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DIVERSITY OF INVASIVE ALIEN PLANTS SPECIES OF LESSER HIMALAYAS-PAKISTAN

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Abstract

The objective of current study is the comprehensive account regarding the diversity of invasive alien plants of Lesser Himalayas-Pakistan with special emphasis on family, habit, nativity, mode of introduction, and global distribution. A total of 73 invasive alien species under 65 genera and 30 families have been documented in present research study which is based upon field observations, herbarium, literature consultations and review. As far as mode of introduction of species is concerned 37% species, have been introduced intentionally wile rest of species were unintentionally established via different means, the most common is trade. Analysis of status or life form of these plant species indicates that herbs are dominant (44), while shrubs (10 species), Grass (6 species), Trees (10species), undershrub, climber, and Fern (1 species each). Perennial habit is represented by 43 invasive plant species followed by 25 annual and rest of species shows both annual and perennial habit. Nativity analysis revealed that majority of invasive alien plant species are reported from American subcontinent (51%). Plant invasions adversely affect indigenous flora, ecosystem functions which results in ecological and economic imbalance of a particular region. Impacts of biological invasions are complex as it alters the species composition and its dynamics. Due to biological invasions plant communities in an area become less diverse that is proved as a threat to native diversity of invaded region. A better planning strategies and appropriate control measures (indigenous biological and cultural weed control measures) is the urgent need of time. This will give a clear strategy to mitigate the existing and future adverse effects of alien plant invasions on ecological processes that are vulnerable.

Key words: Diversity, Invasive species, Biological invasions, Lesser Himalaya, Floristic inventory.

Introduction

Invasive alien species (IAPS) of plants are exotic species, established themselves outside their natural range that negatively affect native flora, environment, ecosystem processes, and habitat in invaded regions (Naz *et al.,* 2021). These species can be introduced either accidently or intentionally (Masters & Norgrove, 2010). According to International Union for Conservation of Nature (IUCN) and Natural Resources, alien invasive species are foreign species that establishes itself in a semi natural ecosystem or environment and threatens native biological diversity.

Richardson & Rejmanek (2011) indicate that 0.5–0.7% of worldwide species tree and shrubs are invasive outside from their normal range. IAPS are very aggressive in nature and suppress the indigenous vegetation thus they are now serious threat causing to vegetation biodiversity. According to Pant & Sharma (2010), invasive species reduce biodiversity and change hydrology and ecosystem dynamics. Rate of invasive alien plant species have been rapidly increased all over the globe posing a great threat to indigenous biodiversity, native habitats, and ecological functions (Booth *et al.,* 2003; Hulme, 2003; Shinwari & Qaisar 2011). Biological invasions cause natural groups to change and ecological traits to change at an exceptional rate. Deleterious effects of IAPS ecosystem processes are linked with human well beings as they alter natural environment, ecosystem structure as well as economic cost (Crowl *et al.,* 2008; Mazza *et al.,* 2014). Grice in 2006 reported that IAPS are responsible in degradation of native plant species in ecosystems by outcompeting the available resources e.g., nutrients, space and as well as modified ecological systems (Hameed *et al.,* 2020; Hussain *et al.,* 2020: Yaseen *et al.,* 2015; Yaseen *et al.,* 2019).

Rapid increase in biotic invasions have been observed over a due course of time, the main reason for this rapid increase is growing market globalization, increase in worldwide trade, travel and tourism (Abbasi *et al.,* 2012; Eiswerth *et al.,* 2005; Majeed *et al.,* 2021). Murphy *et al.,* (2013) and invasive plants have been expanding throughout protected areas in the Himalaya region, according to Aryal *et al*., (2017), posing a threat to wildlife habit and nutrition availability. According to Alexander *et al.,* (2016), in mountain ecosystems IAPS are found in plentiful at lesser and mid elevation and this establishment of IAPS is due to ongoing climate drift (increased warming) and anthropogenic changes.

The Lesser Himalayan regions have always been encroached by invasive alien plants. As this region shows great variation in altitude and wide range of climatic zones which supports growth of diversified and rich vegetation in this region of world (Shaheen *et al*., 2011; Khan *et al.,* 2020; Malik *et al.,* 2019; Sultana *et al.,* 2011). A very few studies have been conducted on the diversity and distribution of IAPS in Lesser Himalayas. However, a comprehensive study focusing on this vast territory is unavailable. It is necessary to implement effective IAPS management, and understanding on the diversity, habitat and origin of invasive species is required. Therefore, present study is conducted to enumerate the invasive alien plant species of Lesser Himalayan Region of Pakistan and its diversity with future implication of this region. This study will also be helpful for policy makers in developing the management approaches to control the aggression of alien invasive species.

Study area: Pakistan has a unique resource in the form of a diverse and rich botanical heritage. The Himalaya is a beautiful natural region where the glory of the world's tallest mountains is reflected in the raw beauty and distinctive culture of the people who live in their shadow (Sekar, 2012). The Himalayas are considered one of the world's youngest mountain peaks. The Greater, Lesser Himalayas and Outer Himalayas are the three corresponding ranges that make up the Himalayan range (Akhtar *et al.,* 2021; Zareen *et al.,* 2018).

Chilas, Deosai, Kaghan, Kashmir and Kohistan, are all part of Pakistan's Himalayan range. The lower Himalaya ranges in elevation from 2000 to 3000 meters and is located between 33°-44′ and 35°-35′ north latitude, and 72°-33′ to 74°-05′ east longitude. Lesser Himalayas cover a total area of 23295 km^2 in Pakistan (Ahmad *et al.,* 2018; Hussain & Ilahi, 1991) and entire population of this territory is around 10 million (Pakistan Bureau of Statistics, 2008). The geography, heights, aspects, vegetation cover, and climate of the Lesser Himalayas vary dramatically. Subtropical continental lowland and subtropical continental highland are the two main types of land in the Lesser Himalayas. The plains and foothills zone make up the subtropical continental lowland, whereas the outer and middle Himalayas, Siwalik, Murree and the entire Hazara Hills make up the subtropical continental highland (Abbasi *et al.,* 2013; Akhter *et al.,* 2021; Kayani *et al.,* 2019).

As far as rain fall is concerned the Southern parts of Lesser Himalayas receive 70-90 mm average rainfall whereas in the north, it ranges from 100 to 130 mm. Snow makes up a substantial portion of winter precipitation, from western disturbance. The northern portions of the country receive scant rain but get a lot of snow in the winter (Hussain & Ilahi, 1991, Kayani *et al.,* 2017; Khan *et al.,* 2010). The vegetation cover of Lesser Himalaya is divided into four zones, subtropical; temperate; sub-alpine, and alpine.

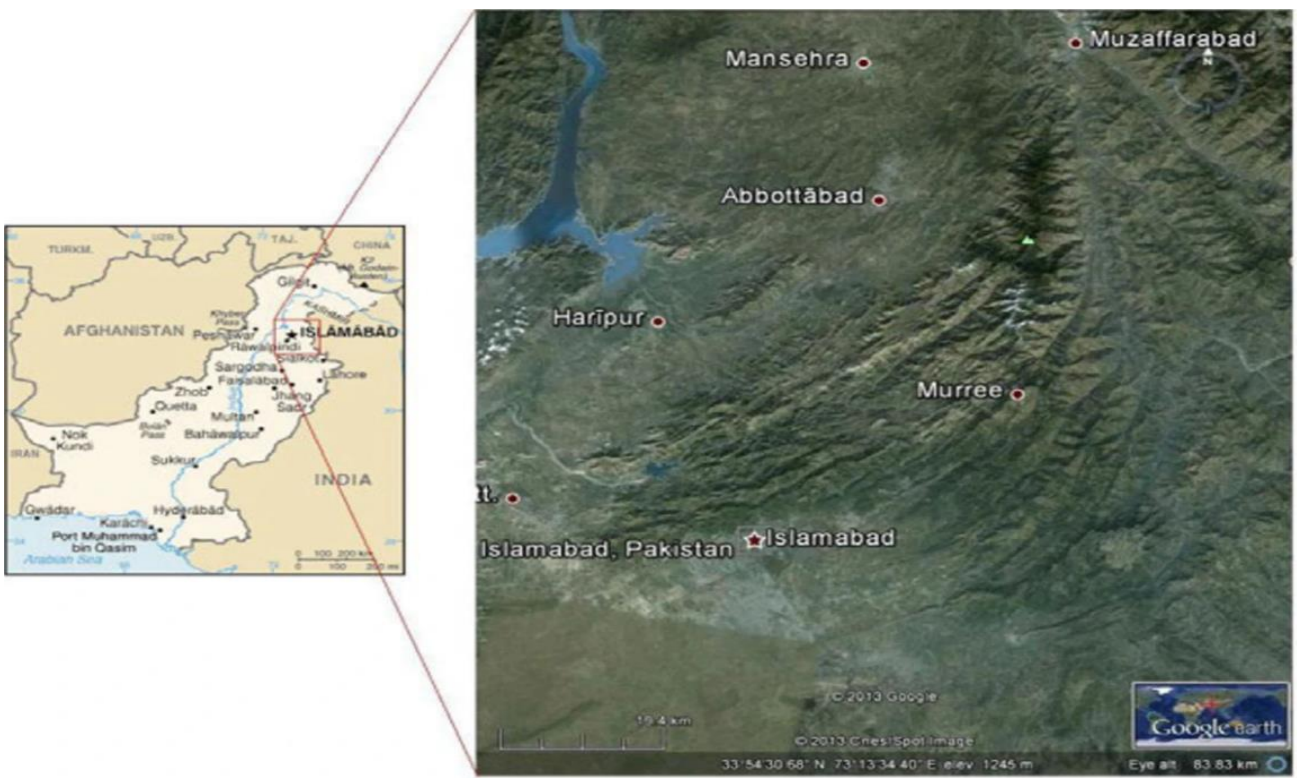

Fig. 1. Location Map of Study area (Abbasi *et al.*, 2013).

Material and Methods

Field studies were done to record the highest proportion of alien invasive plant species in various locations across Pakistan's Lesser Himalayan range, particularly during the flowering and fruiting periods of each taxon. Margalla Hills National Park, Islamabad; Murree Hills and their allied parts in Punjab province, Abbottabad; Haripur; and Mansehra districts in Khyber Pakhtunkhwa are among the important sampling sites (Fig. 1). In case of any ambiguities, voucher specimens were compared, with type specimens stored in Herbarium of Pakistan (ISL) located in Quaid-i-Azam University Islamabad. Vouchering of all the documented species were properly processed and deposited in the Herbarium of Pakistan (ISL), Islamabad. The information about nativity of invasive plants, habitat, habit, global distribution were collected through published literature and online resources (http://www.plantsoftheworldonline.org, https://keyserver.lucidcentral.org, http://www.efloras.org).

Plant species were divided into annual and perennials on the basis of habit or life form while on the basis of status are classified into herbs, shrubs and trees. Different habitats of invasive plants such as wastelands, agriculture crops, grasslands, cultivated fields, aquatic etc. were also recorded. The invasive plant species found in Lesser Himalayan of Pakistan in current research are arranged alphabetically in tabular form followed by common English Name, Global distribution, Nativity, Flower Color and Flowering Period, Habit, Habitat, Status and Purpose of Introduction as shown in Figures 2, 3 & 4.

Results

During present investigations a total of 73 species categorized into 65 genera and 30 families were invasive alien plants found in flora of Pakistani Himalaya region (Table 1). The most dominant family is Asteraceae (nine species) followed by Euphorbiaceae, Fabaceae, Poaceae (7 species each) (Fig. 5). In the terms of nativity, the most of alien species were originated from American sub-continent (51%), followed by Europe (14 %), Asian region (11 %) (Fig. 6).

Invasive plants in this region were introduced for different purposes and data analysis revealed that 41 species were introduced or established unintentionally, 11 species as ornamental, 6 species as food, 3 as fodder, 4 as plantation, 2 for medicinal, 1 species for horticulture while purpose of 5 plant species were not known (Fig. 7). Results of present studies shows that perennials comprise 59 % while 34 % were annual (Fig. 8).

Data analysis of lifeform indicates that herbs constitute 60% (44 plants), while shrubs and trees were represented by 10 plant each whereas grasses were represented by only 6 species viz., *Arundo donax, Cynodon dactylon, Imperata cylindrica*, *Paspalum paspalodes, Phragmites australis, Sorghum halepense* , climbers, under shrubs and Fern are repersneted by one (1) species each namely, *Cassia occidentalis, Bougainvillea glabra, Salvinia molesta* (Fig. 9).

As far as habitat is concerned, most invasive species were popularized in wastelands, and cultivated fields, roadsides while other favorable habitats include grass lands, garbage heaps, garden areas, coastal dunes, along riverbeds, forest, parks, lawns, hilly areas, and railways respectively.

Fig. 2. Invasive alien species; (a) *Achyranthes aspera* (b) *Ailanthus altissima* (c) *Amaranthus viridis* (d) *Bougainvillea glabra* (e) *Broussonetia papyrifera* (f) *Cannabis sativa* (g) *Capsella bursa-pastoris* (h) *Cassia occidentalis* (i) *Chenopodium murale* (j) *Cichorium intybus* (k) *Citharexylum spinosum* (l) *Cleome viscosa* (m) *Conyza bonariensis* (n) *Croton bonplandianum* (o) *Cynodon dactylon.*

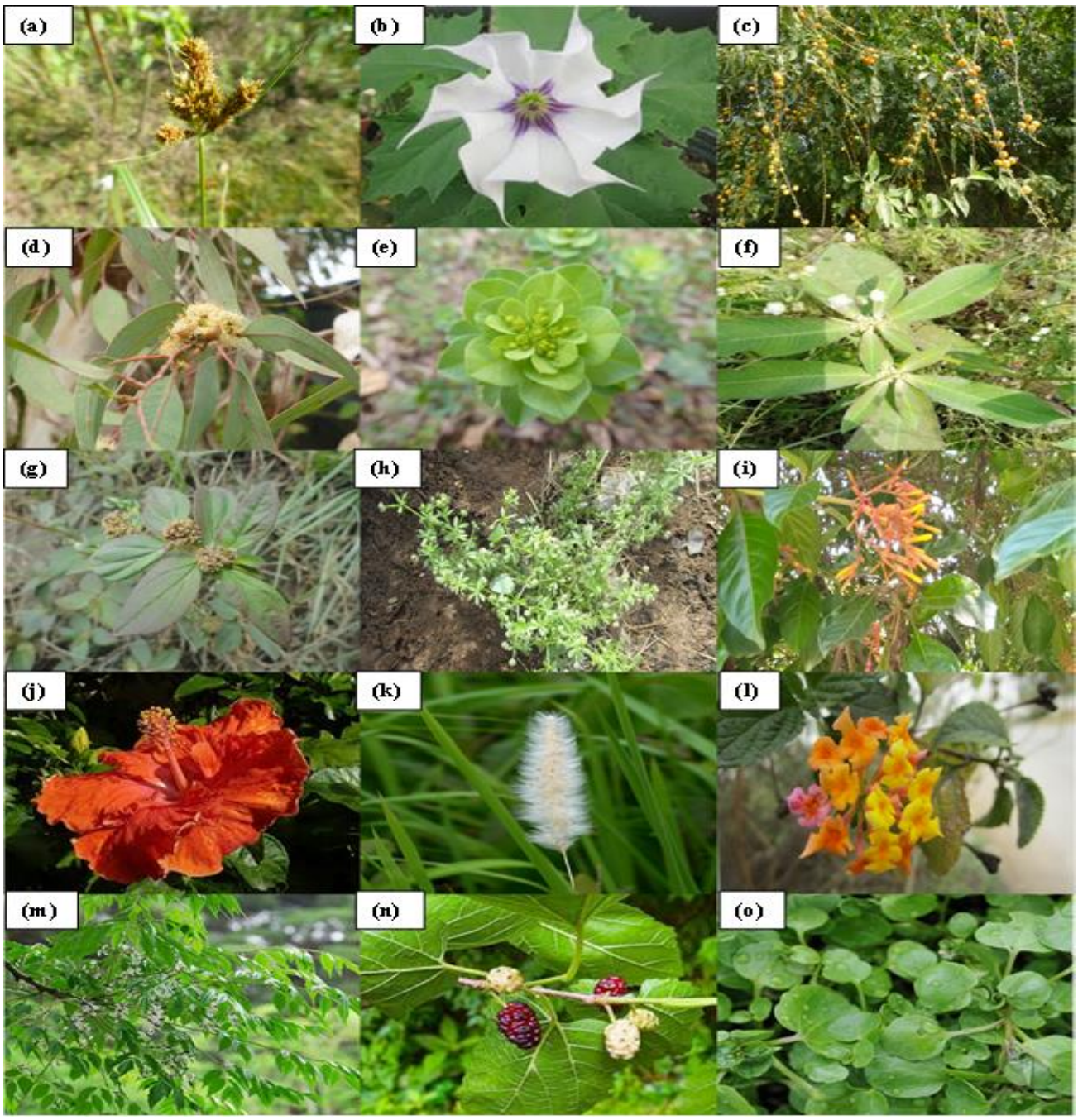

Fig. 3. Invasive alien species; (a) *Cyperus rotundus* (b) *Datura stramonium* (c) *Duranta repens* (d) *Eucalyptus camaldulensis* (e) *Euphorbia helioscopia* (f) *Euphorbia heterophylla* (g) *Euphorbia hirta* (h) *Galium aparine* (i) *Hamelia patens* (j) *Hibiscus rosa-sinensis* (k) *Imperata cylindrica* (l) *Lantana camara* (m) *Melia azedarach* (n) *Morus alba* (o) *Nasturtium officinale*.

Discussion

Alien species become invasive, when they are accidentally or purposefully familiarized outside their original range into new habitats, where they exhibit a rapid rate of growth by invading and outcompeting native vegetation (Bahadur *et al.,* 2020). Invasive alien plant species are localized in diverse range of ecosystems all over the globe. According to Singh (2005) the most common types of IAS in terrestrial geographic range are plants, mammals, and insects but Holm *et al.,* (1991) stated plants are recognized one of the worst invaders in the world.

Exotic plants have been introduced into Pakistan for a long time but comprehensive studies on invasive species in Pakistan especially in Lesser Himalayan region are still missing (Bano *et al.,* 2012; Mashwani *et al.,* 2012; Shinwari *et al.,* 2017). Therefore, catalogue of invasive alien plants and data set is not available to capture the comprehensive information regarding the alien invasive plants in Pakistan. In this scenario, this study conducted to focused documentation of invasive alien flora in Lesser Himalayan-Pakistan (Bano *et al.,* 2014; Habiba *et al.,* 2016; Mulkkhan *et al.,* 2013; Rashid *et al.,* 2015). This study plant species invasiveness will benefit groundwork for future research into the protection of indigenous and natural, forest vegetation in Pakistan's Lesser Himalaya.

In Lesser Himalayan-Pakistan majority of invasive species, belongs to Asteraceacous species followed by Poaceae. Jaryan *et al.,* (2013) conducted research studies about the alien invasive plants (Indian Himalayan State; Himachal Pradesh) and he found that family Asteraceae as a dominant family followed by Poaceae. Studies reported from Europe (Lambdon *et al.,* 2008) and China (Weber *et al*., 2008; Wu *et al*., 2010) reported patterns similar to dominant family in alien flora but our results shows that family Euphorbiaceae and Fabaceae also contributed equal share as Poaceae (7 Species each) . According to Heywood in 1989 indicates that most of weeds belong to these families. Findings of our study shows that majority of invasive alien plant in Pakistani Lesser Himalayan (51%) are native to American continent, this is in agreement to other studies conducted by Weber *et al.,* (2008) and Chandra Sekar, (2012). Perennials are recorded 59% as a predominant flora while in terms of habit of alien invasive flora of this region shows a preponderance of herbs (60%).

Among the intentionally introduced species most of species are introduced as ornamentals (11 species) these results are in accordance with the studies of Reichard & White (2001), Mack & Erneberg (2002), while 41 species were entered in this region unintentionally. The escape of these species into nature, on the other hand, might have devastating consequences. It is observed that a huge number of invasive alien species are found in lesser Himalayan as compared to higher altitudes which indicates that species are capable to acclimatize at lower altitude more easily, so species diversity decreases in higher altitude.

Fig. 4. Invasive alien species; (a) *Oxalis corniculata* (b) *Portulaca oleracea* (c) *Prosopis juliflora* (d) *Ruellia tuberosa* (e) *Ricinus communis* (f) *Sapium sebiferum* (g) *Silybum marianum* (h) *Taraxacum officinale* (i) *Tridax procumbens* (j) *Trifolium alexandrium* (k) *Verbena tenuisecta* (l) *Xanthium strumarium*.

Table 1. Alien Invasive Plants of Lesser Himalayan Pakistan.

Sr. No.	Botanical name/ author citation	Family	Common English Name	Global Distribution	Nativity	Flowering Period	Flower Color	Habit	Habitat	Status	Purpose of Introduction
1.	*Achyranthes aspera* L.	Amaranthaceae	Prickly chaff flower, Devil's horsewhip	Tropics regions of Europe, Africa, Asia, Australia, and Americas	South-East Asia and Africa	July-December	Greenish white often tinged with purple red	Perennial	Cultivated Fields, Grasslands, Forest, Disturbed Areas, Waste Lands	Herb	Unintentional
2.	*Ailanthus altissima* (Mill.) Swingle	Simaroubaceae	Tree of Heaven	East Asia, USA, China, Canada, Hawaii, Europe, Africa, New Zealand,	Asia	June-July	White or Greenish Yellow	Perennial	Bushland, Waterways, Gullies, Forest Margins, Pastures, Forestry Plantations, Urban Areas, Disturbed Sites, Waste Areas and Roadsides	Tree	Plantation
3.	*Amaranthus spinosus* L.	Amaranthaceae	Spiny amaranth, Spiny pigweed	Tropical America, Japan, West and South Africa, Indonesia	Tropical America	July-September	Green	Annual	Cultivated Fields, Waste Places, Roadsides, Garbage Heaps	Herb	Unintentional
4.	*Amaranthus viridis* L.	Amaranthaceae	Slender Amaranth,	Tropics, Subtropics, Warm Temperate regions	Tropical America	Though out the year	Green	Annual	waste ground and roadside	Herb	Unintentional
5.	*Arundo donax* L.	Poaceae	Giant Reed	Arabian Peninsula, Northern Africa, Western Asia, Ukraine, Sub-Continent	Africa/Europe	September	White	Perennial	Riversides, Ditches, Marshland, Hillsides	Grass	Unintentional
6.	*Boerhavia repens* L.	Nyctaginaceae	Creeping Spiderling	Tropical Africa and Asia, Spain	Africa	June-September	White, Pink, Pale Purple	Perennial	Along Roadsides, Dry Riverbeds, Irrigated Fields	Herb	Unintentional
7.	*Bougainvillea glabra* Choisy	Nyctaginaceae	Paper Flower	Tropics And Subtropics, Brazil	Brazil	Flowers Throughout the Year	Lilac	Perennial	Ornamental	Climber	Ornamental
8.	*Broussonetia papyrifera* L.	Moraceae	Paper Mulberry	Japan, China, Japan, Korea, Vietnam, Myanmar, Thailand, Cambodia, Malaysia	S.E. Asia	March- May	Pale Green, Red	Perennial	Roadsides	Tree	Plantation
9.	*Cannabis sativa* L.	Cannabaceae	Hemp	China, Denmark, New Mexico, New York, New Zealand, Europe, Turkey	Central Asia	April-September	Whitish to Yellowish Green	Perennial	Waste Lands, along Roadsides	Herb	Unintentional
10.	*Capsella bursa-pastoris* (L.) Medik.	Brassicaceae	Shepherd's Purse	Temp. Eurasia, N. Africa	Europe	April-September	White	Annual	Roadsides, Waste Lands, Part Shade, Agriculture Fields	Herb	Unintentional
11.	*Cassia obtusifolia* L.	Fabaceae	Java Bean	Mexico, Central America, Caribbean and Tropical South America, South-Eastern Asia, Oceania	South America	March- August	Bright Yellow	Annual/Biennial	Along Roadside, Undergrowth Tree, Wastelands, Agriculture Fields	Shrub	N/A
12.	*Cassia occidentalis* L.	Fabaceae	Coffee Senna, Negro Coffee	Tropical And Sub-Tropical Americas, Southern and Eastern USA	Trop. America	Summer and autumn	Yellow	Annual	Roadsides, Wastelands, Disturbed Sites, Grass Lands	Under Shrub	Unintentional
13.	*Celosia argentea* L.	Amaranthaceae	Feather Celosia	Tropical Africa, China, Brazil, Afghanistan	Trop. Africa	Septembe-January	Bright Red	Annual	Cultivated Fields, Roadsides	Herb	Food
14.	*Chenopodium album* L.	Amaranthaceae	Lamb's Quarters, Goosefoot	Morocco, Srilanka, Yemen, Finland, Victoria, Colombia	Europe	July -October	Green	Annual	Cultivated fields, wasteland, pastures, uncultivated land, roadsides, and riverbanks	Herb	Food
15.	*Chenopodium murale* L.	Amaranthaceae	Nettle leaf Goosefoot, Australian-Spinach	Egypt, Sudan, Oman, Poland, Australia, Peru	Trop. America	July - September	NA	Annual	Cultivated Fields, Waste Lands	Herb	Unintentional
16.	*Chloris barbata* Sw	Poaceae	Windmill Grass or Finger Grass	Tropical Regions of World, Central and South America	Trop. America	April-May	Purple	Perennial	Wastelands,	Herb	Unintentional

Table 1. (Cont'd.).

Sr. No.	Botanical name/ author citation	Family	Common English Name	Global Distribution	Nativity	Flowering Period	Flower Color	Habit	Habitat	Status	Purpose of Introduction
17.	*Cichorium intybus* L.	Asteraceae	Chicory	Europe, North Africa, West Central Asia	Europe	July -October	Bright Blue but Rarely White or Pink	Perennial	Waste Lands, along Roadsides	Herb	Food
18.	*Citharexylum spinosum* L	Verbenaceae	Fiddle Wood Tree	USA, Australia, Fiji, Bahamas	West Indies	March - June	White	Perennial	Gardens, Agriculture Fields, Coastland, Disturbed Areas, Roadsides,	Tree	Ornamental
19.	*Cleome viscosa* L.	Cleomaceae	Asian Spider Flower, Tick Weed	Americas, Africa, Asia	Trop. America	July- October	Yellow	Annual	Waste Lands	Herb	Unintentional
20.	*Conyza bonariensis* (L.) Cronquist	Asteraceae	Asthma Weed, Hairy Fleabane	North America, Thermo-cosmopolitan species	Trop. America	March-September	White sometimes tinged Purple/ Red	Perennial	Cultivated Lands, Garden Areas, Wasteland, Roadsides	Herb	Unintentional
21.	*Croton bonplandianum* Baill.	Euphorbiaceae	Bonpland's Croton	S. Bolivia, Paraguay, S.W. Brazil, N. Argentina	South America	Almost throughout the year	Pale-creamy-yellow or nearly white	Perineal	Waste Lands	Herb	Unintentional
22.	*Cynodon dactylon* L.	Poaceae	Bermuda Grass	Tropical and Warm Temperate regions Throughout the World	Australia	Almost throughout the year	Green or Purplish	Perennial	Roadsides, lawns, .on Sandy Wastes, any Uncultivated area	Grass	Unintentional
23.	*Cyperus rotundus* L.	Cyperaceae	Purple Nut Sedge, Nutgrass	Tropical, Subtropical America, Africa, Eurasia	Europe	April-October	Red-Brown Spikelets	Perennial	Cultivated Fields, Roadsides, Wastelands, Grassland, Riverbanks	Herb	Unintentional
24.	*Datura stramonium* L.	Solanaceae	Thorn apple	Temperate and Subtropical regions	North America	June-July	White or Purplish	Annual	Wastelands	Herb	Unintentional
25.	*Duranta repens* L.	Verbenaceae	Brazilian Sky Flower, Golden Dew Drop	S. America, W. Indies, Tropical Africa, Asia, Australia	South America	Throughout The Year	Bluish White	Perennial	Wastelands, Roadsides, Wood Lands,	Shrub	Ornamental
26.	*Eclipta prostrata* (L.) Mant.	Asteraceae	False Daisy	Subtropical, Tropical, Warm Temperate Regions	South America	July - October	White sometimes Yellow with lobes	Annual	Roadsides	Herb	Unintentional
27.	*Eucalyptus camaldulensis* Dehnh.	Myrtaceae	Red River Gum	USA, France, Greece, India, Cyprus, Portugal, Spain, Australia	Australia	March-May	White	Perennial	Roadside, Forests	Tree	Plantation
28.	*Euphorbia helioscopia* L.	Euphorbiaceae	Sun Spurge	Europe, N. Africa, Asia	Europe/Asia	April-June	Yellow-Light Green	Annual	Cultivated Fields, Waste Lands	Herb	Unintentional
29.	*Euphorbia heterophylla* L.	Euphorbiaceae	Mexican Fire Plant	Kenya, Bhutan, Jordan, Costa Rica, Cuba	South America	March- June	Greenish Yellow	Annual	Cultivated Fields	Herb	Unintentional
30.	*Euphorbia hirta* L.	Euphorbiaceae	Common Spurge, Asthma Weed, Milk Weed	Tropical & Subtropical America, Asia	South America	Almost throughout the year	Greenish-Yellow, Pinkish Purple	Annual	Cultivated Fields, Roadsides	Herb	Unintentional
31.	*Euphorbia serpens* Kunth	Euphorbiaceae	Matted Sandmat	Tropical & Subtropical America, Easter Island, SE. Canada	Trop. America	March- June	Maroon Purple Or White	Annual	Along Roadsides	Herb	Unintentional
32.	*Galium aparine* L.	Rubiaceae	Bedstraw, Goose Grass	North Africa, Siberia, India, Europe, Asia Minor, Iran, Afghanistan, Pakistan	Africa/Europe	March - July	White	Annual	Wastelands, Disturbed Sites, Pastures, Grasslands, Open Woodlands	Herb	Unintentional

Table 1. (Cont'd.).

Sr. No.	Botanical name/ author citation	Family	Common English Name	Global Distribution	Nativity	Flowering Period	Flower Color	Habit	Habitat	Status	Purpose of Introduction
33.	*Gnaphalium polycaulon* Pers.	Asteraceae	Cudweed	Asia, Australia, West Indies, Brazil, Egypt, Tropical and South Africa	South America	All the year	Pale Buff/ Purple-Tinged	Annual	Waste Lands	Herb	Unintentional
34.	*Heliotropium curassavicum* L.	Boraginaceae	Seaside Heliotrope, Salt Heliotrope, Quail Plant	America, Europe, Africa, Pakistan, India and Australia, Spain, Sri Lanka, Tanzania, Tunisia, Turkey, West Himalaya	Trop. America/Australia	March- October	White	Perennial	Riverbanks, Lakes Ponds, Wetlands, Desert Areas, Oases, Along Seashores, Dunes	Herb	Unintentional
35.	*Hibiscus rosa-sinensis* L.	Malvaceae	Chinese Hibiscus, Chinese Rose	India, Sri-Lanka, Thailand, South Africa, Philippines, Myanmar, China and Pakistan	Vanuatu (Oceania)	July-December	Red	Perennial	Ornamental Plant	Shrub	Ornamental
36.	*Imperata cylindrical* (L.) P.Beauv.	Poaceae	Cogonrass	Warm Temperate to Tropical Areas of the World	Trop. America			Perennial	Sandy Arears, Cultivated Fields	Grass	Ornamental
37.	*Ipomoea carnea* Jacq.	Convolvulaceae	Bush Morning Glory, Pink Morning Glory	Mexico to S. Tropical America, Asia	Tropical America	All the year round	Pink, Light Mauve	Perineal	Roadsides, Wastelands, Riversides, Drainage Ditches	Shrub	Unintentional
38.	*Lantana camara* L.	Verbenaceae	Common Lantana	Mexico Central America The Caribbean, Africa, India And In South-Eastern Asia, Pacific Islands	South America	Throughout The Year	Orange or Yellow, Turning to Red or Scarlet Later	Perennial	Roadsides, Wastelands, Railways, Parklands, Grasslands	Shrub	Ornamental
39.	*Lepidium didymum* L.	Brassicaceae	Lesser Swine-Cress	China, Taiwan, Germany, Mexico, Newzeland	South America	March- June	Greenish	Annual Or Biennial	Waste Lands, Roadsides, Cultivated Fields	Herb	Food
40.	*Malva parviflora* L.	Malvaceae	Cheese Weed	Europe, N. Africa, S. and W-Asia	Europe	March- May	White Pinkish at the Tips	Annual	Crop Fields, Waste Land, Grasslands, at Forest Edges, Wood, Stony Hills	Herb	Unintentional
41.	*Medicago sativa* L.	Fabaceae	Alfalfa, Lucerne	North America, Pakistan, India, Central Asia To Europe and N. Africa	Africa/Europe	May-September	Violet To Pale Lavender	Perennial		Herb	Fodder
42.	*Melia azedarach* L.	Meliaceae	Bead Tree, Persian Lilac	East Asia, India, Vietnam, Central, China, ,Sri Lanka, Nepal, Thailand, Indonesia, Philippines	Asia	April-May	Lilac	Perennial	Along Roadsides, Plains, Foothills	Tree	Medicinal
43.	*Morus alba* L.	Moraceae	Common Mulberry, Silkworm Mulberry, White Mulberry,	Central And Northern China, Tropical and Southern Africa, USA, Southern South America, Hawaii, Indian Subcontinent	Asia	February-April	White To Pinkish-Purple or Black	Perennial	Roadsides, Fields	Tree	Horticulture
44.	*Nasturtium officinale* W.T. Aiton	Brassicaceae	Watercress	Europe, central Asia, N & NE. Tropical Africa	Europe	March- July	Milky White	Perennial	Steady and Flowing Waters, Shores, Swamps	Herb	Unintentional
45.	*Nerium oleander* L.	Apocynaceae	Oleander/ Nerium	Temperate and Subtropical Areas, China, India	Asia/Europe	June- October	Red/ Pink in Wild, In Cultivars White, Cream	Annual	Riverbanks, River Gravels	Shrub	Ornamental
46.	*Oxalis corniculata* L.	Oxalidaceae	Yellow Sorrel	A Cosmopolitan Weed	Europe	March - December	Pale Yellow	Annual/ Perennial	Wastelands, Garden Weed	Herb	Unintentional

Table 1. (Cont'd.).

Sr. No.	Botanical name/ author citation	Family	Common English Name	Global Distribution	Nativity	Flowering Period	Flower Color	Habit	Habitat	Status	Purpose of Introduction
47.	*Paspalum paspalodes* (Michx.) Scribn.	Poaceae	Knotgrass	Tropics and Sub-Tropics Throughout the World	Trop. America	April-May and Again August-September	Pale Green	Perennial	Gardens, Ditches, Rice Fields	Grass	Unintentional
48.	*Passiflora incarnata* L.	Passifloraceae	Purple Passionflower, Maypop	Southeast United States	Central America	July -August	Purplish Blue	Perennial	Sandy Soil, Low Moist Wood, Open Areas	Shrub	N/A
49.	*Passiflora suberosa* L.	Passifloraceae	Corky Passionflower	S. America, C. America Caribbean; Se N. America, East Asia, Australia, India And Southern And Eastern Africa	South America	July- October	Pale Greenish or White	Perennial	Open Woodlands, Wastelands, Gardens, Riparian Vegetation	Herb	Unintentional
50.	*Persicaria glabra* (Wild.) M.Gómez	Polygonaceae	Dense Flower Knotweed	Tropical Asia, Pakistan, India, Malaysia, Philippine Africa	North America and Eurasia	April-November	Pink	Perennial	Ditches, Riverbanks, Lakes, Plains to 1000 M in or Near Water	Shrub	Unintentional
51.	*Phragmites australis* (Cav.) Trin. ex Steud.	Poaceae	Common Reed	Temperate Regions of Both Hemispheres in The Old World and The New.	Australia	July –October	Purple	Perennial	Shallow water, Wet soil, Extremely Poor Soils and Very Acid Habitats	Grass	Unintentional
52.	*Phyla nodiflora* (L.) Greene	Verbenaceae	Frog Fruit	Warmer Regions of The Temperate Zone to The Tropical Zone All Around the World	South America	March-June	Light Pink White	Perennial	Stream Banks, Grassy Places	Herb	Ornamental
53.	*Physalis divaricata* D. Don	Grossulariaceae	Pygmy Ground cherry	Afghanistan, Nepal	America	August-October	Yellow	Annual	Wastelands, Crop Fields, Roadsides	Herb	N/A
54.	*Plantago major* L	Plantaginaceae	Broadleaf Plantain, White Man's Foot	Europe, Northern and Central Asia	Europe	August. - September	Greenish/ Yellowish White	Perennial	Gardens, Lawns, Grassy Riverbanks	Herb	Unintentional
55.	*Portulaca oleracea* L.	Portulacaceae	Common Purslane	SW America, Warm Temperate, Tropical and Subtropical Regions Throughout The World,	South America	July-October	Yellow	Annual or Perennial	Crop Fields, Disturbed Sites, Gardens, Roadsides, Landscaped Areas	Herb	Food
56.	*Prosopis glandulosa* Torr.	Fabaceae	Honey Mesquite	Northern Mexico, Eastern Asia, Australia, Western Asia, Indian Sub-Continent, Tropical Southern America	South America	April-August	Yellow Green	Perennial	Grass Lands, Wastelands	Tree	N/A
57.	*Prosopis juliflora* (Sw.) DC.	Fabaceae	Ironwood, Mesquite	Mexico, Central America, Brazil, The Caribbean, Africa, Western Asia, Indian Sub-Continent	South America	March- June	Light Yellow	Perennial	Wastelands	Tree	Plantation
58.	*Ricinus communis* L.	Euphorbiaceae	Castor-Oil Plant	Tropical & Subtropical regions, Asia, Africa	Africa	Almost throughout the year	Yellow	Perennial	Dry Riverbeds, Waterways, Along Roadsides, railways, Wastelands Pastures, Gardens,	Shrub	Food
59.	*Ruellia tuberosa* L.	Acanthaceae	Meadow Weed, Minnieroot	Trop. America, Asia and Africa	Trop. S. America	March-June	Mauve/Bluish Purple	Annual	Riverbanks	Herb	Unintentional

Table 1. (Cont'd.).

Sr. No.	Botanical name/ author citation	Family	Common English Name	Global Distribution	Nativity	Flowering Period	Flower Color	Habit	Habitat	Status	Purpose of Introduction
60.	*Rumex hastatus* D. Don	Polygonaceae	Arrow Leaf Dock	E. Asia Himalayan, Afghanistan, Pakistan, India, Nepal, Bhutan, China	Asia	March-August	Pinkish Green	Perennial	Wastelands, Dry Mountain Slopes, Shady Slopes	Shrub	Medicinal
61.	*Salvinia modesta, molesta* D.S. Mitchell	Salviniaceae	African payal, aquarium water moss	South America, Africa, the Indian Sub-continent, south-eastern Asia, southern USA	South America	-	-	Perennial	Rivers, Streams, Lakes, Dams, Swamps, Irrigation Channels, Drainage Lines, Rice Crops	Fern	Unintentional
62.	*Sapium sebiferum* L.	Euphorbiaceae	Chinese Tallow Tree, Popcorn Tree	Tropical Asia, Japan, Northern Africa, Central and Southern Europe, Indian Sub-continent, South America	China/ Taiwan	January-February	Yellow	Perennial	Riverside, Wet Forests, Grassland	Tree	Ornamental
63.	*Sida cordata* Burm.f.	Malvaceae	Country-Mallow	Tropical & Subtropical Asia, Dominican Republic, Mauritius	South America	October - November	Yellow	Perennial	Wastelands, Roadsides	Herb	Unintentional
64.	*Silybum marianum* L.	Asteraceae	Milk Thistle	Southern Europe, South Australia, Southern Russia, Asia minor, North America	Africa/Europe	March- June	Purple	Annual	Waste Lands, along roadsides, Agriculture fields,	Herb	Unintentional
65.	*Sorghum halepense* (L.)Pers.	Poaceae	Johnson Grass	Europe, Mediterranean, Syria and Mauritania	Europe	May-October	Cream to Buff-Yellow	Perennial	Dry Open Habitats	Grass	Fodder
66.	*Tagetes minuta* L.	Asteraceae	Khaki bush, Mexican Marigold	South America, Tropics, Subtropics, Temperate Countries	South America	October	Yellow to orange	Annual	Waste Lands, Cultivated Lands, Roadsides	Herb	Ornamental
67.	*Taraxacum officinale* L.	Asteraceae	Dandelion	Eurasia, North Africa, North and South America, New Zealand, Australia	Europe	April-May	Yellow	Perennial	Roadsides, Cultivated Fields	Herb	Unintentional
68.	*Thuja orientalis* L.	Cupressaceae	Chinese Arborvitae, White Cedar	E Canada, E United States, E Asia, W China, N Korea	North America	March-May	Green	Perennial	Steep Dry Rocky Valley Slopes, Wet Forests	Tree	Ornamental
69.	*Tridax procumbens* L.	Asteraceae	Coatbuttons/ Tridax Daisy	Tropics and Subtropics	South America	All around the year	White, cream or pale yellow	Annual or Perennial	Cultivated Fields, Waste Lands	Herb	Unintentional
70.	*Trifolium alexandrium* L.	Fabaceae	Egyptian Clover, Berseem Clover	N. Africa - Egypt; W. Asia - Lebanon, Israel, Jordan	Asia	April- June	White	Annual	Cultivated Fields	Herb	Fodder
71.	*Trifolium repens* L.	Fabaceae	White Clover	Africa, Europe, The Middle East, Western Asia, Russia	Europe/Asia	April-June	White To Pale Pink	perennial	Grassland And Lawns, Parks, Roadsides, Wastelands	Herb	N/A
72.	*Verbena tenuisecta* Briq.	Verbenaceae	South American Moss Verbena	South America, Southern and Eastern Australia	South America	March- May	Purple	Annual	Roadsides, Pastures	Herb	Unintentional
73.	*Xanthium strumarium* L. P. P.	Asteraceae	Donkey Burr, Common Cocklebur	Temperate Zone, Subtropical Mediterranean Climates	South America	July-August	Greenish or yellowish	Annual	Along Roadsides, Cultivated Fields, coastal dunes	Herb	Unintentional

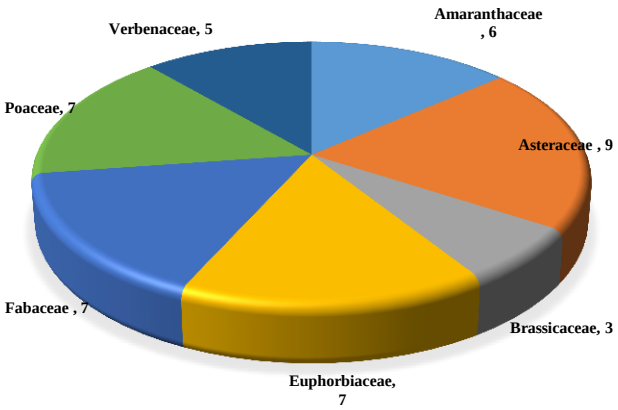

Fig. 5. Dominant families showing no. of invasive plant species in Lesser Himalayas-Pakistan.

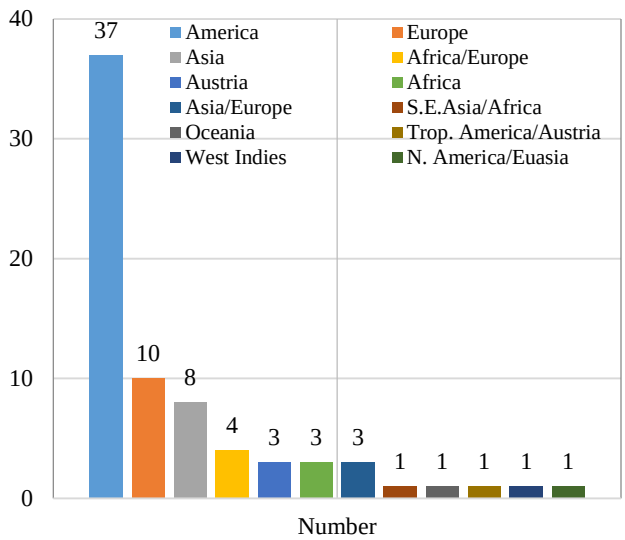

Fig. 6. Contribution of different continents to the alien flora of Lesser Himalayas-Pakistan.

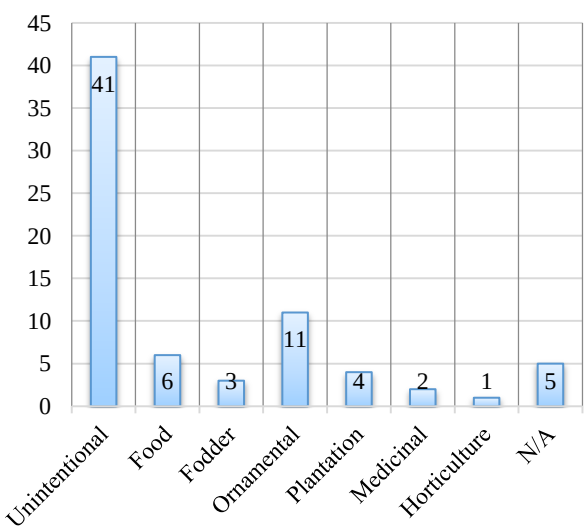

Fig. 7. Purpose of introduction of invasive species in Lesser Himalayas-Pakistan.

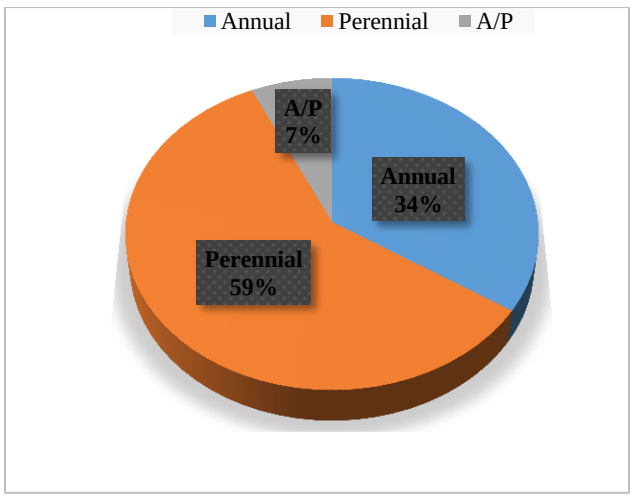

Fig. 8. Showing the Habit of invasive species in Lesser Himalayas-Pakistan.

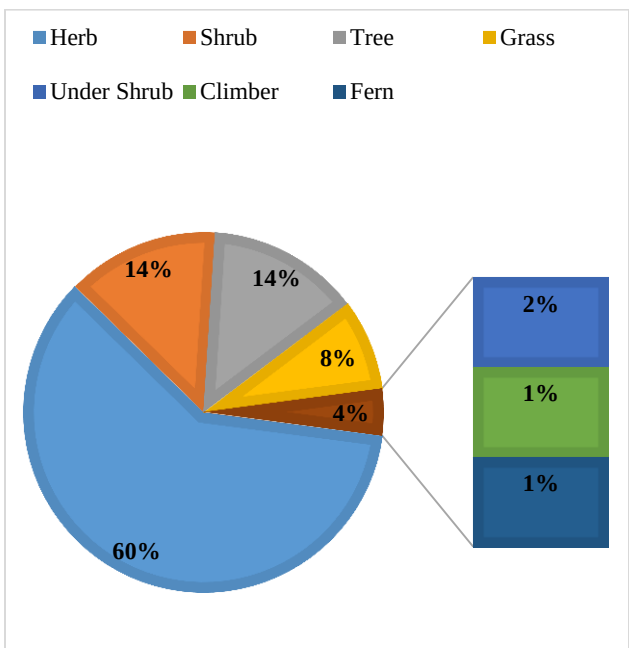

Fig. 9. Life forms / status of invasive plant species.

Conclusion

The present research provides insight on status of invasiveness of alien species of Lesser Himalayan region in Pakistan. Proper cataloguing regarding the alien invasive species is considered as an important aspect of conversation strategy that is unfortunately missing. Plant invasions adversely affect the indigenous flora, local community composition, ecosystem functions which results in loss of genetic biodiversity, species extinction, and huge ecological and economic imbalance. The risk of increase in population of alien invasive flora is growing day by day with the increase in tourism and global trade. Effective management of these species is urgently needed, which necessitates understanding of their morphology, ecology, phenology, physiology, reproductive biology, and phytochemistry. In Pakistan the major obstacles in handling the alien invasive plants problem are lack of awareness and

proper initiatives. So, to deal with alien plant species a better planning and clear policy approach is essential. It is hoped that listing and analysis of alien invasive plant species in Lesser Himalayan region of Pakistan will be helpful in filling the gap with respect to information of alien species. This analysis will also help in formulating management strategies for alien invasive plants species.

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