

Floristic Composition and Nativity Analysis: Hastinapur Wildlife Sanctuary

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ABSTRACT

Biological invasion is considered as a significant contributor to the human-driven global environment change that has resulted in loss of native biodiversity and alteration in different aspects of the functioning of invaded ecosystems. Present work aimed at understanding the trend of intrusion of alien flora in a dry tropical region of a protected area, the Hastinapur Wildlife Sanctuary, located in the midst of rapidly urbanizing five districts of Uttar Pradesh in India. Survey visits to the sanctuary were carried out during the period 2021-2023 and species list was compiled with the help of recorded flora and other published works and each species was assigned its nativity. Out of a total of 591 plant species distributed over 106 families, 62% were aliens and only 38% flora were natives. Highest alien flora were of American biogeographic origin (26%), followed by Asian (21%),

African (7%), European (5%) and Australian (3%). The dominant families included Poaceae, Fabaceae and Asteraceae, Malvaceae and Cyperaceae comprising 43.1% of total flora recorded. Herbaceous were maximum in number (71%), followed by tree (14%), shrub (10%) and climber (5%) flora. The study revealed increasing trend of intrusion of alien flora, predominated by the flora of American and Asian biogeographic origin, into the protected area of Hastinapur Wildlife Sanctuary. Thus, this study has implication for necessary management measures against the naturalizing, colonizing and invasive alien weeds in protected areas, especially across urbanizing anthropecosystems in Indian dry tropics.

Keywords Biological invasion, Protected areas, Biodiversity conservation, Invasive species, Alien-flora, Dry tropics.

INTRODUCTION

Biological invasion of alien species is the second worst threat after habitat destruction, according to the Convention on Biological Diversity, 1992. In fact, the spread of non-native, alien or exotic species has been acknowledged in recent years, as one of the greatest threats to biodiversity. These biological invasions have been considered as major contributors to the human-caused global environmental change which has ultimately contributed to the disruption of ecological harmony in native ecosystems and relegating several rare species to the brink of extinction. Such invasions often result into the substantial economic loss, reduc-

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tion of biological diversity, and disrupted functioning of invaded ecosystems (Mack *et al.* 2000).

From an ecological perspective, any introduced species that establishes itself, naturalizes, and spreads in an ecosystem beyond its native range is considered invasive (Williamson 1996). The introduction of these invasive species can occur accidentally, through escape after being imported for a limited purpose, or deliberately on a large scale (Levine 1989). Many people introduce non-native species into new habitats for economic gain (McNeely 2001), and most cases of invasiveness can be traced back to intended or unintended consequences of economic activities (Perrings *et al.* 2002). Globalization and rapid alteration of natural habitats have especially accelerated the pace of invasion over the past century (Schei 1996). At continental and global scales, species invasions have reduced the regional distinctiveness of flora and fauna (Vitousek *et al.* 1997). In many continental regions, 20% or more of plant species are now reportedly non-native, and in many islands, the proportion of non-native plant species is 50% or higher (Rejmánek and Randall 1994).

Compared to the native species, invasive weeds grow and produce biomass more quickly. They are also highly competitive, have high reproductive efficiency—producing a lot of seeds—efficient dispersal, vegetative reproduction, quick establishment, and other characteristics that aid in their ability to adapt to new environments (Simberloff *et al.* 2005, Sharma *et al.* 2005). Many of these species are very tolerant of various abiotic environments and have the potential to be allelopathic (Sharma *et al.* 2005, Huang *et al.* 2009). However, in determining the success of an invasion, the biotic and abiotic characteristics of the target habitat are probably just as significant as the autecological characteristics of the invasive species (Higgins and Richardson 1996).

The structure and function of an ecosystem may undergo significant, permanent changes as a result (Mooney and Hobbs 2000, Sakai *et al.* 2001). It destroys native species in competition and results in significant financial losses (Dukes and Mooney 2004, D'Antonio and Hobbie 2005). These days, ecologists are well aware of the issues posed by alien species

encroaching on natural habitats and the detrimental consequences these incursions have on native biodiversity patterns across the world. Certain alien species can induce changes in the pattern of plant succession, disturb the cycles of fire and nutrients, and displace or replace native plant and animal species once they get established.

To monitor the spread and impact in different places and to develop appropriate management plans, it appears that a regional and national authentic database on alien flora is necessary. Such studies may be considered of greater importance in areas that are protected in nature. Hastinapur Wildlife Sanctuary (HWLS) located in western Uttar Pradesh was primarily declared a sanctuary in 1986 for the realized need to conserve grassland habitat and swamp deer in this protected area. However, it now belongs to the category IV of IUCN Protected Area Management categories (Goyal *et al.* 2022). Khan (1999) remarked conservation concern for the flora and fauna, especially the viable population of swamp deer in HWLS.

The present work aimed to assess the impact of biological invasions on the floristic composition of vegetation in Hastinapur Wildlife Sanctuary, which has faced anthropic pressure in the region for over 4-5 decades. The major objective of the present study was to assess the nativity of plant species in Hastinapur Wildlife Sanctuary.

MATERIALS AND METHODS

Study area

The study area was Hastinapur Wildlife Sanctuary (spread over an area of 1789 km²) located along the banks of the Ganga in Western Uttar Pradesh in India. It is located between 77°30' and 78°30' E longitudes and 28°46' and 29°35' N latitudes. It lies at the junctions of Muzaffarnagar, Bijnor, Meerut, Amroha and Hapur. Initially this sanctuary was established for the purpose to provide protection to swamp deer, the state animal of Uttar Pradesh, and to conserve the fast vanishing, unique biome, locally known as Gangetic Khadar. It has a variety of landforms and habitats viz., wetland, marshes, dry sand beds and gently sloping ravines known as Khola. Presently, major portion of

the wildlife sanctuary area is under the cultivation and urban area whereas the natural habitat forms a small part of the sanctuary.

Floristic data collection

Survey visits to HWLS were undertaken during the period 2021-2023 and a comprehensive inventory of the flora of sanctuary was compiled based on extensive and scientific literature that was published pertaining to the floristic composition of the sanctuary e.g. Agarwal (2009). The information on habit of plants was recorded. All the plants were listed alphabetically on the basis of the continent of their origin with author citation and family name. Plant species recorded from the sanctuary were categorized under four habit groups viz., tree, shrub, herb and climbers. The scientific names of these species were updated using taxonomic online databases viz., Plants of the world online (<http://www.powo.science.kew.org>) (POWO) and E-Floras (<http://www.efloras.org>).

Nativity analysis

Biogeographic origin of the species was assessed on the basis of Plants of the world online (<http://www.powo.science.kew.org>); specialized internet web pages (www.efloras.org) and published research papers e.g. Khuroo *et al.* (2012, 2021), Agrawal and Narayan (2017), Singh *et al.* (2010) and others. A biogeographic approach was followed in assigning the native ranges to each species. The origin of the alien species was recognized at continental scale, Asia (excluding the Indian sub-continent), Europe, Africa, North America, South America and Oceania/Australia. Plant species with multiple biogeographic origins that included the Indian sub-continent were considered as its natives. The species with nativity referred for tropical America/South America/North America were assigned native to America.

RESULTS

Agrawal (2009) reported a total of 752 species in HWLS. However, we compiled floristic details on family, habit and nativity of a total of 591 plant species distributed over 106 families (Table 1). Nativity of the rest of the species could not be obtained. The

Table 1. Family, habit and nativity of plant species of Hastinapur Wildlife Sanctuary in India. (Codes: IS – Indian sub-continent, AS – Asia, AM (inclusive of North America, South America and Tropical America), AF – Africa, EU – Europe, OA – Oceania/Australia).

Sl. No.	Species	Family	Biogeographic origin	Habit
1	<i>Abelmoschus esculentus</i> Moench	Malvaceae	AF	Herb
2	<i>Abelmoschus manihot</i> (L.) Medik.	Malvaceae	AS	Shrub
3	<i>Abildgaardia ovata</i> (Burm.f.) Kral	Cyperaceae	OA	Herb
4	<i>Abrus precatorius</i> L.	Fabaceae	IS	Herb
5	<i>Abutilon hirtum</i> (Lam.) Sweet	Malvaceae	AS	Shrub
6	<i>Abutilon indicum</i> (L.) Sweet	Malvaceae	AS	Shrub
7	<i>Abutilon ramosum</i> (Cav.) Guill. and Perr.	Malvaceae	IS	Shrub
8	<i>Acacia auriculiformis</i> A.Cunn. ex Benth.	Fabaceae	OA	Tree
9	<i>Acalypha indica</i> L.	Euphorbiaceae	IS	Herb
10	<i>Achyranthes aspera</i> L.	Amaranthaceae	IS	Herb
11	<i>Acmella ciliata</i> (Kunth) Cass.	Asteraceae	AM	Herb
12	<i>Adenostemma lavenia</i> (L.) Kuntze	Asteraceae	AS	Herb
13	<i>Aegle marmelos</i> (L.) Corrêa	Rutaceae	IS	Tree
14	<i>Aerva javanica</i> Juss.	Amaranthaceae	AM	Herb
15	<i>Aerva lanata</i> (L.) Juss.	Amaranthaceae	IS	Herb
16	<i>Aerva sanguinolenta</i> (L.) Blume	Amaranthaceae	IS	Herb
17	<i>Aeschynomene indica</i> L.	Fabaceae	AM	Herb
18	<i>Afrohybanthus enneaspermus</i> (L.) Flicker	Violaceae	IS	Herb
19	<i>Ageratina adenophora</i> (Spreng.) R.M.King & H.Rob.	Asteraceae	AM	Herb
20	<i>Ageratum conyzoides</i> L.	Asteraceae	AM	Herb
21	<i>Ageratum houstonianum</i> Mill.	Asteraceae	AM	Herb
22	<i>Ailanthus excelsus</i> Roxb.	Simaroubaceae	AM	Tree

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
23	<i>Albizia lebbek</i> (L.) Benth.	Fabaceae	IS	Tree
24	<i>Albizia odoratissima</i> (L.f.) Benth.	Fabaceae	IS	Tree
25	<i>Alhagi maurorum</i> Medik.	Fabaceae	AS	Shrub
26	<i>Aloe vera</i> (L.) Burm.f.	Asphodelaceae	AM	Herb
27	<i>Alpinia zerumbet</i> (Pers.) B.L.Burt & R.M.Sm.	Zingiberaceae	AS	Herb
28	<i>Alternanthera paronychioides</i> A.St.-Hil.	Amaranthaceae	AM	Herb
29	<i>Alternanthera philoxeroides</i> (Mart.) Griseb.	Amaranthaceae	AM	Herb
30	<i>Alternanthera pungens</i> Kunth	Amaranthaceae	AM	Herb
31	<i>Alternanthera sessilis</i> (L.) DC.	Amaranthaceae	AM	Herb
32	<i>Alysicarpus monilifer</i> (L.) DC.	Fabaceae	IS	Herb
33	<i>Alysicarpus rugosus</i> (Willd.) DC.	Fabaceae	AF	Herb
34	<i>Alysicarpus vaginalis</i> (L.) DC.	Fabaceae	IS	Herb
35	<i>Amaranthus blitum</i> subsp. <i>oleraceus</i> (L.) Costea	Amaranthaceae	IS	Herb
36	<i>Amaranthus spinosus</i> L.	Amaranthaceae	AM	Herb
37	<i>Amaranthus tricolor</i> L.	Amaranthaceae	AS	Herb
38	<i>Amaranthus viridis</i> L.	Amaranthaceae	IS	Herb
39	<i>Ammannia baccifera</i> L.	Lythraceae	AS	Herb
40	<i>Ampelocissus latifolia</i> (Roxb.) Planch.	Vitaceae	IS	Climber
41	<i>Andrographis echinoides</i> (L.) Nees	Acanthaceae	IS	Herb
42	<i>Androsace umbellata</i> (Lour.) Merr.	Primulaceae	IS	Herb
43	<i>Anethum graveolens</i> L.	Apiaceae	AS	Herb
44	<i>Anisomeles indica</i> (L.) Kuntze	Lamiaceae	AS	Shrub
45	<i>Annona squamosa</i> L.	Annonaceae	AM	Tree
46	<i>Antigonon leptopus</i> Hook. & Arn.	Polygalaceae	AM	Climber

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
47	<i>Apluda mutica</i> L.	Poaceae	AS	Herb
48	<i>Aponogeton natans</i> (L.) Engl. & K.Krause	Aponogetonaceae	IS	Herb
49	<i>Arabidopsis thaliana</i> (L.) Heynh.	Brassicaceae	EU	Herb
50	<i>Arenaria serpyllifolia</i> L.	Caryophyllaceae	AS	Herb
51	<i>Argemone mexicana</i> L.	Papaveraceae	AM	Herb
52	<i>Argemone ochroleuca</i> Sweet	Papaveraceae	AM	Herb
53	<i>Arnebia hispidissima</i> (Lehm.) A.DC.	Boraginaceae	IS	Herb
54	<i>Artemisia capillaris</i> Thunb.	Asteraceae	AS	Herb
55	<i>Artemisia japonica</i> Thunb.	Asteraceae	AS	Herb
56	<i>Artemisia nilagirica</i> (C.B. Clarke) Pamp.	Asteraceae	AS	Shrub
57	<i>Artocarpus heterophyllus</i> Lam.	Moraceae	IS	Tree
58	<i>Artocarpus lacucha</i> Roxb. ex Buch.-Ham.	Moraceae	IS	Tree
59	<i>Arundinella nepalensis</i> Trin.	Poaceae	IS	Herb
60	<i>Arundinella pumila</i> (Hochst. ex A.Rich.) Steud.	Poaceae	AS	Herb
61	<i>Arundo donax</i> L.	Poaceae	IS	Herb
62	<i>Asparagus racemosus</i> Willd.	Asparagaceae	IS	Herb
63	<i>Asphodelus tenuifolius</i> Cav.	Asphodelaceae	IS	Herb
64	<i>Avena sterilis</i> L.	Poaceae	IS	Herb
65	<i>Averrhoa carambola</i> L.	Oxalidaceae	AS	Tree
66	<i>Axonopus compressus</i> (Sw.) P.Beauv.	Poaceae	IS	Herb
67	<i>Azadirachta indica</i> A. Juss.	Meliaceae	IS	Tree
68	<i>Bacopa monnieri</i> (L.) Wettst.	Plantaginaceae	AS	Herb
69	<i>Bambusa bambos</i> (L.) Voss	Poaceae	IS	Herb
70	<i>Barleria cristata</i> L.	Acanthaceae	AS	Shrub
71	<i>Barleria prionitis</i> L.	Acanthaceae	IS	Herb
72	<i>Basella alba</i> L.	Basellaceae	AF	Climber

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
73	<i>Bassia indica</i> (Wight) A.J.Scott	Amaranthaceae	IS	Herb
74	<i>Bauhinia purpurea</i> L.	Fabaceae	AS	Tree
75	<i>Bauhinia racemosa</i> Lam.	Fabaceae	IS	Tree
76	<i>Bauhinia variegata</i> L.	Fabaceae	IS	Tree
77	<i>Bergera koenigii</i> L.	Rutaceae	IS	Tree
78	<i>Bergia ammannioides</i> Roxb.	Elatinaceae	AS	Herb
79	<i>Bidens pilosa</i> L.	Asteraceae	AM	Herb
80	<i>Blainvillea acmella</i> (L.) Philipson	Asteraceae	AM	Herb
81	<i>Blepharis integrifolia</i> var. <i>integrifolia</i>	Acanthaceae	IS	Herb
82	<i>Blepharis maderaspatensis</i> (L.) B.Heyne ex Roth	Acanthaceae	IS	Herb
83	<i>Blumea axillaris</i> DC.	Asteraceae	AM	Herb
84	<i>Blumea lacera</i> (Burm.f.) DC.	Asteraceae	IS	Herb
85	<i>Blumea sinuata</i> (Lour.) Merr.	Asteraceae	IS	Herb
86	<i>Boerhavia chinensis</i> subsp. <i>natalensis</i> (Meikle) Govaerts	Nyctaginaceae	AS	Herb
87	<i>Boerhavia diffusa</i> L.	Nyctaginaceae	AS	Herb
88	<i>Bolboschoenus maritimus</i> (L.) Palla	Cyperaceae	EU	Herb
89	<i>Bombax ceiba</i> L.	Malvaceae	IS	Tree
90	<i>Bothriochloa pertusa</i> (L.) A.Camus	Poaceae	IS	Herb
91	<i>Breynia vitis-idaea</i> (Burm.f.) C.E.C.Fisch.	Phyllanthaceae	AS	Shrub
92	<i>Broussonetia papyrifera</i> (L.) Vent.	Moraceae	AS	Tree
93	<i>Bulbostylis barbata</i> (Rottb.) C.B.Clarke	Cyperaceae	IS	Herb
94	<i>Butea monosperma</i> (Lam.) Kuntze	Fabaceae	IS	Tree
95	<i>Caesalpinia pulcherrima</i> (L.) Sw.	Fabaceae	AM	Shrub
96	<i>Caesulia axillaris</i> Roxb.	Asteraceae	IS	Herb
97	<i>Cajanus platycarpus</i> (Benth.) Maesen	Fabaceae	IS	Shrub
98	<i>Cajanus scarabaeoides</i> (L.) Thouars	Fabaceae	IS	Herb

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
99	<i>Calotropis gigantea</i> (L.) W.T.Aiton	Apocynaceae	AF	Shrub
100	<i>Calotropis procera</i> (Aiton) Dryand.	Apocynaceae	AF	Shrub
101	<i>Campsis grandiflora</i> (Thunb.) K.Schum.	Bignoniaceae	AS	Climber
102	<i>Canna indica</i> L.	Cannaceae	AM	Tree
103	<i>Cannabis sativa</i> L.	Cannabaceae	IS	Herb
104	<i>Capparis decidua</i> Edgew.	Capparaceae	IS	Shrub
105	<i>Capparis zeylanica</i> L.	Capparaceae	IS	Climber
106	<i>Capsella bursa-pastoris</i> Medik.	Brassicaceae	AS	Herb
107	<i>Cardamine impatiens</i> L.	Brassicaceae	AS	Herb
108	<i>Cardiospermum halicacabum</i> L.	Sapindaceae	AM	Climber
109	<i>Carissa carandas</i> L.	Apocynaceae	IS	Shrub
110	<i>Carissa spinarum</i> L.	Apocynaceae	IS	Shrub
111	<i>Carthamus oxyacantha</i> M.Bieb.	Asteraceae	AS	Herb
112	<i>Cassia fistula</i> L.	Fabaceae	IS	Tree
113	<i>Cassia renigera</i> Wall. ex Benth.	Fabaceae	IS	Tree
114	<i>Casuarina equisetifolia</i> L.	Casuarinaceae	OA	Tree
115	<i>Catharanthus pusillus</i> G.Don	Apocynaceae	AM	Herb
116	<i>Catharanthus roseus</i> (L.) G.Don	Apocynaceae	AM	Herb
117	<i>Causonis trifolia</i> (L.) Mabb. and J.Wen	Vitaceae	OA	Climber
118	<i>Ceiba pentandra</i> (L.) Gaertn.	Malvaceae	AM	Tree
119	<i>Celastrus paniculatus</i> Willd.	Celastraceae	IS	Climber
120	<i>Celosia argentea</i> L.	Amaranthaceae	AM	Herb
121	<i>Cenchrus americanus</i> (L.) Morrone	Poaceae	EU	Herb

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
122	<i>Cenchrus biflorus</i> Roxb.	Poaceae	IS	Herb
123	<i>Cenchrus ciliaris</i> L.	Poaceae	AM	Herb
124	<i>Cenchrus pennisetiformis</i> Steud.	Poaceae	AF	Herb
125	<i>Cenchrus setiger</i> Vahl	Poaceae	AF	Herb
126	<i>Centella asiatica</i> (L.) Urb.	Apiaceae	IS	Herb
127	<i>Centipeda minima</i> (L.) A.Braun & Asch.	Asteraceae	IS	Herb
128	<i>Ceratophyllum demersum</i> L.	Ceratophyllaceae	AM	Herb
129	<i>Chamaecrista absus</i> (L.) H.S.Irwin & Barneby	Fabaceae	AM	Herb
130	<i>Chamaecrista pumila</i> (Lam.) V.Singh	Fabaceae	AM	Herb
131	<i>Chenopodium album</i> L.	Amaranthaceae	EU	Herb
132	<i>Chenopodium murale</i> L.	Amaranthaceae	AS	Herb
133	<i>Chloris barbata</i> Sw.	Poaceae	AM	Herb
134	<i>Chrysopogon fulvus</i> (Spreng.) Chiov.	Poaceae	IS	Herb
135	<i>Chrysopogon zizanioides</i> (L.) Roberty	Poaceae	IS	Herb
136	<i>Cichorium intybus</i> L.	Asteraceae	AS	Herb
137	<i>Cirsium arvense</i> (L.) Scop.	Asteraceae	EU	Herb
138	<i>Cissampelos pareira</i> L.	Menispermaceae	IS	Climber
139	<i>Cissus quadrangularis</i> L.	Vitaceae	IS	Climber
140	<i>Citrullus colocynthis</i> (L.) Schrad.	Cucurbitaceae	IS	Herb
141	<i>Cleome gynandra</i> L.	Cleomaceae	AM	Herb
142	<i>Cleome viscosa</i> L.	Cleomaceae	AM	Herb
143	<i>Clerodendrum infortunatum</i> L.	Lamiaceae	IS	Shrub
144	<i>Clitoria ternatea</i> L.	Fabaceae	AM	Climber
145	<i>Coccinia grandis</i> (L.) Voigt	Cucurbitaceae	IS	Climber
146	<i>Cocculus hirsutus</i> (L.) W.Theob.	Menispermaceae	IS	Shrub
147	<i>Coix lacryma-jobi</i> L.	Poaceae	AS	Herb
148	<i>Colocasia esculenta</i> (L.) Schott	Araceae	IS	Herb

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
149	<i>Combretum indicum</i> (L.) DeFilipps	Combretaceae	AS	Climber
150	<i>Combretum nanum</i> Buch.-Ham.	Combretaceae	IS	Herb
151	<i>Commelina benghalensis</i> L.	Commelinaceae	IS	Herb
152	<i>Commelina caroliniana</i> Walter	Commelinaceae	IS	Herb
153	<i>Convolvulus arvensis</i> L.	Convolvulaceae	AS	Climber
154	<i>Conyza stricta</i> Willd.	Asteraceae	AS	Herb
155	<i>Corchorus aestuans</i> L.	Malvaceae	AM	Herb
156	<i>Corchorus capsularis</i> L.	Malvaceae	AS	Herb
157	<i>Corchorus olerius</i> L.	Malvaceae	AF	Herb
158	<i>Corchorus tridens</i> L.	Malvaceae	AF	Herb
159	<i>Corchorus trilocularis</i> L.	Malvaceae	AF	Herb
160	<i>Cordia dichotoma</i> G.Forst.	Boraginaceae	IS	Tree
161	<i>Coriandrum sativum</i> L.	Apiaceae	AS	Herb
162	<i>Corymbia citriodora</i> (Hook.) K.D.Hill & L.A.S.Johnson	Myrtaceae	OA	Tree
163	<i>Cotula anthemoides</i> L.	Asteraceae	IS	Herb
164	<i>Crinum asiaticum</i> L.	Amaryllidaceae	IS	Herb
165	<i>Crotalaria juncea</i> L.	Fabaceae	OA	Herb
166	<i>Crotalaria mysorensis</i> Roth	Fabaceae	IS	Herb
167	<i>Croton bonplandianus</i> Baill.	Euphorbiaceae	AM	Herb
168	<i>Cryptostegia grandiflora</i> Roxb. ex R.Br.	Apocynaceae	AF	Climber
169	<i>Cucumis maderaspatanus</i> L.	Cucurbitaceae	IS	Herb
170	<i>Cucumis melo</i> L.	Cucurbitaceae	IS	Herb
171	<i>Curcuma longa</i> L.	Zingiberaceae	IS	Herb
172	<i>Cuscuta chinensis</i> Lam.	Convolvulaceae	IS	Climber
173	<i>Cuscuta reflexa</i> Roxb.	Convolvulaceae	IS	Climber
174	<i>Cyanotis axillaris</i> (L.) D.Don ex Sweet	Commelinaceae	IS	Herb
175	<i>Cyanthillium cinereum</i> (L.) H.Rob.	Asteraceae	AS	Herb

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
176	<i>Cyathocline purpurea</i> Kuntze	Asteraceae	AS	Herb
177	<i>Cymbopogon jwarancusa</i> (Jones ex Roxb.) Schult.	Poaceae	IS	Herb
178	<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	IS	Herb
179	<i>Cynoglossum zeylanicum</i> (Sw. ex Lehm.) Thunb. ex Brand	Boraginaceae	IS	Herb
180	<i>Cyperus alulatus</i> J.Kern	Cyperaceae	AS	Herb
181	<i>Cyperus brevifolius</i> (Rottb.) Hassk.	Cyperaceae	OA	Herb
182	<i>Cyperus compactus</i> Retz.	Cyperaceae	AS	Herb
183	<i>Cyperus cyperoides</i> (L.) Kuntze	Cyperaceae	AS	Herb
184	<i>Cyperus difformis</i> L.	Cyperaceae	AM	Herb
185	<i>Cyperus iria</i> L.	Cyperaceae	AM	Herb
186	<i>Cyperus michelianus</i> subsp. <i>pygmaeus</i> (Rottb.) Asch. & Graebn.	Cyperaceae	EU	Herb
187	<i>Cyperus mindorensis</i> (Steud.) Huygh	Cyperaceae	OA	Herb
188	<i>Cyperus niveus</i> Retz.	Cyperaceae	AF	Herb
189	<i>Cyperus panicus</i> (Rottb.) Boeckeler	Cyperaceae	AF	Herb
190	<i>Cyperus rotundus</i> L.	Cyperaceae	IS	Herb
191	<i>Cyperus squarrosus</i> L.	Cyperaceae	AM	Herb
192	<i>Dactyloctenium aegyptium</i> (L.) Willd.	Poaceae	AM	Herb
193	<i>Dalbergia sissoo</i> Roxb.	Fabaceae	IS	Tree
194	<i>Datura innoxia</i> Mill.	Solanaceae	AM	Shrub
195	<i>Datura metel</i> L.	Solanaceae	AM	Shrub
196	<i>Datura stramonium</i> L.	Solanaceae	AM	Herb
197	<i>Daucus carota</i> L.	Apiaceae	EU	Herb
198	<i>Delonix regia</i> (Bojer ex Hook.) Raf.	Fabaceae	AF	Tree
199	<i>Dendrocalamus strictus</i> (Roxb.) Nees	Poaceae	IS	Shrub
200	<i>Dendrophthoe falcata</i> (L.f.) Ettingsh.	Loranthaceae	IS	Shrub
201	<i>Dentella repens</i> J.R.Forst. & G.Forst.	Rubiaceae	AS	Herb
202	<i>Descurainia sophia</i> (L.) Webb ex Prantl	Brassicaceae	AM	Herb

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
203	<i>Desmostachya bipinnata</i> (L.) Stapf	Poaceae	IS	Herb
204	<i>Dichanthium annulatum</i> (Forssk.) Stapf	Poaceae	AS	Herb
205	<i>Dichrocephala integrifolia</i> (L.f.) Kuntze	Asteraceae	AS	Herb
206	<i>Dicliptera paniculata</i> (Forssk.) I.Darbysh.	Acanthaceae	AM	Herb
207	<i>Digera muricata</i> Mart.	Amaranthaceae	AM	Herb
208	<i>Digitaria sanguinalis</i> (L.) Scop.	Poaceae	AM	Herb
209	<i>Digitaria violascens</i> Link	Poaceae	AS	Herb
210	<i>Dioscorea bulbifera</i> L.	Dioscoreaceae	IS	Climber
211	<i>Diospyros montana</i> Roxb.	Ebenaceae	IS	Tree
212	<i>Dysphania ambrosioides</i> (L.) Mosyakin & Clemants	Amaranthaceae	AM	Herb
213	<i>Echinochloa colona</i> (L.) Link	Poaceae	AM	Herb
214	<i>Echinochloa colonum</i> subsp. <i>edulis</i> (Honda) Banfi & Galasso	Poaceae	AM	Herb
215	<i>Echinochloa crus-galli</i> (L.) P.Beauv.	Poaceae	AM	Herb
216	<i>Eclipta prostrata</i> (L.) L.	Asteraceae	AM	Herb
217	<i>Ehretia aspera</i> Willd.	Boraginaceae	IS	Tree
218	<i>Eleocharis atropurpurea</i> (Retz.) J.Presl & C.Presl	Cyperaceae	OA	Herb
219	<i>Eleocharis palustris</i> (L.) Roem. & Schult.	Cyperaceae	AM	Herb
220	<i>Eleusine coracana</i> (L.) Gaertn.	Poaceae	AF	Herb
221	<i>Eleusine indica</i> (L.) Gaertn.	Poaceae	AS	Herb
222	<i>Elytraria acaulis</i> (L.f.) Lindau	Acanthaceae	IS	Herb
223	<i>Emilia sonchifolia</i> (L.) DC.	Asteraceae	AM	Herb
224	<i>Enteropogon dolichostachyus</i> (Lag.) Keng	Poaceae	AM	Herb
225	<i>Enydra fluctuans</i> Lour.	Asteraceae	IS	Herb
226	<i>Epilobium hirsutum</i> L.	Onagraceae	AS	Herb
227	<i>Eragrostis ciliaris</i> (L.) R.Br.	Poaceae	IS	Herb

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
228	<i>Eragrostis minor</i> Host	Poaceae	EU	Herb
229	<i>Eragrostis multiflora</i> Trin.	Poaceae	EU	Herb
230	<i>Eragrostis pilosa</i> (L.) P.Beauv.	Poaceae	AS	Herb
231	<i>Eragrostis tenella</i> (L.) P.Beauv. ex Roem. & Schult.	Poaceae	IS	Herb
232	<i>Eragrostis unioides</i> (Retz.) Nees ex Steud.	Poaceae	IS	Herb
233	<i>Erigeron bonariensis</i> L.	Asteraceae	AM	Herb
234	<i>Erigeron canadensis</i> L.	Asteraceae	AM	Herb
235	<i>Eriocaulon cinereum</i> R.Br.	Eriocaulaceae	AS	Herb
236	<i>Eschenbachia japonica</i> (Thunb.) J.Kost.	Asteraceae	AS	Herb
237	<i>Eucalyptus camaldulensis</i> Dehnh.	Myrtaceae	OA	Tree
238	<i>Eucalyptus globulus</i> Labill.	Myrtaceae	OA	Tree
239	<i>Eulaliopsis binata</i> (Retz.) C.E.Hubb.	Poaceae	IS	Herb
240	<i>Euphorbia antiquorum</i> L.	Euphorbiaceae	IS	Tree
241	<i>Euphorbia dracunculoides</i> Lam.	Euphorbiaceae	AF	Herb
242	<i>Euphorbia hirta</i> L.	Euphorbiaceae	AM	Herb
243	<i>Euphorbia prolifera</i> Buch.-Ham.	Euphorbiaceae	IS	Herb
244	<i>Euphorbia thymifolia</i> L.	Euphorbiaceae	AM	Herb
245	<i>Euploca strigosa</i> (Willd.) Diane & Hilger	Boraginaceae	IS	Herb
246	<i>Evolvulus alsinoides</i> L.	Convolvulaceae	AM	Herb
247	<i>Evolvulus nummularius</i> (L.) L.	Convolvulaceae	AM	Herb
248	<i>Fernandoa adenophylla</i> (Wall. ex G.Don) Steenis	Bignoniaceae	IS	Tree
249	<i>Ficus benghalensis</i> L.	Moraceae	IS	Tree
250	<i>Ficus palmata</i> Forssk.	Moraceae	IS	Tree
251	<i>Ficus racemosa</i> L.	Moraceae	IS	Tree
252	<i>Ficus religiosa</i> L.	Moraceae	IS	Tree
253	<i>Ficus semicordata</i> Buch.-Ham. ex Sm.	Moraceae	IS	Tree

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
254	<i>Ficus virens</i> Aiton	Moraceae	AS	Tree
255	<i>Fimbristylis bisumbellata</i> (Forssk.) Bubani	Cyperaceae	IS	Herb
256	<i>Fimbristylis dichotoma</i> (L.) Vahl	Cyperaceae	AS	Herb
257	<i>Fimbristylis quinquangularis</i> subsp. <i>quinquangularis</i>	Cyperaceae	AS	Herb
258	<i>Flacourtia indica</i> (Burm.f.) Merr.	Salicaceae	AS	Shrub
259	<i>Flueggea virosa</i> (Roxb. ex Willd.) Royle	Phyllanthaceae	AF	Shrub
260	<i>Fumaria indica</i> (Hausskn.) Pugsley	Papaveraceae	IS	Herb
261	<i>Galium aparine</i> L.	Rubiaceae	AS	Herb
262	<i>Gamochaeta pensylvanica</i> (Willd.) Cabrera	Asteraceae	AM	Herb
263	<i>Glinus lotoides</i> L.	Molluginaceae	IS	Herb
264	<i>Gloriosa superba</i> L.	Colchicaceae	AS	Herb
265	<i>Gnaphalium polycaulon</i> Pers.	Asteraceae	AM	Herb
266	<i>Gomphrena celosioides</i> Mart.	Amaranthaceae	AM	Herb
267	<i>Grangea maderaspatana</i> (L.) Poir.	Asteraceae	AM	Herb
268	<i>Grevillea robusta</i> A.Cunn. ex R.Br.	Proteaceae	OA	Tree
269	<i>Grewia asiatica</i> L.	Malvaceae	AF	Tree
270	<i>Grewia hirsuta</i> Vahl	Malvaceae	IS	Shrub
271	<i>Grewia sapida</i> Roxb. ex DC.	Malvaceae	AS	Shrub
272	<i>Grona triflora</i> (L.) H.Ohashi & K.Ohashi	Fabaceae	AS	Herb
273	<i>Guilandina bonduc</i> L.	Fabaceae	AM	Shrub
274	<i>Hackelochloa granularis</i> (L.) Kuntze	Poaceae	OA	Herb
275	<i>Helichrysum luteoalbum</i> (L.) Rchb.	Asteraceae	AM	Herb
276	<i>Helicteres isora</i> L.	Malvaceae	IS	Tree
277	<i>Heliotropium europaeum</i> L.	Boraginaceae	EU	Herb
278	<i>Heteropogon contortus</i> (L.) P.Beauv. ex Roem. & Schult.	Poaceae	IS	Herb

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
279	<i>Hibiscus cannabinus</i> L.	Malvaceae	IS	Herb
280	<i>Hibiscus lobatus</i> (Murray) Kuntze	Malvaceae	IS	Herb
281	<i>Hibiscus sabdariffa</i> L.	Malvaceae	IS	Herb
282	<i>Himalaiella heteromalla</i> (D.Don) Raab-Straube	Asteraceae	IS	Herb
283	<i>Holarrhena pubescens</i> Wall. & G.Don	Apocynaceae	IS	Tree
284	<i>Holoptelea integrifolia</i> (Roxb.) Planch.	Ulmaceae	IS	Tree
285	<i>Hydrilla verticillata</i> (L.f.) Royle	Hydrocharitaceae	AM	Herb
286	<i>Hydrocotyle sibthorpioides</i> Lam.	Araliaceae	IS	Herb
287	<i>Hydrolea zeylanica</i> (L.) Vahl	Hydroleaceae	IS	Herb
288	<i>Hygrophila auriculata</i> (Schumach.) Heine	Acanthaceae	IS	Herb
289	<i>Hygrophila polysperma</i> (Roxb.) T.Anderson	Acanthaceae	IS	Herb
290	<i>Hygroryza aristata</i> (Retz.) Nees ex Wight & Arn.	Poaceae	IS	Herb
291	<i>Hyptis suaveolens</i> (L.) Poit.	Lamiaceae	AM	Herb
292	<i>Ichnocarpus frutescens</i> (L.) W.T.Aiton	Apocynaceae	IS	Shrub
293	<i>Impatiens balsamina</i> L.	Balsaminaceae	AM	Herb
294	<i>Imperata cylindrica</i> (L.) Raeusch.	Poaceae	AM	Herb
295	<i>Indigofera hirsuta</i> L.	Fabaceae	AF	Herb
296	<i>Indigofera linifolia</i> (L.f.) Retz.	Fabaceae	AM	Herb
297	<i>Indigofera linnaei</i> Ali	Fabaceae	AF	Herb
298	<i>Ipomoea aquatica</i> Forssk.	Convolvulaceae	AS	Climber
299	<i>Ipomoea cairica</i> (L.) Sweet	Convolvulaceae	AF	Herb
300	<i>Ipomoea carnea</i> Jacq.	Convolvulaceae	AM	Shrub
301	<i>Ipomoea eriocarpa</i> R.Br.	Convolvulaceae	AF	Herb
302	<i>Ipomoea nil</i> (L.) Roth	Convolvulaceae	AM	Climber

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
303	<i>Ipomoea obscura</i> (L.) Ker Gawl.	Convolvulaceae	AF	Herb
304	<i>Ipomoea pes-tigridis</i> L.	Convolvulaceae	AF	Herb
305	<i>Ipomoea quamoclit</i> L.	Convolvulaceae	AM	Climber
306	<i>Isachne himalaica</i> Hook.f.	Poaceae	IS	Herb
307	<i>Ischaemum rugosum</i> Salisb.	Poaceae	AS	Herb
308	<i>Ixeris polycephala</i> Cass.	Asteraceae	AS	Herb
309	<i>Jacaranda mimosifolia</i> D.Don	Bignoniaceae	AM	Tree
310	<i>Jasminum arborescens</i> Roxb.	Oleaceae	IS	Shrub
311	<i>Juncus bufonius</i> L.	Juncaceae	AM	Herb
312	<i>Justicia adhatoda</i> L.	Acanthaceae	IS	Shrub
313	<i>Lablab purpureus</i> (L.) Sweet	Fabaceae	AF	Herb
314	<i>Lactuca dissecta</i> D.Don	Asteraceae	AS	Herb
315	<i>Lactuca serriola</i> L.	Asteraceae	AF	Herb
316	<i>Lagerstroemia indica</i> L.	Lythraceae	AS	Tree
317	<i>Lagerstroemia speciosa</i> Pers.	Lythraceae	IS	Tree
318	<i>Lantana camara</i> L.	Verbenaceae	AM	Shrub
319	<i>Lantana veronicifolia</i> Hayek	Verbenaceae	IS	Shrub
320	<i>Lathyrus aphaca</i> L.	Fabaceae	IS	Herb
321	<i>Lathyrus sativus</i> L.	Fabaceae	AS	Herb
322	<i>Lathyrus sphaericus</i> Retz.	Fabaceae	AS	Herb
323	<i>Lawsonia inermis</i> L.	Lythraceae	IS	Tree
324	<i>Leersia hexandra</i> Sw.	Poaceae	AM	Herb
325	<i>Lemna minor</i> L.	Araceae	EU	Herb
326	<i>Lemna perpusilla</i> Torr.	Araceae	IS	Herb
327	<i>Lemna trisulca</i> L.	Araceae	IS	Herb
328	<i>Leonotis nepetifolia</i> (L.) R.Br.	Lamiaceae	AF	Herb
329	<i>Lepidium didymum</i> L.	Brassicaceae	AM	Herb
330	<i>Leptadenia pyrotechnica</i> (Forssk.) Decne.	Apocynaceae	IS	Herb

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
331	<i>Leptadenia reticulata</i> (Retz.) Wight & Arn.	Apocynaceae	IS	Shrub
332	<i>Leptochloa chinensis</i> (L.) Nees	Poaceae	AS	Herb
333	<i>Leptochloa panicea</i> (Retz.) Ohwi	Poaceae	AS	Herb
334	<i>Leucaena leucocephala</i> (Lam.) de Wit	Fabaceae	AM	Tree
335	<i>Leucas aspera</i> Link	Lamiaceae	IS	Herb
336	<i>Limnophila indica</i> (L.) Druce	Plantaginaceae	AS	Herb
337	<i>Lindenbergia indica</i> (L.) Vatke	Orobanchaceae	IS	Herb
338	<i>Linum usitatissimum</i> L.	Linaceae	AS	Herb
339	<i>Lolium temulentum</i> L.	Poaceae	EU	Herb
340	<i>Lotus corniculatus</i> L.	Fabaceae	IS	Herb
341	<i>Louisiella paludosa</i> (Roxb.) Landge	Poaceae	OA	Shrub
342	<i>Ludwigia ascendens</i> (L.) H.Hara	Onagraceae	AM	Herb
343	<i>Ludwigia octovalvis</i> (Jacq.) P.H.Raven	Onagraceae	AF	Herb
344	<i>Ludwigia perennis</i> L.	Onagraceae	AF	Herb
345	<i>Lysiloma latisiliquum</i> (L.) Benth.	Fabaceae	AM	Shrub
346	<i>Lysimachia arvensis</i> (L.) U.Manns & Anderb.	Primulaceae	IS	Herb
347	<i>Madhuca longifolia</i> var. <i>latifolia</i> (Roxb.) A.Chev.	Sapotaceae	IS	Tree
348	<i>Maerua oblongifolia</i> A.Rich.	Capparidaceae	IS	Shrub
349	<i>Mallotus philippensis</i> (Lam.) Müll.Arg.	Euphorbiaceae	IS	Tree
350	<i>Malva parviflora</i> L.	Malvaceae	EU	Herb
351	<i>Malvastrum coromandelianum</i> (L.) Garcke	Malvaceae	AM	Shrub
352	<i>Mangifera indica</i> L.	Anacardiaceae	IS	Tree
353	<i>Manilkara hexandra</i> Dubard	Sapotaceae	IS	Tree
354	<i>Martynia annua</i> L.	Martyniaceae	AM	Herb
355	<i>Mazus pumilus</i> (Burm.f.) Steenis	Mazaceae	AS	Herb

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
356	<i>Mecardonia procumbens</i> (Mill.) Small	Plantaginaceae	AM	Herb
357	<i>Medicago lupulina</i> L.	Fabaceae	IS	Herb
358	<i>Medicago polymorpha</i> L.	Fabaceae	AS	Herb
359	<i>Medicago sativa</i> L.	Fabaceae	AS	Herb
360	<i>Megathyrsus maximus</i> (Jacq.) B.K.Simon & S.W.L. Jacobs	Poaceae	AF	Herb
361	<i>Melaleuca citrina</i> (Curtis) Dum.Cours.	Myrtaceae	OA	Shrub
362	<i>Melia azedarach</i> L.	Meliaceae	AS	Tree
363	<i>Melilotus albus</i> Medik.	Fabaceae	IS	Herb
364	<i>Melilotus indicus</i> (L.) All.	Fabaceae	IS	Herb
365	<i>Melochia corchorifolia</i> L.	Malvaceae	AM	Herb
366	<i>Merremia aegyptia</i> (L.) Urb.	Convolvulaceae	AM	Climber
367	<i>Merremia dissecta</i> Hallier f.	Convolvulaceae	AM	Herb
368	<i>Merremia hederacea</i> (Burm.f.) Hallier f.	Convolvulaceae	IS	Herb
369	<i>Millingtonia hortensis</i> L.f.	Bignoniaceae	IS	Tree
370	<i>Mimosa pudica</i> L.	Fabaceae	AM	Herb
371	<i>Mimosa rubicaulis</i> subsp. <i>himalayana</i> (Gamble) H.Ohashi	Fabaceae	IS	Herb
372	<i>Mimusops elengi</i> L.	Sapotaceae	IS	Tree
373	<i>Mirabilis jalapa</i> L.	Nyctaginaceae	AM	Herb
374	<i>Misopates orontium</i> (L.) Raf.	Plantaginaceae	EU	Herb
375	<i>Mollugo pentaphylla</i> L.	Molluginaceae	IS	Herb
376	<i>Momordica dioica</i> Roxb. ex Willd.	Cucurbitaceae	IS	Herb
377	<i>Moringa oleifera</i> Lam.	Moringaceae	IS	Tree
378	<i>Morus alba</i> L.	Moraceae	AS	Tree
379	<i>Mucuna pruriens</i> (L.) DC.	Fabaceae	AS	Climber
380	<i>Murdannia nudiflora</i> (L.) Brenan	Commelinaceae	AS	Herb
381	<i>Murraya paniculata</i> (L.) Jack	Rutaceae	IS	Shrub

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
382	<i>Musa paradisiaca</i> L.	Musaceae	OA	Herb
383	<i>Najas minor</i> All.	Hydrocharitaceae	AS	Herb
384	<i>Nasturtium officinale</i> R.Br.	Brassicaceae	EU	Herb
385	<i>Neltuma juliflora</i> (Sw.) Raf.	Fabaceae	AM	Tree
386	<i>Nelumbo nucifera</i> Gaertn.	Nelumbonaceae	AM	Climber
387	<i>Neonauclea purpurea</i> (Roxb.) Merr.	Rubiaceae	IS	Tree
388	<i>Nicotiana plumbaginifolia</i> Viv.	Solanaceae	AM	Herb
389	<i>Nyctanthes arbor-tristis</i> L.	Oleaceae	IS	Tree
390	<i>Nymphaea nouchali</i> Burm.f.	Nymphaeaceae	IS	Herb
391	<i>Nymphaea pubescens</i> Willd.	Nymphaeaceae	IS	Herb
392	<i>Nymphoides hydrophylla</i> (Lour.) Kuntze	Menyanthaceae	IS	Herb
393	<i>Ocimum americanum</i> L.	Lamiaceae	AM	Herb
394	<i>Ocimum basilicum</i> L.	Lamiaceae	AS	Herb
395	<i>Ocimum tenuiflorum</i> L.	Lamiaceae	IS	Herb
396	<i>Oenanthe javanica</i> DC.	Apiaceae	AS	Herb
397	<i>Oenothera laciniata</i> Hill	Onagraceae	AM	Herb
398	<i>Oenothera rosea</i> Aiton	Onagraceae	AM	Herb
399	<i>Oldenlandia corymbosa</i> L.	Rubiaceae	AF	Herb
400	<i>Oligochaeta divaricata</i> K.Koch	Asteraceae	AS	Herb
401	<i>Operculina turpethum</i> (L.) Silva Manso	Convolvulaceae	OA	Herb
402	<i>Oplismenus burmanni</i> (Retz.) P.Beauv.	Poaceae	AF	Herb
403	<i>Oplismenus compositus</i> (L.) P.Beauv.	Poaceae	IS	Herb
404	<i>Opuntia elatior</i> Mill.	Cactaceae	AM	Shrub
405	<i>Orthosiphon pallidus</i> Benth.	Lamiaceae	IS	Shrub
406	<i>Oryza rufipogon</i> Griff.	Poaceae	IS	Herb
407	<i>Ottelia alismoides</i> (L.) Pers.	Hydrocharitaceae	IS	Herb
408	<i>Oxalis corniculata</i> L.	Oxalidaceae	EU	Herb

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
409	<i>Oxalis dehradunensis</i> Raizada	Oxalidaceae	AM	Herb
410	<i>Parkinsonia aculeata</i> L.	Fabaceae	AM	Tree
411	<i>Parthenium hysterophorus</i> L.	Asteraceae	AM	Herb
412	<i>Paspalidium flavidum</i> A.Camus	Poaceae	AS	Herb
413	<i>Paspalum distichum</i> L.	Poaceae	AM	Herb
414	<i>Paspalum scrobiculatum</i> L.	Poaceae	IS	Herb
415	<i>Paspalum vaginatum</i> Sw.	Poaceae	AM	Herb
416	<i>Passiflora caerulea</i> L.	Passifloraceae	AM	Climber
417	<i>Pedaliium murex</i> L.	Pedaliaceae	AM	Herb
418	<i>Pergularia daemia</i> (Forssk.) Chiov.	Apocynaceae	IS	Herb
419	<i>Persicaria barbata</i> (L.) Hara	Polygalaceae	AS	Herb
420	<i>Persicaria glabra</i> (Willd.) M.Gómez	Polygonaceae	IS	Herb
421	<i>Persicaria hydropiper</i> (L.) Delarbre	Polygonaceae	EU	Herb
422	<i>Persicaria lapathifolia</i> (L.) Delarbre	Polygonaceae	AS	Herb
423	<i>Phalaris minor</i> Retz.	Poaceae	IS	Herb
424	<i>Phoenix sylvestris</i> (L.) Roxb.	Arecaceae	AS	Tree
425	<i>Phyla nodiflora</i> (L.) Greene	Verbenaceae	AM	Herb
426	<i>Phyllanthus debilis</i> J.G.Klein ex Willd.	Phyllanthaceae	IS	Herb
427	<i>Phyllanthus emblica</i> L.	Phyllanthaceae	IS	Tree
428	<i>Phyllanthus fraternus</i> G.L.Webster	Phyllanthaceae	IS	Herb
429	<i>Phyllanthus maderaspatensis</i> L.	Phyllanthaceae	IS	Herb
430	<i>Phyllanthus urinaria</i> L.	Phyllanthaceae	AS	Herb
431	<i>Physalis angulata</i> L.	Solanaceae	AM	Shrub
432	<i>Physalis lagascae</i> Roem. and Schult.	Solanaceae	AM	Herb
433	<i>Physalis minima</i> L.	Solanaceae	AM	Herb
434	<i>Pithecellobium dulce</i> (Roxb.) Benth.	Fabaceae	AM	Tree

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
435	<i>Plantago amplexicaulis</i> Cav.	Plantaginaceae	EU	Herb
436	<i>Pleurolobus gangeticus</i> (L.) J.St.-Hil. ex H.Ohashi and K.Ohashi	Fabaceae	IS	Shrub
437	<i>Plumbago zeylanica</i> L.	Plumbaginaceae	AS	Herb
438	<i>Poa annua</i> L.	Poaceae	AS	Herb
439	<i>Polyalthia longifolia</i> (Sonn.) Hook.f. and Thomson	Annonaceae	IS	Tree
440	<i>Polycarpaea corymbosa</i> (L.) Lam.	Caryophyllaceae	IS	Herb
441	<i>Polygonum plebeium</i> R.Br.	Polygonaceae	OA	Herb
442	<i>Polypogon fugax</i> Nees ex Steud.	Poaceae	AS	Herb
443	<i>Polypogon monspeliensis</i> (L.) Desf.	Poaceae	AS	Herb
444	<i>Pongamia pinnata</i> (L.) Pierre	Fabaceae	IS	Tree
445	<i>Pontederia crassipes</i> Mart.	Pontederiaceae	AM	Herb
446	<i>Pontederia hastata</i> L.	Pontederiaceae	AS	Herb
447	<i>Pontederia vaginalis</i> Burm.f.	Pontederiaceae	AS	Herb
448	<i>Portulaca oleracea</i> L.	Portulacaceae	AM	Herb
449	<i>Portulaca pilosa</i> L.	Portulacaceae	AM	Herb
450	<i>Portulaca quadrifida</i> L.	Portulacaceae	AM	Herb
451	<i>Potamogeton crispus</i> L.	Potamogetonaceae	AS	Herb
452	<i>Potamogeton nodosus</i> Poir.	Potamogetonaceae	AM	Herb
453	<i>Potentilla supina</i> L.	Rosaceae	IS	Herb
454	<i>Pouzolzia zeylanica</i> (L.) Benn.	Urticaceae	AS	Herb
455	<i>Pseudoconyza viscosa</i> (Mill.) D'Arcy	Asteraceae	IS	Herb
456	<i>Psidium guajava</i> L.	Myrtaceae	AM	Tree
457	<i>Pulicaria wightiana</i> C.B. Clarke	Asteraceae	AM	Herb

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
458	<i>Pupalia lappacea</i> (L.) Juss.	Amaranthaceae	IS	Herb
459	<i>Pyrostegia venusta</i> (Ker Gawl.) Miers	Bignoniaceae	AM	Climber
460	<i>Ranunculus sceleratus</i> L.	Ranunculaceae	AS	Herb
461	<i>Ranunculus trichophyllus</i> Chaix	Ranunculaceae	AM	Herb
462	<i>Rhynchosia capitata</i> (B.Heyne ex Roth) DC.	Fabaceae	IS	Herb
463	<i>Rhynchosia minima</i> (L.) DC.	Fabaceae	IS	Herb
464	<i>Rhynchostylis retusa</i> (L.) Blume	Orchidaceae	AS	Herb
465	<i>Ricinus communis</i> L.	Euphorbiaceae	AF	Shrub
466	<i>Rorippa indica</i> (L.) Hiern	Brassicaceae	AS	Herb
467	<i>Rostellularia quinqueangularis</i> (J.Koenig ex Roxb.) Nees	Acanthaceae	AS	Herb
468	<i>Rotala indica</i> (Willd.) Koehne	Lythraceae	AS	Herb
469	<i>Ruellia prostrata</i> Poir.	Acanthaceae	AS	Herb
470	<i>Rumex crispus</i> L.	Polygonaceae	EU	Herb
471	<i>Rumex dentatus</i> L.	Polygonaceae	AS	Herb
472	<i>Rungia pectinata</i> (L.) Nees	Acanthaceae	IS	Herb
473	<i>Rungia repens</i> (L.) Nees	Acanthaceae	IS	Herb
474	<i>Saccharum spontaneum</i> L.	Poaceae	IS	Herb
475	<i>Sagittaria sagittifolia</i> L.	Alismataceae	IS	Herb
476	<i>Saraca asoca</i> (Roxb.) J.J.de Wilde	Fabaceae	IS	Tree
477	<i>Schleichera oleosa</i> (Lour.) Oken	Sapindaceae	IS	Tree
478	<i>Schoenoplectiella mucronata</i> (L.) J.Jung and H.K.Choi	Cyperaceae	AS	Herb
479	<i>Schoenoplectus lacustris</i> (L.) Palla	Cyperaceae	EU	Herb
480	<i>Schoenoplectus litoralis</i> (Schrad.) Palla	Cyperaceae	EU	Herb

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
481	<i>Scoparia dulcis</i> L.	Plantaginaceae	AM	Herb
482	<i>Senegalia catechu</i> (L.f.) P.J.H.Hurter and Mabb.	Fabaceae	IS	Tree
483	<i>Senna alata</i> (L.) Roxb.	Fabaceae	AM	Shrub
484	<i>Senna occidentalis</i> (L.) Link	Fabaceae	AM	Herb
485	<i>Senna siamea</i> (Lam.) H.S.Irwin and Barneby	Fabaceae	AS	Tree
486	<i>Senna sophora</i> (L.) Roxb.	Fabaceae	AM	Tree
487	<i>Senna tora</i> (L.) Roxb.	Fabaceae	AM	Herb
488	<i>Sesamum indicum</i> L.	Pedaliaceae	AF	Herb
489	<i>Sesbania bispinosa</i> (Jacq.) W.Wight	Fabaceae	AM	Herb
490	<i>Sesbania sesban</i> (L.) Merr.	Fabaceae	AF	Tree
491	<i>Seseli diffusum</i> (Roxb. ex Sm.) Santapau and Wagh	Apiaceae	IS	Herb
492	<i>Setaria geminata</i> (Forssk.) Veldkamp	Poaceae	AM	Herb
493	<i>Setaria intermedia</i> Roem. & Schult.	Poaceae	IS	Herb
494	<i>Setaria palmifolia</i> (J.Koenig) Stapf	Poaceae	AM	Herb
495	<i>Setaria parviflora</i> (Poir.) Kerguelen	Poaceae	AM	Herb
496	<i>Setaria verticillata</i> (L.) P.Beauv.	Poaceae	EU	Herb
497	<i>Sida acuta</i> Burm.f.	Malvaceae	AM	Herb
498	<i>Sida cordata</i> (Burm.f.) Borss.Waalk.	Malvaceae	AM	Shrub
499	<i>Sida cordifolia</i> L.	Malvaceae	IS	Shrub
500	<i>Sida rhombifolia</i> L.	Malvaceae	AM	Herb
501	<i>Sigesbeckia orientalis</i> L.	Asteraceae	AS	Herb
502	<i>Silene conoidea</i> L.	Caryophyllaceae	AS	Herb
503	<i>Sisymbrium irio</i> L.	Brassicaceae	IS	Herb
504	<i>Solanum nigrum</i> L.	Solanaceae	AM	Herb
505	<i>Solanum virginianum</i> L.	Solanaceae	IS	Herb
506	<i>Soliva anthemifolia</i> (Juss.) Sweet	Asteraceae	OA	Herb
507	<i>Sonchus asper</i> (L.) Hill	Asteraceae	AS	Herb

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
508	<i>Sonchus oleraceus</i> L.	Asteraceae	AS	Herb
509	<i>Sonchus wightianus</i> DC.	Asteraceae	IS	Herb
510	<i>Sorghum halepense</i> (L.) Pers.	Poaceae	EU	Herb
511	<i>Sparganium erectum</i> L.	Typhaceae	AS	Herb
512	<i>Spermacoce articularis</i> L.f.	Rubiaceae	AM	Herb
513	<i>Sphaeranthus indicus</i> L.	Asteraceae	IS	Herb
514	<i>Sphenoclea zeylanica</i> Gaertn.	Sphenocleaceae	IS	Herb
515	<i>Spirodela polyrhiza</i> (L.) Schleid.	Araceae	AM	Herb
516	<i>Sporobolus diandrus</i> (Retz.) P.Beauv.	Poaceae	IS	Herb
517	<i>Stellaria media</i> (L.) Vill.	Caryophyllaceae	EU	Herb
518	<i>Streblus asper</i> Lour.	Moraceae	IS	Tree
519	<i>Striga angustifolia</i> (D.Don) C.J.Saldanha	Orobanchaceae	IS	Herb
520	<i>Stuckenia pectinata</i> (L.) Börner	Potamogetonaceae	IS	Herb
521	<i>Syzygium cumini</i> (L.) Skeels	Myrtaceae	IS	Tree
522	<i>Tamarindus indica</i> L.	Fabaceae	AF	Tree
523	<i>Tecoma stans</i> (L.) Juss. ex Kunth	Bignoniaceae	AM	Tree
524	<i>Tectona grandis</i> L.f.	Lamiaceae	IS	Tree
525	<i>Telosma cordata</i> (Burm.f.) Merr.	Apocynaceae	AS	Climber
526	<i>Tephrosia pumila</i> (Lam.) Pers.	Fabaceae	IS	Herb
527	<i>Tephrosia purpurea</i> (L.) Pers.	Fabaceae	IS	Herb
528	<i>Terminalia arjuna</i> (Roxb. ex DC.) Wight and Arn.	Combretaceae	IS	Tree
529	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	Combretaceae	IS	Tree
530	<i>Thysanolaena latifolia</i> (Roxb. ex Hornem.) Honda	Poaceae	IS	Herb
531	<i>Tinospora cordifolia</i> (Willd.) Miers ex Hook.f. and Thomson	Menispermaceae	IS	Climber

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
532	<i>Toona ciliata</i> M.Roem.	Meliaceae	OA	Tree
533	<i>Torenia crustacea</i> (L.) Cham. and Schldtl.	Linderniaceae	AS	Herb
534	<i>Trapa natans</i> L.	Lythraceae	AS	Herb
535	<i>Triadica sebifera</i> (L.) Small	Euphorbiaceae	AS	Tree
536	<i>Trianthema portulacastrum</i> L.	Aizoaceae	AM	Herb
537	<i>Trianthema triquetra</i> Willd. ex Spreng.	Aizoaceae	IS	Herb
538	<i>Tribulus terrestris</i> L.	Zygophyllaceae	AM	Herb
539	<i>Trichodesma indicum</i> (L.) Lehm.	Boraginaceae	IS	Herb
540	<i>Trichosanthes cucumerina</i> L.	Cucurbitaceae	IS	Herb
541	<i>Tridax procumbens</i> L.	Asteraceae	AM	Herb
542	<i>Trifolium resupinatum</i> L.	Fabaceae	AS	Herb
543	<i>Trifolium tomentosum</i> L.	Fabaceae	EU	Herb
544	<i>Trigonella balansae</i> Boiss. and Reut.	Fabaceae	IS	Herb
545	<i>Tripidium bengalense</i> (Retz.) H.Scholz	Poaceae	IS	Herb
546	<i>Tripidium ravennae</i> (L.) H.Scholz	Poaceae	AS	Herb
547	<i>Triticum aestivum</i> L.	Poaceae	AM	Herb
548	<i>Triumfetta rhomboidea</i> Jacq.	Malvaceae	AM	Herb
549	<i>Tropaeolum majus</i> L.	Tropaeolaceae	AM	Herb
550	<i>Uraria picta</i> (Jacq.) Desv. ex DC.	Fabaceae	IS	Herb
551	<i>Urena lobata</i> L.	Malvaceae	AM	Shrub
552	<i>Urochloa panicoides</i> P.Beauv.	Poaceae	AF	Herb
553	<i>Urochloa ramosa</i> (L.) T.Q.Nguyen	Poaceae	AF	Herb
554	<i>Urochloa reptans</i> (L.) Stapf	Poaceae	AS	Herb
555	<i>Utricularia aurea</i> Lour.	Lentibulariaceae	AS	Herb
556	<i>Vaccaria hispanica</i> (Mill.) Rauschert	Caryophyllaceae	EU	Herb
557	<i>Vachellia farnesiana</i> (L.) Wight and Arn.	Fabaceae	AM	Shrub

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
558	<i>Vachellia nilotica</i> (L.) P.J.H.Hurter & Mabb.	Fabaceae	IS	Tree
559	<i>Vallisneria spiralis</i> L.	Hydrocharitaceae	AM	Herb
560	<i>Vallisneria spiralis</i> L.	Hydrocharitaceae	AM	Herb
561	<i>Verbascum coromandelianum</i> (Vahl) Hub.-Mor.	Scrophulariaceae	IS	Herb
562	<i>Verbascum thapsus</i> L.	Scrophulariaceae	AS	Herb
563	<i>Verbena officinalis</i> L.	Verbenaceae	AM	Herb
564	<i>Verbesina encelioides</i> (Cav.) A.Gray	Asteraceae	AM	Herb
565	<i>Veronica agrestis</i> L.	Plantaginaceae	AS	Herb
566	<i>Veronica anagallis-aquatica</i> L.	Plantaginaceae	IS	Herb
567	<i>Vicia faba</i> L.	Fabaceae	EU	Herb
568	<i>Vicia hirsuta</i> (L.) Gray	Fabaceae	AS	Herb
569	<i>Vicia sativa</i> L.	Fabaceae	EU	Herb
570	<i>Vicoa indica</i> DC.	Asteraceae	IS	Herb
571	<i>Vigna aconitifolia</i> (Jacq.) Maréchal	Fabaceae	IS	Herb
572	<i>Vitex negundo</i> L.	Lamiaceae	AS	Shrub
573	<i>Vitis vinifera</i> L.	Vitaceae	AS	Climber
574	<i>Wahlenbergia marginata</i> (Thunb.) A.DC.	Campanulaceae	AS	Herb
575	<i>Waltheria indica</i> L.	Malvaceae	AM	Shrub
576	<i>Withania somnifera</i> (L.) Dunal	Solanaceae	IS	Shrub
577	<i>Wolffia arrhiza</i> (L.) Horkel ex Wimm.	Araceae	EU	Herb
578	<i>Wolffia microscopica</i> (Griff.) Kurz	Araceae	IS	Herb
579	<i>Xanthium strumarium</i> subsp. <i>Strumarium</i>	Asteraceae	EU	Herb
580	<i>Youngia japonica</i> (L.) DC.	Asteraceae	AM	Herb
581	<i>Zaleya decandra</i> (L.) Burm.f.	Aizoaceae	AM	Herb
582	<i>Zannichellia palustris</i> L.	Potamogetonaceae	AM	Herb

Table 1. Continued.

Sl. No.	Species	Family	Biogeographic origin	Habit
583	<i>Zea mays</i> L.	Poaceae	AM	Herb
584	<i>Zehneria scabra</i> Sond.	Cucurbitaceae	AM	Climber
585	<i>Zephyranthes minuta</i> (Kunth) D.Dietr.	Amaryllidaceae	AM	Herb
586	<i>Zeuxine strateumatica</i> (L.) Schltr.	Orchidaceae	AS	Herb
587	<i>Zingiber officinale</i> Roscoe	Zingiberaceae	IS	Herb
588	<i>Ziziphus mauritiana</i> Lam.	Rhamnaceae	IS	Tree
589	<i>Ziziphus nummularia</i> (Burm.f.) Wight and Arn.	Rhamnaceae	IS	Shrub
590	<i>Ziziphus oenopolia</i> (L.) Mill.	Rhamnaceae	IS	Shrub
591	<i>Zygodphyllum indicum</i> (Burm.f.) Christenh. and Byng	Zygodphyllaceae	IS	Herb

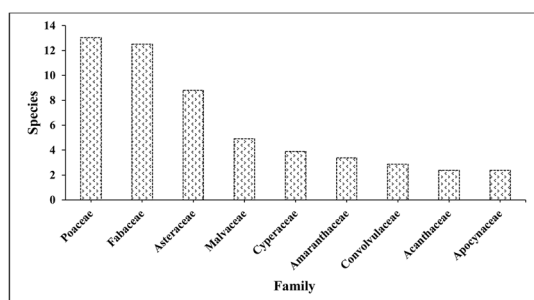


Fig. 1. Dominant angiospermic families (>2 species) of the plant species in Hastinapur Wildlife Sanctuary.

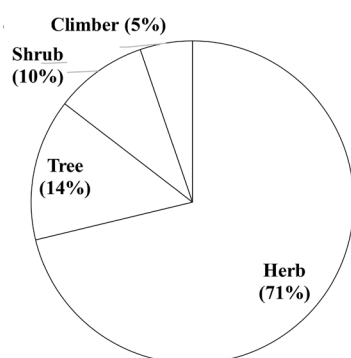


Fig. 2. Habit-wise distribution of the flora of Hastinapur Wildlife Sanctuary.

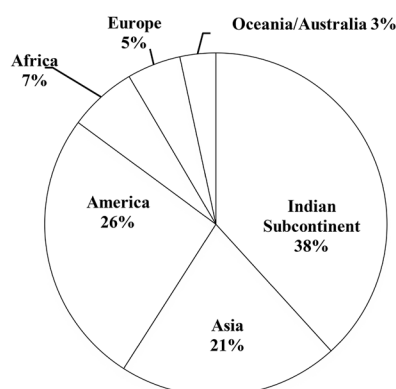


Fig. 3. Contribution of different geographical regions to the flora of Hastinapur Wildlife Sanctuary.

dominant families included Poaceae, Fabaceae and Asteraceae, Malvaceae and Cyperaceae comprising 43.14% of total flora recorded (Fig. 1). Herbs were largest in number (71%), followed by trees (14%), shrubs (10%) and climbers (5%) (Fig. 2). Plant species of Indian-sub continent were highest in number (38%), followed by American continents (North and South combined) (26%), Asian (21%), Africa (7%), Europe (5%) and Oceania/Australia (3%) (Fig. 3).

DISCUSSION

The study revealed a very considerable scale (62%) of intrusion by the alien flora in the Hastinapur Wildlife sanctuary. of these, the American floristic elements (26%) were predominant, closely followed by the flora of Asian bio-geographic origin (21%). This could be attributed to a high scale of urbanization of the five districts that impacted floristic composition of HWLS, transfer of propagules from the anthropic areas in vicinity ostensibly due to increasing transportation, trade and other development-related activities. In fact, accelerated invasion by alien plants the world over has been suggested due to globalization in trade, transport and tourism (van Kleunen *et al.* (2019). In the last three decades, India has reportedly been a witness to rapid economic development and enhanced international trade that could be attributed to the facilitation of establishment and spread of alien flora (Khuroo *et al.* 2012 and Inderjit *et al.* 2018) into the sanctuary as well. Agrawal and Narayan (2017) reported intrusion of 89% alien plant species in a dry

tropical region of Bulandshahr in the national capital region of Delhi in India of these exotics, they reported preponderance of American floristic elements to the scale of 31% (combined North and South America). In contrast, it was only 26% flora of American origin in this study. However, the investigated area of HWLS also lying in the vicinity of rapidly developing areas in the state of Uttar Pradesh, recorded relatively a higher number of indigenous plant species (38%) compared to only 11% native species reported by Agrawal and Narayan (2017). This could be on account of the protected nature of the investigated sanctuary, albeit under immense anthropic pressure.

Alien flora have often been reported to outcompete the indigenous species in open areas created for fresh agricultural activities or for developmental purposes. The herbaceous species, especially grass flora, may be considered ecological opportunists to occupy such open areas with higher scale of success. This is evinced by >70% agricultural areas in this sanctuary and >70% flora being herbaceous, as recorded in the present study. This is corroborated by the largest floristic representations in Poaceae. The second largest family of Fabaceae reflected the adaptational significance of leguminous species in dry tropics (Gupta and Narayan 2006, 2010). The third largest family Astraceae recorded in this study is indicative of growing preponderance of weedy floristic elements. Khuroo *et al.* (2021) in their annotated inventory of alien flora of India reported Asteraceae (27) and Fabaceae (20) as the top most dominant families, together accounting for 32.4% of the total 145 Indian invasive flora reported by them.

Some of the alien flora have turned aggressive invaders especially *Parthenium hysterophorus* spreading successfully across all parts of the country, reflective of its high ecological amplitude. Another prominent invasive weed *Lantana camara*, a perennial weed has fast spread into forested regions of Dehradun at foothills in India. Many alien species e.g. *Chenopodium murale*, are rapidly turning invasive in Indian dry tyropical ecosystems (Gupta and Narayan 2012). Their expansion has been reported on account of their higher phenotypic plasticity across varying resource states of soils that facilitated their colonizability in new areas.

In light of the global acknowledgement of the impact of alien flora having deterministic impact on the organization of plant communities, especially in Indian dry tropics (Agrawal and Narayan 2017) and reducing biodiversity and productivity of natural ecosystems, through different mechanisms, including phenotypic plasticity and allelopathic impact, the increasing advancement of alien flora in HWLS calls for their active management measures. For the development of a suitable management strategy, it is necessary that ecology and genetic make-up of the concerned alien species (Wittenberg and Cock 2001, Lee 2002), especially those spreading fast and colonizing new areas, need to be analyzed at priority.

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