Tracking the Invasion Pathway: Assesment of α-Diversity and Invasiveness of Alien Ornamental Plants of Srinagar(Kashmir, J&K), India

Shabana Aslam[1], *Khursheed Ahmad Ganaie[2], AQ John[3] and GH Dar[1]

1. Department of Botany, University of Kashmir, Srinagar, J& K, India190006
2. Department of Botany, Islamia college of Science and Commerce, Srinagar, J& K, India 190006
3. Division of Floriculture, Medicinal and Aromatic plants, SKUAST- Kashmir, J& K, India 191121

Shabana_botany@yahoo.com; khursheedtrali@yahoo.co.in

Abstract: The valley of Kashmir is famous for its marvellous landscape which attracts tourists from all along the globe. The landscaping of this heavenly abode predominantly involves alien ornamental plants. The present study puts on record the alien ornamental flora of Srinagar Kashmir, and thus, is a first compilation of alien ornamental flora of the region. The study enlists the occurrence of 271 exotic ornamental species distributed in 187 genera, belonging to 85 families, therefore piling up the total number of alien plant species in the Kashmir Himalayas to 704. The taxonomic composition analysis of alien ornamental flora of the region revealed that dicots are represented by 223 species (82%) belonging to 151 genera and 65 families while as monocots comprised of 39 species (15%) dispersed in 28 genera and 13 families. Gymnosperms are represented by 9 species (3%), 8 genera and 7 families. Asteraceae (11.07%), Rosaceae (9.59%), Oleaceae (4.79%) are the largest families of exotic ornamental plants introduced into the Kashmir Himalayas. Out of 85 families, 42 are represented by a single genus and single species. The highest number of alien ornamental species have come from the continent Asia (31%) followed by Europe (30%) and North America (20%). The study reports the occurrence of 133 alien ornamental species for the first time from Kashmir Himalayas. Our analysis of alien species establishment and invasion is not in consonance with Williamson's tens rule and proposes that human assisted species selection, introduction and establishment change the entire dimensions of tens rule to maximum values in invasion biology. [Nature and Science 2010;8(3):79-95]. (ISSN: 1545-0740).

Key words: Exotic, alien, ornamental flora, Kashmir, Himalayas, New records

1. Introduction

Nature gave birth to life on the floor of planet Earth and then life diversified into a large number of living forms or species on the back of a long temporal continuum. The heterogeneous spatial scale of Earth fueled this diversification with high degree of rigidity, evolving an estimated millions of number of species. The continental drift stemmed isolated continents in which species evolved to the dictation of their unique physical (abiotic)-biotic environments. This resulted in specific continental biotas, stabilizing particular continental ecosystems. In addition, the continents offered huge dispersal or bio-geographical barriers limiting intercontinental species dispersal and thus lending rigidity and uniqueness to the continental biotas and evolutionary processes. This is the geological pattern of biogeography of species and communities entrenched in millions of years. The diversity of a particular continent is uniquely organized on the trophic shelf with unique species-species interaction, across trophic level energy flow and nutrient cycling. This functional or ecological organization and niche specialization of component species lend life and stability to the particular ecosystems. This is Nature's way of running and controlling life, life processes, ecosystem and ecosystem sustaining services. Any disturbance which alters this functional organization strikes at the heart of ecosystem, impairing ecosystem functioning, ecosystem stability and survival.

According to Pysek et al 2002, alien species also called exotic, introduced, non-native species are defined as plant species in a given area outside the native distributional range, whose presence is due to intentional or unintentional human involvement. The industrial development and globalization bridged huge distances between continents and countries with modern means of transportation (Jenkin 1996). This high order mobility of human beings served as a dispersing force for living species—plants, animals, insects, bacteria, viruses and other organisms nullifying and overcoming the usual bio-geographical or dispersal barriers which isolated them over millions of years (Jenkin 1996, Davis 2003). Globalization of trade, with enhanced transport, resulted in amplified intercontinental translocation of species (accidental as well as deliberate), causing homogenization or globalization of floras (Mckinney and Lockwood 1999, Drake *et al.* 1989, Olden 2006). This has greatly altered the composition of biodiversity in different ecosystems (Vitousek *et al.* 1996; Mack *et al.* 2000).

The anthropogenic facilitated dispersal exposes species to new environments. All the introduced species do not survive in the new environment (Carey 1996, Lewis and Kareiva 1993) and the niche availability proves decisive. Some species find the new environmental complex suitable for their growth and reproduction and thus get established (Williamson 1996) with 33% maximum values of establishment in case of intentional and careful introduction (Williamson and Fitter 1996). Without direct human intervention, some of these non-native species are capable of independent growth, and sustain self-replacing populations. Such plants are categorized as 'Naturalized'. According to Williamson's ten rule, 10% of these naturalized exotic species turn invasive which means that they produce reproductive offspring often in large numbers and have the potential to spread to large areas (Williamson 1996, Pysek *et al.* 2004).This group of alien species-Invasive alien species is the nuisance group with tremendous negative ecological and biological implications. In the new introduced habitat the alien species enjoy competitive advantage in the utilization of resources and release from their native range enemies- stiff competitors, pathogens, parasites, predators or herbivores and many more others (Nunez et al 2008, Theubad and Simberloff 2001; Hierro et al 2004). This advantage coupled to high fecundity and high clutch size synergistically enhances the proliferation of these alien invasive species (Bazazz 1986) which then speedily change the contours of community composition and ecosystem function (Simon and Townsend 2003, Gibbs and Wainhouse 1986, Oak 1989). This high order reproduction and proliferation of alien invasive species leave the native species in an ecologically suffocating environment with impaired growth and reproduction (Gentle and Druggin 1997, Parker et al 1999). In case of animal invasive species, this population explosion in the introduced environment explodes on their prey populations be it plant or animal causing their shrinkage and sublimation to extinction. Thus invasive species are notoriously known for extinction of species and erosion of biodiversity (Vitousek et al 1996; Olden 2006). Globally invasive species are ranked as second worst cause of species extinction and biodiversity loss (Wilcove et al. 1998, Stein et al. 2008, Richardson et al. 1989). This threat drove ecologists and biologists to seriously study all aspects of alien species biology so that the biodiversity and ecosystems services are protected from their ill effects (Allandorf and Lundquist 2003). In Kashmir Himalayas the exotic ornamental plants are deliberately introduced for varied landscaping purposes (Shabana 2009). The present study was undertaken with a view to assess the species and taxonomic diversity of these exotic ornamentals, tracing their origin or nativity, studying their rate of establishment and invasiveness since no such specific study has been undertaken till date from this region.

2. Materials and methods

2.1. Study Area

Situated in the North western extremity of India, the Jammu and Kashmir State is depicting a bewildering variety in its topography, culture, tradition, people and natural splendour. The State is bordered by Pakistan, Afghanistan and China from west to east; from south to east, the boundary of the State touches Punjab and Himachal Pradesh.

The Kashmir Valley or the Vale of Kashmir, the central part of the Jammu and Kashmir State, is a beautiful valley enclosed in a magnificent amphitheatre of mountain ranges, the Great Himalayas and the Pir Panjal. It extends between the latitudes 32°17′N to 36°58′N and longitudes 37°26′E to 80°30′E, with an average altitude of about 1650 m from the mean sea level, and an annual precipitation of about 794.7 mm. Traversed throughout by the river, the Valley is about 187 km long and 116 km wide, formed by Jhelum River (Fig. 1).

2.2. Floristic study

The ornamental flora of district Srinagar (Kashmir India) was scanned for exotic species. The specimens were collected and then identified upto the level of species and variety. Only alien species were included in the list. A species was listed as alien or exotic following Pysek et al (2002) which envisages that there is no evidence that it has any area in the subcontinent (India) where it is native. Following Pysek et al (2002), the nativity of the species was recognised at the continental level viz Asia (barring the subcontinent India), Africa, Australia, North America, South America, and Europe. The species which have been raised through hybridisation by various gardeners and nursery men have been listed as species of Garden Origin. Previous floristic reports of the occurrence of a species from the region are given and those taxa not collected and characterised till date were ranked as first reports from the region. The voucher specimen of all collected and characterised species have been deposited in KASH-Kashmir University Herbarium. The assessment of alien species establishment was carried out using all previous records of all nurseries and our own observations of a decade.

2.3. Terminology used

Introduction means importing exotic species into the region, establishment means successful survival of this species while as naturalization means ability to form self sustaining populations.

3. Results

The exotic ornamental flora of central Kashmir is represented by a total of 271 species belonging to 187 genera and 85 families. The taxonomic composition analysis of alien ornamental flora revealed that dicots are represented by 223 species (82%) belonging to 151 genera and 65 families while as monocots comprised of 39 species (15%) dispersed in 28 genera and 13 families. Gymnosperms in the region are represented by 9 species (3%), 8 genera and 7 families. Of the 85 families within which the 271 species of alien ornamental plants are distributed, 10 families account for 46.86 % (127 species) of the total alien ornamental flora. The families are, Asteraceae (11.07%), Rosaceae (9.59%), Oleaceae (4.79%), Papilionaceae (3.69%), Salicaceae (3.69%), Amaryllidaceae (3.32%), Caryophylaceae (3.32%), Liliaceae (3.32%), Amaranthaceae (2.58%), Brassicaceae (2.21%). Among 85 families, 42 families are represented by one genus with one species each. Out of these, 30 families belong to dicots, six to monocots, and six to gymnosperms. These families include Alstroemeriaceae, Araceae, Araucariaceae, Arecaceae, Balsaminaceae, Begoniaceae, Buddlejaceae, Buxaceae, Caesalpeniaceae Campanulaceae, Cannabaceae, Cannaceae, Capparidaceae, Convolvulaceae, Cornaceae, Cycadaceae, Ericaceae, Euphorbiaceae, Ginkgoaceae, Hydrophyllaceae, Juglandaceae, Lythraceae, Meliaceae, Mimosaceae, Myrtaceae, Passifloraceae, Phormiaceae, Pinaceae, Platanaceae, Poaceae, Portulaceae, Punicaceae, Rutaceae, Sapindaceae, Simaroubaceae, Tamaricaceae, Taxaceae, Taxodiaceae, Theaceae, Tropaeolaceae, Ulmaceae and Verbenaceae.

Habit analysis of the alien ornamental flora of campus revealed that herbs (134) predominated shrubs (75) and trees (62) in number. Herbaceous perennials account for 27.30% of total alien flora followed by herbaceous annuals which contribute 22.14%. The species belong to different life forms as classified below:

Table 1. **Deciduous Trees**

Species	**Family**	**Origin**	**Flowering period**	**Voucher specimen number (by Shabana & Dar)**	**Primary Published source**
Acer negundo,L.	Aceraceae	NAM	Apr-May	003	Ara et al. (1995)
Acer palmatum,Thunb. var Atropurpureum	Aceraceae	AS	Apr	004	**FR**
Ailanthus altissima,Swingle	Simaroubaceae	AS	Jun	111	Ara et al. (1995)
Albizia julibrissin, Durazz var. Rosea	Mimosaceae	AS	Jun-Jul	001	Ara et al. (1995)
Castanea sativa,Mill.	Fagaceae	EU;AS;AF	Jun-Jul	041	Dar et al. (2002)
Catalpa bignonioides, Scop.	Bignoniaceae	NAM	May-Jun	175	Ara et al. (1995)
Celtis australis,L.	Ulmaceae	EU;AS	Mar-May	009	Ara et al. (1995)
Cercis siliquastrum,L.	Papilionaceae	EU;AS	Apr-May	151	Singh & Misri (1974)
Crataegus laevigata	Rosaceae	EU;AS;AF	Apr-May	005	**FR**
Cydonia oblonga, Mill.	Rosaceae	AS	Apr	073	Dar et al. (2002)
Ficus carica,L.	Moraceae	EU	May-Jul	211	Dar et al. (2002)
Fraxinus excelsior,L.	Oleaceae	EU;AS	Apr	002	Stewart (1972)
Fraxinus americana,L.	Oleaceae	NAM	Apr	186	**FR**
Ginkgo biloba, L.	Ginkgoaceae	AS	Apr	150	Javeid (1964)
Gleditsia tricanthos,L.	Caesalpiniaceae	NAM	May-Jun	121	**FR**
Juglans regia,L.	Juglandaceae	AS	Mar-Apr	248	Ara et al. (1995)

Koelreuteria paniculata,Laxm.	Sapindaceae	AS	Jul	006	Singh & Misri (1974)
Laburnum anagyroides, Medic.	Papilionaceae	EU	Apr	123	Ara et al. (1995)
Lagerstroemia indica,L.	Lythraceae	AS	Jul-Aug	011	Ara et al. (1995)
Magnolia kobus, DC.	Magnoliaceae	AS	Apr-May	033	Ara et al. (1995)
Magnolia liliflora, Desr.	Magnoliaceae	AS	Apr-May	063	Ara et al. (1995)
Magnolia x *soulangiana*,Soul.	Magnoliaceae	GO	Apr-May	100	**FR**
Malus domestica, Borkh.	Rosaceae	EU;AS	Apr	176	Dar et al.
Melia azedarach, L.	Meliaceae	AS	May	152	Ara et al. (1995)
Morus alba, L.	Moraceae	AS	Apr	200	Dar et al. (2002)
Morus nigra, L.	Moraceae	AS	Apr	007	Dar et al. (2002)
Platanus orientalis,L.	Platanaceae	EU;AS	Apr	162	Stewart (1972)
Populus alba,L.	Salicaceae	EU;AS;AF	Mar-Apr	024	Javeid (1972)
Populus balsamifera,	Salicaceae	NAM	Mar-Apr	026	Stewart (1972)
Populus deltoides, Marsh	Salicaceae	NAM	Mar-Apr	025	Ara et al. (1995)
Populus nigra,L.	Salicaceae	EU;AS;AF	Mar-Apr	031	Ara et al. (1995)
Prunus amygdalus, Batsch.	Rosaceae	AS;AF	Mar	101	Dar et al. (2002)
Prunus armeniaca,L.	Rosaceae	AS	Mar	122	Dar et al. (2002)
Prunus avium,L.	Rosaceae	EU;AS;AF	Mar	225	Dar et al. (2002)
Prunus cerasus,L.	Rosaceae	EU;AS	Apr	112	Dar et al. (2002)
Prunus cerasifera,Ehrh.	Rosaceae	EU;AS	Apr	042	Stewart (1972)
Prunus cerasifera var issardi	Rosaceae	EU;AS	Apr	074	**FR**
Prunus cerasifera var Rosea	Rosaceae	EU;AS	Apr	043	**FR**
Prunus persica,Batsch.	Rosaceae	AS	Apr	102	Dar et al. (2002)
Punica granatum,L.	Punicaceae	EU	May-Aug		
Pyrus communis,L.	Rosaceae	EU;AS	Apr	032	Dar et al. (2002)
Pyrus pashia, Ham.ex DC.	Rosaceae	AS	Apr	008	Ara et al. (1995)
Quercus robur,L.	Fagaceae	EU	Apr	023	Singh & Kachroo (1976)
Robinia pseudoacacia,L.	Papilionaceae	NAM	May	124	Stewart (1972)
Salix alba,L.	Salicaceae	EU;ASAF	Mar-Apr	013	Javeid (1972)
Salix aegyptica,	Salicaceae	EU;AS	Mar-Apr	015	Ara et al. (1995)
Salix bablyonica,L.	Salicaceae	AS	Mar-Apr	018	Javeid (1972)
Salix caprea,L.	Salicaceae	EU;AS	Feb-Mar	017	**FR**
Salix fragilis,L.	Salicaceae	EU	Mar-Apr	019	Ara et al. (1995)
Salix matsudana,Koidz. var	Salicaceae	AS	Apr	014	**FR**

Tortuosa, Hort.					
Sophora japonica,L.	Papilionaceae	AS	Aug	016	Stewart (1972)
Sophora japonica,L. var Pendula	Papilionaceae	AS	Aug	113	**FR**
Tamarix parviflora,,DC.	Tamaricaceae	EU	Apr	010	Singh & Misri (1974)

Table 2. **Evergreen Trees**

Species	**Family**	**Origin**	**Flowering period**	**Voucher specimen number (by Shabana & Dar)**	**Primary Published source**
Cupressus macrocarpa, Hartw. var *Cashmeriana*	Cupressaceae	NAM	Feb-Apr	034	**FR**
Cupressus sempervirens, L.	Cupressaceae	EU;AS	Feb-Apr	021	Ara et al. (1995)
Cryptomeria japonica D.Don	Taxodiaceae	AS	Feb-Mar	161	Dar et al. (2002)
Eriobotrya japonica, Lindl.	Rosaceae	AS	Oct-Dec	027	Dar et al. (2002)
Magnolia grandiflora, L	Magnoliaceae	NAM	Jun-Jul	022	Ara et al. (1995)
Olea europaea,L.	Oleaceae	EU	-	259	Stewart (1972)
Pinus halepensis,Mill.	Pinaceae	EU;AS	Jul-Aug	118	Ara et al. (1995)
Taxus baccatta, L.	Taxaceae	EU;AF; NAM	Sept-Oct	177	Dar (2004)
Thuja orientalis,L.	Cupressaceae	AS	Feb-Apr	020	Ara et al. (1995)

Table 3. **Deciduous Shrubs**

Species	**Family**	**Origin**	**Flowering period**	**Voucher specimen number (by Shabana & Dar)**	**Primary Published source**
Hydrangea arborescens,L.	Hydrangeaceae	NAM	Jun-Jul	115	**FR**
Hydrangea macrophylla, Ser.	Hydrangeaceae	AS	Jun-Jul	226	**FR**
Jasminum nudiflorum, Lindl.	Oleaceae	AS	Mar-Apr	029	**FR**
Kerria japonica, DC.	Rosaceae	AS	Apr	215	Ara et al. (1995)
Paeonia suffruticosa, Andr.	Paeoniaceae	AS	Apr-May	160	Ara et al. (1995)
Philadelphus coronarius, L.	Philadelphaceae	EU	May-Jun	213	**FR**
Abutilon x hybridum, Voss.	Malvaceae	GO	May-Jun	133	**FR**
Philadelphus incanus, Koehne.	Philadelphaceae	NAM	May-Jun	136	Ara et al. (1995)
Azalea hybrids	Ericaceae	GO	May	260	**FR**
Amorpha fruticosa, L.	Papilionaceae	NAM	May-Jun	028	Ara et al. (1995)
Rosa x damascena; Mill.	Rosaceae	GO	May	224	Ara et al. (1995)
Berberis thunbergii, DC.	Berberidaceae	AS	Apr	258	**FR**
Rosa cultivars	Rosaceae	GO	May	061	**FR**
Buddleja davidii,Franch.	Buddlejaceae	AS	Jun-Aug	056	Ara et al. (1995)
Sambucus nigra,L.	Caprifoliaceae	EU;AS	May-Jun	235	Ara et al. (1995)
Chaenomeles lagenaria, Koidz.	Rosaceae	AS	Mar-Apr	039	Ara et al. (1995)
Solanum capsicastrum,Link.	Solanaceae	SAM	May	125	**FR**
Spartium junceum,L.	Papilionaceae	EU;AF	May-Jun	040	Ara et al. (1995)
Forsythia x intermedia, Zabel	Oleaceae	GO	Mar-Apr	075	**FR**
Fuschia hybrida, Voss.	Onagraceae	GO	Apr-Jun	264	**FR**
Spiraea japonica,L.	Rosaceae	AS	Jun	178	**FR**
Hibiscus syriacus, L.	Malvaceae	AS	Jun-Aug	201	Ara et al. (1995)
Spiraea prunifolia, Sieb. &	Rosaceae	AS	Apr-May	230	Ara et al. (1995)

Zucc.					(1995)
Spiraea x *Vanhouttei*,Zabel.	Rosaceae	GO	Apr-May	057	**FR**
Syringa x *laciniata*,Mill.	Oleaceae	GO	Apr	088	Ara et al. (1995)
Syringa persica,L.	Oleaceae	GO	Apr	249	Ara et al. (1995)
Syringa vulgaris,L.	Oleaceae	EU	Apr	174	Ara et al. (1995)
Viburnum opulus,L. var. Roseum	Caprifoliaceae	EU;AS; AF	Apr-May	212	Ara et al. (1995)
Weigela florida,DC.	Caprifoliaceae	AS	Apr-May	030	Ara et al. (1995)

Table 4. **Evergreen Shrubs**

Species	**Family**	**Origin**	**Flowering period**	**Voucher specimen number (by Shabana & Dar)**	**Primary Published source**
Abelia x *grandiflora*, Rehd.	Caprifoliaceae	GO	Jun	247	**FR**
Aucuba japonica var Variegata	Cornaceae	AS	May	185	**FR**
Araucaria heterophylla, (Salisb.) Franco.	Araucariaceae	SAM;AUS	-	262	**FR**
Buxus sempervirens, Hook.	Buxaceae	EU;AS;AF	Mar-Apr	099	Ara et al. (1995)
Camelia japonica,L.	Theaceae	AS	Mar-Apr	202	**FR**
Chamaerops humilis,L.	Arecaceae	EU	-	103	**FR**
Citrus sinenesis,Osbeck	Rutaceae	AS	May-Jun	272	Stewart **(**1972**)**
Cycas revoluta,Thunb.	Cycadaceae	AS	-	261	**FR**
Euonymous japonicus, Thunb.	Celastraceae	AS	Jun-Jul	035	Ara et al. (1995)
Fatsia japonica,Decne.	Araliaceae	AS	Oct-Nov	117	Ara et al. (1995)
Ligustrum japonicum, Thunb.	Oleaceae	AS	Jun-Jul	054	**FR**
Ligustrum lucidum,Ait.	Oleaceae	AS	Jun-Jul	037	Ara et al.(1995)
Ligustrum ovalifolium, Hassk.	Oleaceae	AS	Jun	179	Ara et al. (1995)
Ligustrum vulgare,L.	Oleaceae	EU;AS; AF	Jun	060	Ara et al. (1995)
Mahonia aquifolium,Nutt.	Berberidaceae	NAM	Mar-Apr	227	**FR**
Myrtus communis,L.	Myrtaceae	EU	Jul-Sept	012	**FR**
Nerium indicum,Mill.	Apocynaceae	EU	Jun-Jul	153	Ara et al. (1995)
Schefflera actinophylla,	Araliaceae	AUS		214	**FR**
Yucca aliofolia, L.	Agavaceae	NAM	Jun-Jul	071	Ara et al. (1995)
Yucca gloriosa,L.	Agavaceae	NAM	May-Sept	036	**FR**

Table 5. **Deciduous Woody Vines**

Species	Family	Origin	Flowering period	Voucher specimen number (by Shabana & Dar)	Primary Published source
Campsis grandiflora,Loisel.	Bignoniaceae	AS	Jun-Aug	116	Ara et al. (1995)
Campsis radicans,Seem.	Bignoniaceae	NAM	Jun-Aug	045	Ara et al. (1995)
Celastrus paniculatus, Willd.	Celastraceae	AUS;NAM	May	180	**FR**
Parthenocissus quinquefolia, Planch.	Vitaceae	NAM	May-Jun	062	Ara et al. (1995)
Parthenocissus tricuspidata, Planch.	Vitaceae	AS	Jun-Jul	204	Ara et al. (1995)
Rosa banksiae, R.Br	Rosaceae	AS	May	087	Ara et al. (1995)
Rosa multiflora,Thunb.	Rosaceae	AS	May	110	
Vitis vinifera,L.	Vitaceae	EU;AS	May	159	Stewart (1972)
Wisteria sinensis,Sims.	Papilionaceae	AS	Apr-May	218	Ara et al. (1995)
Wisteria sinensis,Sims. var Alba, Bailey	Papilionaceae	AS	Apr-May	038	Ara et al. (1995)

Table 6. **Evergreen Woody Vines**

Species	Family	Origin	Flowering period	Voucher specimen number (by Shabana & Dar)	Primary Published source
Hedera canariensis,Willd.	Araliaceae	EU	Sept-Oct	104	**FR**
Hedera helix,L.	Araliaceae	EU	Sept-Oct	098	Stewart (1972)
Hedera helix,L. var 'hibernica',Jaeg.	Araliaceae	EU	Sept-Oct	149	**FR**
Lonicera japonica,Thunb.	Caprifoliaceae	AS	May-Jun	044	Ara et al. (1995)
Lonicera nitida,Wils.	Caprifoliaceae	AS	Apr	126	**FR**
Passiflora caerulea,L.	Passifloraceae	SAM	Jun-Jul	058	**FR**

Table 7. Ground Covers (Deciduous Shrubs)

Species	Family	Origin	Flowering period	Voucher specimen number (by Shabana & Dar)	Primary Published source
*Rosa rugosa,*Thunb.	Rosaceae	EU;AS	May-Jul	119	**FR**
Rosa foetida,Herm.	Rosaceae	AS	May-Jul	092	Ara et al. (1995)

Table 8. Ground covers (Evergreen Shrubs)

Species	Family	Origin	Flowering period	Voucher specimen number (by Shabana & Dar)	Primary Published source
Agave americana,L.	Agavaceae	NAM		047	**FR**
Lavandula angustifolia	Lamiaceae	EU	Jun-Jul	072	**FR**
Phormium tenax,Forst.	Phormiaceae	AUS		065	**FR**
Rosmarinus officinalis,L.	Lamiaceae	EU	Mar-Apr	109	Khuroo et al. (2007)
Ruscus aculeatus,L.	Ruscaceae	EU;AF	Mar-Apr	085	**FR**
Ruscus hypoglossum,L.	Ruscaceae	EU	Mar-Apr	086	**FR**
Santolina chamaecyparissus,L.	Asteraceae	EU	Jun-Jul	127	**FR**
Vinca major,L.	Apocynaceae	EU	Apr-Jun	046	Reshi (1984)
Vinca major,L. var 'variegata', Loud	Apocynaceae	EU	Apr-Jun	273	**FR**

Table 9. **Bulbous Perennials**

Species	Family	Origin	Flowering period	Voucher specimen number (by Shabana & Dar)	Primary Published source
Alstroemeria ligtu, L	Alstroemeriaceae	NAM	Apr-Oct	246	**FR**
Amaryllis belladonna,L.	Amaryllidaceae	AF	Aug-Sept	097	**FR**
Anemone coronaria,L.	Ranunculaceae	EU	Mar-Apr	136	**FR**
Asparagus officinalis,L.	Liliaceae	EU;AS; AF	May	187	Kaul (1963)
Canna indica,L. and cultivars	Cannaceae	NAM	Jul-Sept	051	**FR**
Crinum x *powellii*, Hort. ex Baker	Amaryllidaceae	GO	May-Jun	158	**FR**
Crocus sativus,L.	Iridaceae	AS	Oct-Nov	181	Dar et al. (2002)
Cyclamen persicum, Mill.	Primulaceae	EU;AF	Aug-Nov	120	**FR**
Dahlia sp.	Asteraceae	NAM	Jul-Aug	216	-
Gladiolus cultivars	Iridaceae	GO	Jul-Sept	155	-
Helleborus hybridus,	Ranunculaceae	EU	Feb-Mar	173	**FR**

Hemerocallis fulva,L.	Liliaceae	EU	Jun-Jul	210	Stewart (1972)
Hippeastrum sp.	Amaryllidaceae	NAM	Jul-Sept	228	**FR**
Hosta plantaginea,Asch.	Liliaceae	AS	Jul-Sept	091	**FR**
Hosta ventricosa,Stearn.	Liliaceae	AS	Jul-Sept	223	**FR**
Hyacinthus orientalis,L.	Hyacinthaceae	EU;AS	Mar-Apr	203	Stewart (1972)
Iris ensata,Thunb.	Iridaceae	AS	Apr-May	084	Reshi (1984)
Iris germanica,L.	Iridaceae	EU	Apr-May	215	Kaul (1986)
Iris reticulata, M.Beib.	Iridaceae	EU	Mar	105	Stewart (1972)
Kniphofia uvaria,Hook.	Liliaceae	AF	Jun-Oct	154	**FR**
Lilium regale,Wils.	Liliaceae	AS	Jun-Jul	143	**FR**
Lilium auratum, Lindl.	Liliaceae	AS	Jun-Jul	270	**FR**
Muscari botryoides,Mill.	Hyacinthaceae	EU	Mar-Apr	209	**FR**
Narcissus poeticus,L	Amaryllidaceae	EU	Mar-Apr	066	**FR**
Narcissus pseudonarcissus,L.	Amaryllidaceae	EU	Mar-May	243	Stewart (1972)
Narcissus tazetta,L.	Amaryllidaceae	EU	Feb-Mar	135	Stewart (1972)
Narcissus cultivars	Amaryllidaceae	GO	Feb-May	229	-
Nerine x bowdenii,Wats.	Amaryllidaceae	AF	Sept	108	**FR**
Ornithogallum umbellatum,L.	Liliaceae	EU;AS; AF	Mar-Apr	222	**FR**
Paeonia lactiflora, Pall.	Paeoniaceae	AS	May	271	**FR**
Ranunculus asiaticus,L.	Ranunculaceae	EU;AS; AF	Apr-May	157	Khuroo et al.(2007)
Sternbergia lutea, Roem. & Schult.	Amaryllidaceae	EU;AS	Feb-Mar	059	**FR**
Tulipa cultivars	Liliaceae	EU;AS	Apr-May	182	-
Tradescantia pallida,Hunt. 'Purpurea'	Commelinaceae	NAM	May	148	**FR**
Tradescantia virginiana, L.	Commelinaceae	NAM	May	205	**FR**
Tradescantia sillamontana, Matuda	Commelinaceae	NAM	May	095	**FR**
Zantedeschia aethiopia, Spreng.	Araceae	AF	Apr-Jun	197	Stewart (1972)

Table 10. **Non bulbous Perennials**

Species	**Family**	**Origin**	**Flowering period**	**Voucher specimen number (by Shabana & Dar)**	**Primary Published source**
Alcea officinalis,L.	Malvaceae	AS	Jun-Aug	076	Naqshi et al. (1988)
Alcea rosea, Cav.	Malvaceae	AS	Jun-Aug	144	Naqshi et al. (1988)
Anchusa azurea, Mill.	Boraginaceae	EU;AS; AF	Mar-May	172	**FR**
Aquilegia alpina,L.	Ranunculaceae	EU	May-Jun	137	**FR**
Aquilegia caerulea, James.	Ranunculaceae	NAM	May-Jun	096	**FR**
Aquilegia vulgaris,L.	Ranunculaceae	EU	May-Jun	188	**FR**

Arundo donex,L.	Poaceae	EU	Aug-Sept	265	Stewart (1972)
Begonia semperflorens, Link & Otto.	Begoniaceae	SAM	Jun-Oct	081	**FR**
Bellis perennis,L.	Asteraceae	EU;AS	Apr-Jul	134	Kaul (1986)
Campanula medium,L.	Campanulaceae	EU	May-Jun	255	**FR**
Chrysanthemum coccineum, Willd.	Asteraceae	EU	May-Sept	093	**FR**
Coreopsis grandiflora, Hogg.	Asteraceae	NAM	May-Jul	183	**FR**
Coreopsis verticillata,L.	Asteraceae	NAM	May-Jul	155	**FR**
Dianthus caryophyllus,L.	Caryophyllaceae	EU	Jun-Aug	053	Stewart (1972)
Cheiranthus cheiri,L.	Brassicaceae	EU	Mar-May	080	Stewart (1972)
Euphorbia schillingii, *Radcl.*	Euphorbiaceae	AS	Apr	253	
Gaillardia aristata,Pursh.	Asteraceae	NAM	May-Jul	166	Stewart (1972)
Gaillardia pulchella,Foug.	Asteraceae	NAM	Jun-Oct	240	**FR**
Gazania hybrida,	Asteraceae	AF	May-Jun	131	**FR**
Geranium rotundifolium,L.	Geraniaceae	EU;AS	May	219	Kaul (1986)
Gerbera jamesonii, Bolus.	Asteraceae	AF	May-Oct	171	**FR**
Humulus lupulus,L.	Cannabaceae	EU;AS	Aug-Sept	167	Dar et.al. (2002)
Kalanchoe blossfeldiana, Poellnitz.	Crassulaceae	EU	Jun	266	**FR**
Lunaria annua, L.	Brassicaceae	EU	May-Jun	206	**FR**
Lupinus hartwegii,Lindl.	Papilionaceae	NAM	May-Jun	142	**FR**
Lychnis coronaria, Desr.	Caryophyllaceae	EU	May-Jun	267	Reshi **(**1984**)**
Matthiola incana,R. Br.	Brassicaceae	EU	Apr-May	254	Stewart (1972)
Pelargonium x hortorum, Bailey.	Geraniaceae	AF	May-Oct	245	**FR**
Pelargonium x fragrans, Willd.	Geraniaceae	AF	May-Oct	090	**FR**
Pelargonium peltatum, Ait.	Geraniaceae	AF	May-Oct	232	**FR**
Pelargonium x zonale,Ait	Geraniaceae	AF	May-Oct	184	Stewart (1972)
Phlox paniculata,L.	Polemoniaceae	NAM	Jun-Aug	268	**FR**
Physalis alkekengi,L.	Solanaceae	EU;AS	May	198	**FR**
Primula (Polyantha cultivars)	Primulaceae	EU	Mar-Apr	170	**FR**
Primula (Primrose cultivars)	Primulaceae	EU;AS	Mar-Apr	193	**FR**
Rudbeckia hirta,L.	Asteraceae	NAM	Jun-Aug	129	**FR**
Sedum clavatum,Clausen.	Crassulaceae	NAM	Jul-Sept	269	**FR**
Senecio bicolour,Viv.	Asteraceae	EU	Jul-Sept	257	**FR**
Solidago canadensis,L.	Asteraceae	NAM	Jul-Aug	048	**FR**

Table 11. **Annuals/ Seasonals**

Species	**Family**	**Origin**	**Flowering**	**Voucher**	**Primary**

			period	specimen number (by Shabana & Dar)	Published source
Aegeratum haustonianum, Mill.	Asteraceae	NAM;SAM	Jul-Sept	145	**FR**
Alyssum maritimum,Lam.	Brassicaceae	EU	Apr-May	050	**FR**
Amaranthus caudatus,L.	Amaranthaceae	NAM	Jul-Oct	233	Reshi (1984)
Amaranthus creuntus,L.	Amaranthaceae	NAM;SAM	Jul-Oct	128	Stewart (1972)
Amaranthus hypochondriacus, Rob.	Amaranthaceae	NAM	Jul-Oct	237	**FR**
Amaranthus tricolour, L.	Amaranthaceae	AS	Jul-Oct	077	Stewart (1972)
Antirrhinum majus,L.	Scrophulariaceae	EU	May-Jul	169	Stewart (1972)
Calendula officinalis,L.	Asteraceae	EU	Apr-Jun	194	Stewart (1972)
Callistephus chinensis,Cass.	Asteraceae	AS	Aug-Oct	061	**FR**
Capsicum annum,L. var Conoides, Bailey.	Solanaceae	NAM;SAM	Aug-Oct	079	**FR**
Celosia argentea-cristata, Kuntze.	Amaranthaceae	AS	Jul-Oct	241	**FR**
Celosia argentea-plumosa, Hort.	Amaranthaceae	AS	Jul-Oct	217	**FR**
Chrysanthemum carinatum ,L.	Asteraceae	AS	May-Sept	190	**FR**
Centaurea cyanus,L.	Asteraceae	EU	May	132	**FR**
Centaurea moschata,L.	Asteraceae	EU	May	234	**FR**
Clarkia pulchella,Pursh.	Onagraceae	NAM;SAM	May-Jun	107	**FR**
Cleome spinosa,L.	Capparidaceae	NAM	Aug-Sept	083	**FR**
Coleus blumei,Benth.	Lamiaceae	AS;AF; AUS	Jun-Jul	251	**FR**
Coreopsis tinctoria,Nutt.	Asteraceae	NAM	May-Jun	199	**FR**
Cosmos bipinnatus,Cav.	Asteraceae	NAM	Jul-Oct	078	**FR**
Delphinium ajacis,L.	Ranunculaceae	EU	May-Jun	238	Stewart (1972)
Dianthus barbatus,L.	Caryophyllaceae	EU;AS	May-Jun	141	Stewart (1972)
Dianthus chinensis,L.	Caryophyllaceae	EU;AS	May-Jun	069	**FR**
Dianthus deltoides,L.	Caryophyllaceae	EU;AS	May-Jun	106	**FR**
Dianthus plumaris,L.	Caryophyllaceae	EU	Jun-Aug	236	**FR**
Eschscholtzia californica, Cham	Papaveraceae	NAM	Mar-May	049	Stewart (1972)
Godetia amonea,Den.	Onagraceae	NAM	May-Jun	208	Khuroo et al. (2007)
Gomphrena globosa,L.	Amaranthaceae	SAM	Jul-Oct	139	Stewart (1972)
Gypsophila elegans,Bieb.	Caryophyllaceae	EU;AS	May-Jun	256	**FR**
Helianthus annuus,L.	Asteraceae	NAM	Jul-Sept	147	Stewart (1972)
Helianthus multiflorus,L.	Asteraceae	GO	Jul-Sept	231	**FR**
Helichrysum bracteatum,Andr.	Asteraceae	AUS	May-Oct	192	**FR**
Iberis amara,L.	Brassicaceae	EU	Mar-May	165	Stewart (1972)
Iberis umbellata,L.	Brassicaceae	EU	Mar-May	220	**FR**
Impatiens balsamina,L.	Balsaminaceae	AS	Jul-Sept	163	Stewart (1972)
Ipomoea purpurea,Lam	Convolvulaceae	NAM	Jun-Jul	263	Reshi (1984)
Linaria bipartita,Willd.	Scrophulariaceae	AF	Apr-May	250	**FR**
Linaria macroccana,Hook.	Scrophulariaceae	AF	Apr-May	138	**FR**
Myosotis sylvatica,Hoffm.	Boraginaceae	EU	Mar-Apr	156	**FR**
Nemophila	Hydrophyllaceae	NAM	Jun-Aug	089	**FR**

maculata,Benth.					
Papaver nudicaule,L.	Papaveraceae	EU	May	239	**FR**
Papaver rhoeas,L.	Papaveraceae	EU;AF	May	164	Kaul (1986)
Petunia hybrida,Vilm.	Solanaceae	SAM	Jun-Nov	195	Khuroo et al. (2007)
Phlox drummondii,Hook.	Polemoniaceae	NAM	May-Jul	244	Stewart (1972)
Portulaca grandiflora,Hook.	Portulaceae	SAM	Jul-Sept	094	**FR**
Salvia horminum,L.	Lamiaceae	EU	May	221	**FR**
Salvia splendens,Sello.	Lamiaceae	SAM	Jul-Oct	146	**FR**
Saponeria ocymoides,L.	Caryophyllaceae	EU	Apr-Jun	196	**FR**
Silene schafta,Gmel.	Caryophyllaceae	EU	May	067	Stewart (1972)
Tagetes erecta,L.	Asteraceae	NAM	Jul-Nov	133	Stewart (1972)
Tagetes patula,L.	Asteraceae	NAM	Jul-Nov	207	Stewart (1972)
Tagetes tenuifolia,Cav.	Asteraceae	NAM	Jul-Oct	082	**FR**
Tropaeolum majus,L.	Tropaeolaceae	NAM	Jun-Oct	242	**FR**
Verbena x *hybrida*,Voss.	Verbenaceae	SAM	Jul-Nov	191	**FR**
Viola tricolour,L.var 'hortensis' DC.	Violaceae	EU;AS	Mar-May	068	**FR**
Viola x *wittrockiana* Gams.	Violaceae	EU	Mar-May	189	**FR**
Zinnia angustifolia, HBK.	Asteraceae	NAM	Jul-Oct	140	**FR**
Zinnia elegans,Jacq.	Asteraceae	NAM	Jul-Oct	168	Stewart (1972)
Zinnia a. haagaena, Regel.	Asteraceae	NAM	Jul-Oct	052	**FR**

Abbreviations

AS	Asia	**AF**	Africa
AUS	Australia	**EU**	Europe
NAM	North America	**SAM**	South America
GO	Garden Origin	**FR**	First Report

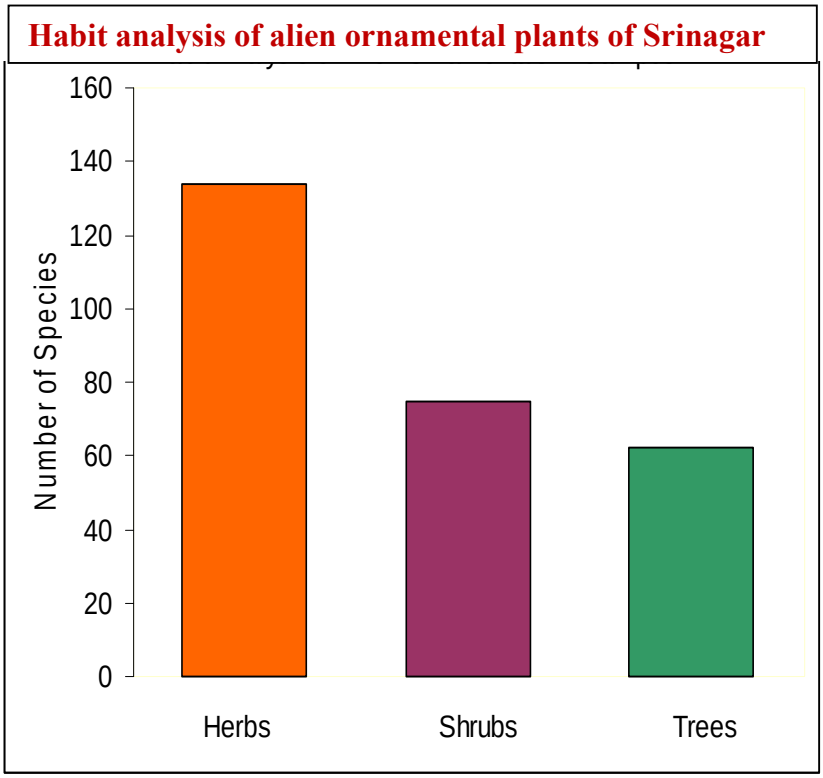

Figure 1

Figure 2

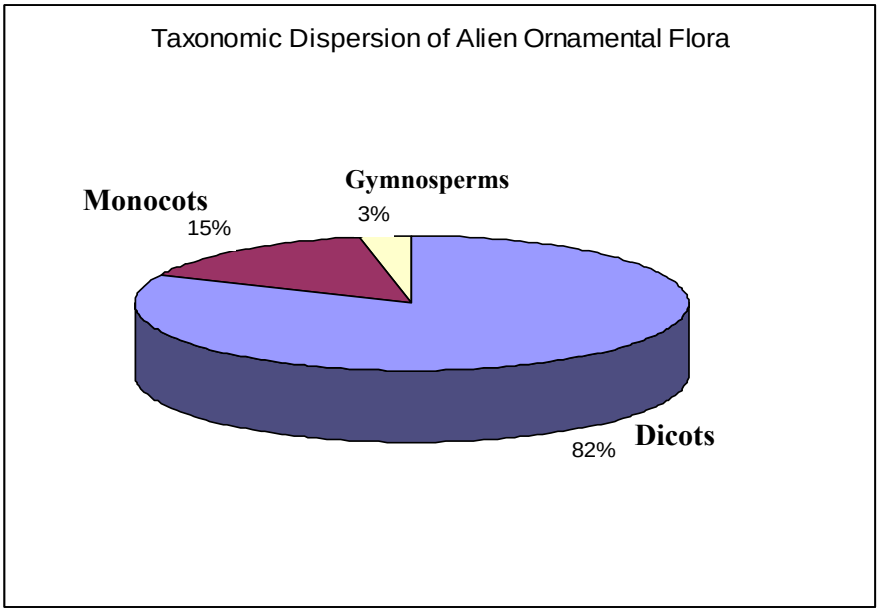

Figure 3

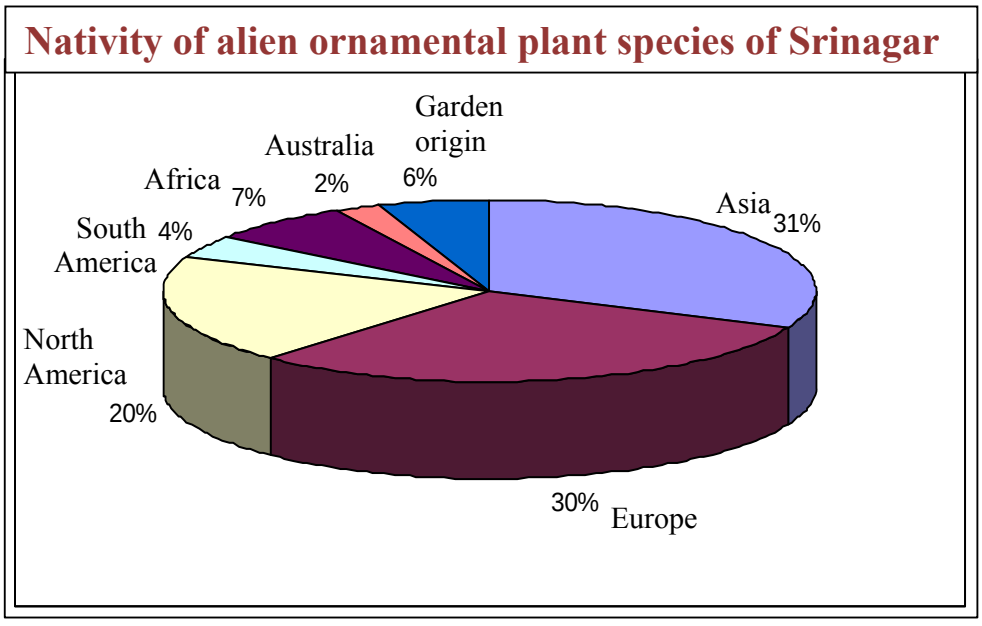

Table 12. Distribution of alien ornamental plant species into various life forms

1. Deciduous trees	53
2. Evergreen trees	09
3. Deciduous shrubs	29
4. Evergreen shrubs	20
5. Deciduous woody vines	10
6. Evergreen woody vines	06
7. Ground covers (deciduous shrubs)	02
8. Ground covers (evergreen shrubs)	08
9. Bulbous perennials	35
10. Non-bulbous perennials	39
11. Annuals/ seasonals	60

Table 13. Top ten families of alien ornamental species

S.No	Family	Number of species	Percentage of species
1	Asteraceae	30	11.07
2	Rosaceae	25	9.59
3	Oleaceae	12	4.42
4	Papilionaceae	10	3.69
5	Salicaceae	10	3.69
6	Amaryllidaceae	09	3.32
7	Caryophyllaceae	09	3.32
8	Liliaceae	09	3.32
9	Amaranthaceae	07	2.58
10	Brassicaceae	06	2.21

Top 10 families contribute 127 species with percentage of 46.86% by proportion. 42 families are represented by one genus with one species each. out of these, 30 families belong to dicots, six to monocots, and six to gymnosperms.These families include Alstroemeriaceae, Araceae, Araucariaceae, Arecaceae, Balsaminaceae, Begoniaceae, Buddlejaceae, Buxaceae, Caesalpeniaceae Campanulaceae, Cannabaceae, Cannaceae, Capparidaceae, Convolvulaceae, Cornaceae, Cycadaceae, Ericaceae, Euphorbiaceae, Ginkgoaceae, Hydrophyllaceae, Juglandaceae, Lythraceae, Meliaceae, Mimosaceae, Myrtaceae, Passifloraceae, Phormiaceae, Pinaceae, Platanaceae, Poaceae, Portulaceae, Punicaceae, Rutaceae, Sapindaceae, Simaroubaceae, Tamaricaceae, Taxaceae, Taxodiaceae, Theaceae, Tropaeolaceae, Ulmaceae, Verbenaceae. The largest genera are *Prunus* with 8 species, *Salix* and *Rosa* with 6 species each, *Dianthus* with 5 species, and *Amaranthus*, *Ligustrum*, *Magnolia*, *Pelargonium*, and *Populus* with 4 species each.

4. Discussion

The exotic species are continuously introduced into the valley for varied purposes (Ara *et al.* 1995, Dar *et al*. 1995, Khuroo *et al*. 2007) with the region hosting almost 704 alien plant species. The ornamental exotic plants are deliberately introduced for landscaping gardens, houses, parks, hospitals, public places, Hospitals and other institutions besides floriculture industry. The present assessment of ornamental plant diversity unravels ornamental horticulture as the major pathway of alien species introduction into the region. The rate of exotic species establishment and naturalization is much higher in Kashmir than depicted by Williamson's 10% rule (Williamson 1996). Our time series analysis revealed that almost 80% of exotic ornamental plant species introduced in the valley established nicely with almost 50% naturalizing in quick succession. The proportion of invasive and potential invasive species is alarmingly high and significantly deviating from Williamson's 10% law. This high proportion of alien invasive species is attributed to the high degree of disturbance, less diversity, availability of barren wastelands in the region and above all niche conservatism based human selection and introduction of alien species. The exotic species with simulating niches or niche conservatism find it easy to establish and naturalise thus enhancing values of establishment and invasion. The establishment of few individuals of an exotic species encourage the private and government agencies related to floriculture to traffic more propagules into the region, thus enhancing the propagule pressure to the maximum limits. The high rate of exotic species establishment in the valley confirms the fact that temperate biomes and ecosystems are prone to biological invasions than tropical ecosystems as proposed by Elton (1958). The tropical ecosystems harbour highest diversity which lends stability to these ecosystems. The high stability ecosystems resist invasion than less stable ones that are less diverse like temperate ecosystems (Kennedy et al 2002, Milbau and Nijs 2004). The high rate of establishment and naturalisation in this temperate pocket can also be attributed to possible richness of vacant niches. Our study does not conform to Williamsons tens law and suggests that human assistance of selection, introduction and establishment of exotic species change the contour of tens law to multiple folds ahead. The exotic flora of the valley is changing the composition, and altering structure and function of this valuable ecosystem. The invasive species are eroding the genetic diversity of the region and are posing threat to the biodiversity. The alien invasive species are penetrating deep into the forests of this region thus threatening their survival and sustenance. Cronon (1983) and Oak (1998) held the same concern for the forests of North America, which have been exposed to peak introductions of invasive organisms. The alien species driven forest damage can manifest in climate change which can drive major changes in socio-economic and other life attributes in the region, as predicted by Ehrlich and Mooney (1983) for invaders which alter the host ecosystem goods and services. The state is having an agriculture based economy which is under a considerable threat of invasive species as globally invasive species are known to have staggering economic and environmental costs (Pimentel et al 2000). Tracing the origin of these alien ornamental species, the introduction pathways radiate from almost all continents and converge into Kashmir which is housing about 704 species of alien plants. Most of the alien ornamental species in the region owe their origin to Asia (31%) followed by Europe (30%), America (24%) and Africa (7%). This depicts that ornamental horticulture is truly a major pathway of alien species introduction into Kashmir Himalayas. Smith and Silva (2004) and Wu et al (2004, a, b) also view ornamental horticulture as a major pathway of exotic species introduction. Among the 271 species of alien ornamental species explored and documented from the region, 133 are reported for the first time from the region (Table1-9). The present study will surely serve as a data base of alien ornamental flora of the region with wide economic and ecological implications. It also brings fore the potential of anthropogenic interferences to enhance rate of alien species establishment, naturalization and magnitude of invasiveness beyond the set rules and laws deduced so far form invasion biology.

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Correspondence to
Dr Khursheed Ahmad
Department of Botany
ICSC, University of Kashmir India
Mob: 09419419147
E mail: khursheedtrali@yahoo.co.in

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