species & Family	Native Region/ Country	Life Form	Habit	Habitat	Purpose of Introduction
13.	<i>Bidens ternatea</i> (Lour.) Merr. & Scheriff. Asteraceae	Trop. America	H	A	CF	Ui
14.	<i>Blainvillea acmella</i> (L.f.) Philipson Asteraceae	Trop. America	H	A	W	Ui
15.	<i>Blumea eriantha</i> DC. Asteraceae	Trop. America	H	P	W	Ui
16.	<i>Blumea lacera</i> (Burm. f.) DC. Asteraceae	Trop. America	H	A	W	Ui
17.	<i>Blumea obliqua</i> (L.) Druce Asteraceae	Trop. America	H	A	W	Ui
18.	<i>Calotropis gigantea</i> (L.) R. Br. Asclepiadaceae	Trop. Africa	S	P	W	Ui
19.	<i>Calotropis procera</i> (Ait.) R. Br. Asclepiadaceae	Trop. Africa	S	P	W	Ui
20.	<i>Cassia absus</i> L. Caesalpiniaceae	Trop. America	H	A	W	Ui
21.	<i>Cassia obtusifolia</i> L. Caesalpiniaceae	Trop. America	H	P	W, F	Ui
22.	<i>Cassia occidentalis</i> L. Caesalpiniaceae	S. America	H	P	W	Ui
23.	<i>Cassia pumila</i> Lam. Caesalpiniaceae	Trop. America	H	A	W	Ui
24.	<i>Cassia tora</i> L. Caesalpiniaceae	S. America	H	A	W	Ui
25.	<i>Cassia uniflora</i> Mill. Caesalpiniaceae	S. America	H	A	W	Ui
26.	<i>Catharanthus pusillus</i> (Murr.) G. Don Apocynaceae	Trop. America	H	A	CF	Ui
27.	<i>Celosia argentea</i> L. Amaranthaceae	Trop. Africa	H	A	CF	Fd
28.	<i>Ceratophyllum demersum</i> L. Ceratophyllaceae	Trop. America	H	A	A	Ui
29.	<i>Chenopodium murale</i> L. Chenopodiaceae	Trop. America	H	A	CF, W	Ui
30.	<i>Chrozophora rotleri</i> (Geis.) Juss. ex Spreng. Euphorbiaceae	Trop. Africa	H	A	W, CF	Ui
31.	<i>Cleome gynandra</i> L. Capparaceae	Trop. America	H	A	W	Ui
32.	<i>Cleome monophylla</i> L. Capparaceae	Trop. Africa	H	A	AR	Ui
33.	<i>Cleome viscosa</i> L. Capparaceae	Trop. America	H	A	W	Ui

SN	Plant Species & Family	Native Region/ Country	Life Form	Habit	Habitat	Purpose of Introduction
34.	<i>Convolvulus arvensis</i> L. Convolvulaceae	Europe	H	A	F, W	Ui
35.	<i>Corchorus aestuans</i> L. Tiliaceae	Trop. America	H	A	F, W	Ui
36.	<i>Corchorus fascicularis</i> Lam. Tiliaceae	Trop. America	H	A	W	Ui
37.	<i>Corchorus olitorius</i> L. Tiliaceae	Trop. Africa	H	A	CF	Ui
38.	<i>Corchorus tridens</i> L. Tiliaceae	Trop. Africa	H	A	AR, W	Ui
39.	<i>Corchorus trilocularis</i> L. Tiliaceae	Trop. Africa	H	A	W	Ui
40.	<i>Croton bonplandianum</i> Baill. Euphorbiaceae	S. America	H	P	W	Ui
41.	<i>Cryptostegia grandiflora</i> R. Br. Asclepiadaceae	Madagascar	H	P	CF	O
42.	<i>Cuscuta chinensis</i> Lam. Cuscutaceae	Mediterranean	H	P	P	Ui
43.	<i>Cyperus difformis</i> L. Cyperaceae	Trop. America	SE	A	CF	Ui
44.	<i>Cyperus iria</i> L. Cyperaceae	Trop. America	SE	A	CF	Ui
45.	<i>Datura ferox</i> L. Solanaceae	South-North America	S	P	W	Ui
46.	<i>Datura innoxia</i> Mill. Solanaceae	Trop. America	S	P	W	Ui
47.	<i>Datura metel</i> L. Solanaceae	Trop. America	S	P	W	Ui
48.	<i>Digera muricata</i> (L.) Mart. Amaranthaceae	S. W. Asia	H	A	CF	Ui
49.	<i>Dinebra retroflexa</i> (Vahl) Panz. Poaceae	Trop. America	G	P	W	Ui
50.	<i>Echinochloa colona</i> (L.) Link Poaceae	S. America	G	A	RB	Ui
51.	<i>Echinops echinatus</i> Roxb. Asteraceae	Afghanistan	H	A	W	Ui
52.	<i>Eclipta prostrata</i> (L.) Mant. Asteraceae	Trop. America	H	A	AR	Ui
53.	<i>Eichhornia crassipes</i> (C. Martius) Solms. Pontederiaceae	Trop. America	H	P	A	Ui
54.	<i>Emilia sonchifolia</i> (L.) DC. Asteraceae	Trop. America	H	A	RB	Ui
55.	<i>Euphorbia cyathophora</i> Murray Euphorbiaceae	Trop. America	H	A	W	Ui
56.	<i>Euphorbia hirta</i> L. Euphorbiaceae	Trop. America	H	A	W, CF	Ui

SN	Plant Species & Family	Native Region/ Country	Life Form	Habit	Habitat	Purpose of Introduction
57.	<i>Euphorbia indica</i> Lamk.	Trop. South America	H	A	W, CF	Ui
58.	<i>Flaveria trinervia</i> (Spreng.) C.Mohr. Asteraceae	Trop. Central America	H	A	W, A	Ui
59.	<i>Galinsoga parviflora</i> Cav. Asteraceae	Trop. America	H	A	RB	Ui
60.	<i>Glossocardia bosvallea</i> (L.f.) DC. Asteraceae	East Indies	H	A	W	Ui
61.	<i>Gomphrena serrata</i> L. Amaranthaceae	Trop. America	H	A	CF	Ui
62.	<i>Grangea maderaspatana</i> (L.) Poir. Asteraceae	S. America	H	A	RB	Ui
63.	<i>Hyptis suaveolens</i> (L.) Poit. Lamiaceae	Trop. America	H	A	AR	Ui
64.	<i>Impatiens balsamina</i> L. Balsaminaceae	Trop. America	H	A	RB	O
65.	<i>Indigofera glandulosa</i> Roxb. ex Willd. Fabaceae	Trop. America	H	A	CF	Ui
66.	<i>Indigofera hirsuta</i> L. Fabaceae	Trop. America	H	A	W	Ui
67.	<i>Indigofera linifolia</i> (L.f.) Retz. Fabaceae	S. America	H	A	AR	Ui
68.	<i>Indigofera linmaei</i> Ali Fabaceae	Trop. Africa	H	A	F	Ui
69.	<i>Indigofera trita</i> L.f. Fabaceae	Trop. Africa	S	P	F	Ui
70.	<i>Ipomoea carnea</i> Jacq. subsp. <i>fistulosa</i> (Mart. ex Choisy) Austin Convolvulaceae	Trop. America	S	P	W	Ui
71.	<i>Ipomoea eriocarpa</i> R.Br. Convolvulaceae	Trop. Africa	H	A	W	Ui
72.	<i>Ipomoea hederifolia</i> L. Convolvulaceae	Trop. America	H	A	F	Ui
73.	<i>Ipomoea nil</i> (L.) Roth Convolvulaceae	N. America	H	A	F, W	Ui
74.	<i>Ipomoea obscura</i> (L.) Ker.-Gawl. Convolvulaceae	Trop. Africa	H	P	W	Ui
75.	<i>Ipomoea pes-tigridis</i> L. Convolvulaceae	Trop. East Africa	H	A	W	Ui
76.	<i>Ipomoea quamoclit</i> L. Convolvulaceae	Trop. America	H	P	W	O

SN	Plant Species & Family	Native Region/ Country	Life Form	Habit	Habitat	Purpose of Introduction
77.	<i>Lagascea mollis</i> Cav. Asteraceae	Central America	H	A	CF	Ui
78.	<i>Lantana camara</i> L. Verbenaceae	Trop. America	H	P	F	O
79.	<i>Leonotis nepetiifolia</i> (L.)R. Br. Lamiaceae	Trop. Africa	H	A	W	Ui
80.	<i>Leucaena latisiliqua</i> (L.) Gilli. Mimosaceae	Trop. America	T	P	W	Fo
81.	<i>Ludwigia perennis</i> L. Onagraceae	Trop. Africa	H	A	RB	Ui
82.	<i>Malachra capitata</i> (L.) L. Malvaceae	Trop. America	H	P	W	Ui
83.	<i>Malvastrum coromandelianum</i> (L.) Garcke Malvaceae	Trop. America	H	A	W	Ui
84.	<i>Martynia annua</i> L. Pedaliaceae	Trop. America	H	P	W	Ui
85.	<i>Melilotus alba</i> Medik. ex Desr. Fabaceae	Europe	H	A	CF	Fd
86.	<i>Merremia aegyptia</i> (L.) Urb. Convolvulaceae	Trop. America	C	P	W	Ui
87.	<i>Mimosa pudica</i> L. Mimosaceae	Brazil	H	P	W	O
88.	<i>Mirabilis jalapa</i> L. Nyctaginaceae	Peru	H	A	W	O
89.	<i>Ocimum americanum</i> L. Lamiaceae	Trop. America	H	A	W	Ui
90.	<i>Opuntia stricta</i> Haw. var. <i>dillenii</i> (Ker.- Gawl.) Benson Cactaceae	Trop. America	S	P	W	Ui
91.	<i>Oxalis corniculata</i> L. Oxalidaceae	Europe	H	P	CF	Ui
92.	<i>Parthenium hysterophorus</i> L. Asteraceae	N. America	H	A	W	Ui
93.	<i>Passiflora foetida</i> L. Passifloraceae	S. America	H	P	W	O
94.	<i>Pedaliium murex</i> L. Pedaliaceae	Trop. America	H	P	W	Ui
95.	<i>Pennisetum purpureum</i> Schum. Poaceae	Trop. America	G	A	F	Fo
96.	<i>Peristrophe paniculata</i> (Forssk.) Brummit Acanthaceae	Trop. America	H	A	W	Ui
97.	<i>Physalis angulata</i> L. Solanaceae	Trop. America	H	A	W	Ui

SN	Plant Species & Family	Native Region/ Country	Life Form	Habit	Habitat	Purpose of Introduction
98.	<i>Physalis minima</i> L. Solanaceae	Trop. America	H	A	W	Ui
99.	<i>Physalis peruviana</i> L. Solanaceae	Peru	H	A	W, CF	Ui
100.	<i>Pilea microphylla</i> (L.) Liebm. Urticaceae	S. America	H	A	RB	O
101.	<i>Portulaca oleracea</i> L. Portulacaceae	S. America	H	A	W	Ui
102.	<i>Portulaca quadrifida</i> L. Portulacaceae	Trop. America	H	A	W	Ui
103.	<i>Prosopis juliflora</i> (Sw.) DC. Mimosaceae	Mexico	S	P	W	Af
104.	<i>Ruellia tuberosa</i> L. Acanthaceae	Trop. America	H	A	RB	Ui
105.	<i>Saccharum spontaneum</i> L. Poaceae	Trop. West Asia	G	P	RB	Ui
106.	<i>Sesbania bispinosa</i> (Jacq.) W. F. Wight Fabaceae	Trop. America	S	A	RB	Ui
107.	<i>Sida acuta</i> Burm. f. Malvaceae	Trop. America	H	A	W	Ui
108.	<i>Solanum nigrum</i> L. Solanaceae	Trop. America	H	A	CF	Ui
109.	<i>Sonchus oleraceus</i> L. Asteraceae	Mediterranean	H	A	RB	Ui
110.	<i>Spermacoce hispida</i> L. Rubiaceae	Trop. America	H	P	CF	Ui
111.	<i>Stachytarpheta jamicensis</i> (L.) Vahl Verbenaceae	America	H	A	W	O
112.	<i>Synedrella nodiflora</i> (L.) Gaertn. Asteraceae	West Indies	H	A	W, AR	Ui
113.	<i>Tribulus lanuginosus</i> L. Zygophyllaceae	Trop. America	H	P	W	Ui
114.	<i>Tribulus terrestris</i> L. Zygophyllaceae	Trop. America	H	P	W	Ui
115.	<i>Tridax procumbens</i> L. Asteraceae	Central America	H	P	CF	Ui
116.	<i>Triumfetta rhomboidea</i> Jacq. Tiliaceae	Trop. America	H	A	W	Ui
117.	<i>Typha angustifolia</i> L. Typhaceae	Trop. America	H	P	RB	Ui
118.	<i>Urena lobata</i> L. Malvaceae	Trop. Africa	S	P	W	Ui
119.	<i>Waltheria indica</i> L. Sterculiaceae	Trop. America	H	P	F	Ui

SN	Plant Species & Family	Native Region/ Country	Life Form	Habit	Habitat	Purpose of Introduction
120.	<i>Xanthium indicum</i> Koenig Asteraceae	Trop. America	S	A	AR	Ui

## RESULTS AND DISCUSSIONS

The present inventory on invasive alien plant species divulged considerable diversity in Khandesh region of Maharashtra State. A total of 120 species belonging to 84 genera and 39 families of angiosperms are recorded. Of these, the dicotyledons are represented by 110 species, 75 genera and 34 families, whereas the monocotyledons belong to 09 species, 08 genera of 05 families. A total of 11 different geographical regions in terms of nativity are noted during this botanization. These species are contributed by major geographical regions such as: various parts of America (84), Africa (16), Europe (04), Mediterranean region (02), Peru, Brazil and Asia (02 each), Madagascar, East and West Indies (01 each).

Thus American floral elements contribute major share (72.5%) of invasive species in Khandesh region. Interestingly, 73% native American species are also reported from Indian Himalayan region (25). However, more than 58% invasive alien flora of India is reported to be native of American continent [19, 20]. The African region is represented by 12.5%, while other regions contribute insignificantly e.g. Peru, Brazil, Afghanistan, Mediterranean and Madagascar. Analysis of annuals and perennials indicate that the former comprise 78 species (65%), while the latter are represented by 42 species (35%). Further analysis of life-forms revealed as many as six forms viz., herbs (99), shrubs (12), climbers (02), sedges (02), grasses (04) and trees (01). The figures in parenthesis stand for number of alien species. The highest number of invasive species in Khandesh are: (i) herbs and (ii) shrubs, the former being very dominant element in the region. There are nine genera that contribute more percentage of alien species. These are: *Ipomoea* (07), *Cassia* (06), *Corchorus* (05), *Alternanthera* and *Indigofera* (04 each), *Cleome*, *Euphorbia*, *Datura* and *Physalis* (03 each). The largest families contributing alien taxa are: Asteraceae (12), Amaranthaceae (10), Convolvulaceae, Solanaceae and Fabaceae (08 each), Caesalpiaceae and Tiliaceae (06 each), Malvaceae and Euphorbiaceae (04 each) and Mimosaceae (03). The family Asteraceae is the most dominant in invasive alien flora of Khandesh. Similar situation in Uttar Pradesh of India is also recorded [20]. It is also to be noted that the Asteraceae is dominant family in alien flora of entire India [22]. Majority of species (71) flourish on wastelands. Some of these also occur in other habitats e.g. *Chenopodium murale*, *Chrozophora rotleri*, *Convolvulus arvensis*, *Corchorus tridens*, *Cryptostegia grandiflora*, *Ipomoea nil*, *Physalis peruviana*,

*Synedrella nodiflora*, *Flaveria trinervia*, *Euphorbia hirta* and *E.indica*. Nearly 22 species inhabit and compete with cultivated or crop plants. Some of these also grow in forested areas e.g. *Cassia obtusifolia*, *Convolvulus arvensis*, *Indigofera linnae*, *Ipomoea nil*, *Lantana camara*, *Pennisetum purpureum* and *Corchorus aestuans*. Nine species, as noted in Table-I, are usually found along roadsides. However, aquatic invasive aliens are few e.g. *Ceratophyllum demersum* and *Eichhornia crassipes*. *Pistia stratiotes*, *Borassus flabellifer*, *Synadenium grantii* and *Opuntia stricta* are noted only in home gardens as a botanical curiosity or as a hedge. They do not exhibit invasiveness in this region, although reported so in other regions in India [19, 25]. Species of *Cyperus* are also found in aquatic or marshy places. *Cuscuta chinensis* is the only alien parasite in the region. As many as 14 aliens inhabit river beds. The literature review indicated some species to be allelopathic e.g. *Argemone mexicana*, *Ageratum conyzoides*, *Cassia uniflora*, *Parthenium hysterophorus*, *Lagascea molis*, *Lantana camara*, *Eichhornia crassipes*, *Prosopis juliflora*, etc. [20, 26, 27, 28, 29].

Annuals are predominant invasive aliens in Khandesh flora and are represented by 78 species out of total 120 species. The annuals vis-à-vis herbaceous invasive aliens appear to have better tolerance to warmer condition prevailing in this part of the Maharashtra State. Some species are introduced intentionally as ornamentals in gardens. However, being invasive in nature, they escaped from cultivation and are naturalized at near suitable habitats e.g. *Antigonum leptopus*, *Asclepias curassavica*, *Cryptostegia grandiflora*, *Impatiens balsamina*, *Ipomoea quamoclit*, *Mimosa pudica*, *Pilea microphylla*, *Mirabilis jalapa* and *Passiflora foetida*. Very recently, *Cassia uniflora* has naturalized faster in this region particularly along roadsides. It is noteworthy that at many places it has practically replaced *Parthenium hysterophorus*, a very noxious alien weed established long back before 1970. Invasion of *Cassia obtusifolia* and *Lantana camara* are certainly responsible for depletion of some forest species in this region.

Majority of these invasive aliens cause interference especially in cultivated lands and grasslands. Farmers have to uproot them for obvious reason. Much of their energy and time is wasted in monitoring them. Even the grazing lands are fully occupied by them because of their gregarious growth. The present author also noted depletion of some forest species. Interferences e.g. changes in soil structure, its



profile, decomposition, changes in hydrological cycle and ecosystem functions although observed in this region, they were not attended at all at any level or by some agencies. This negligence, in near future, will certainly lead to a precarious situation. This trend is also recorded in the other parts of state of Maharashtra, as in India. Globalization of trade, travel and tourism will further boost this trend.

Many alien weedy species are exploited for vegetable and medicinal purposes traditionally [30]. However, their removal is not so effective to check their further growth and dispersal. It is, therefore, necessary to monitor invasion of such aliens through qualitative approach e.g. seasonal species inventory, and quantitative approach employing phytosociological methods and mapping by ground-based methods e.g. GPS and remotely-sensed images. A collaborative effort is desired to monitor them by inviting NGO's, taxonomists, ecologists, besides Government Forest Department, in such a scientific pursuit.

#### ACKNOWLEDGEMENTS

The author is thankful to the authorities of S.S.V.P Sanstha, Dhule (M.S.), India for library facilities and encouragement.

#### ABBREVIATIONS

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

Habit: A: Annual; P: Perennial.

Habitat: W: Wastelands; CF: Cultivated fields; F: Forests; AR: Along roadside; G: Garden; A: Aquatic; P: Parasites; RB: River beds.

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

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