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Documentation of Aquatic Invasive Alien flora of Jammu region, Jammu and Kashmir

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Abstract

The present study deals with the first ever inventorisation and documentation of aquatic invasive alien plant species of Jammu region with background information on family, habit and nativity . Total 55 invasive alien plant species belonging to 24 families were documented. It was prepared based on history, species origin, species behaviour and field observations. A total of 15 different geographic regions in terms of nativity are recorded in the present study. Among these, more than 90% are contributed by four major geographical regions, viz., continent of America, Africa, Europe and Mediterranean. The American continents contributed majority of noxious invasive plants in Jammu region followed by the Europe and Africa respectively. The families Potamogetonaceae and Cyperaceae are the most dominant family with (7 sp. each) followed by Hydrocharitaceae (5 sp.) , Menyanthaceae , Poaceae and Alismataceae (3 sp. each) , Amaranthaceae , Ceratophyllaceae , Polygonaceae , Convolvulaceae , Typhaceae , Najadaceae , Ranunculaceae , Brassicaceae and Characeae with (2 sp. each) and least contributing families are Pontederiaceae , Cabombaceae , Salviniaceae , Isoetaceae , Marsileaceae , Apaceae , Juncaceae , Azollaceae and Plantaginaceae with (1 sp. each). Habit wise analysis shows herbaceous species share 65% (36 sp.) , followed by graminoid 20% (11sp.) , sedges 5.45% (3sp.) , algae 3.6% (2sp.) , Shrub ,climber and fern share 1.8% (1 sp. each).

Keywords : Aquatic Invasive Alien species; Nativity; Jammu; India

Introduction

The value of aquatic resources to humankind is obviously infinite and the induced changes in the goods and services they provide have a strong impact on human welfare. Convention for Biological Diversity visualize “biological invasion of alien species as the second worst threat after habitat destruction”. Aquatic Invasive Alien Species includes both aquatic plant and aquatic animal species that are non indigenous species which threaten the diversity or abundance of native species. Invasive aquatic plants are introduced plants that have adapted to living in, on, or next to water, and that can grow either submerged or partially submerged in water and are also referred to as “nuisance” and “exotic” species as they produce most significant threats to our water resource today. These species include non indigenous flora that may occur within inland, estuarine or marine waters and that presently or potentially threaten ecological processes and natural resources. In addition to the severe and permanent damage to the habitats they invade they also adversely affect individuals by hindering economic development, preventing recreational and commercial activities, decreasing the aesthetic value of nature, and serving as vectors of human disease along with drastically altering the patterns of biodiversity¹ and the supply of all main ecosystem services^{2,3} across the globe. Since the 1970s a significant increase in the non – indigenous species have been identified in harbours, ports, and other man – made areas. Aquatic invasive species can pose significant threats to the fish and other wildlife and their habitats. Introduced species may thrive best in areas where there has been some level of environmental disturbance^{4,5,6} . These species are a negative outcome of the closer integration of the global economic system and have been introduced into an area outside their natural distribution, either by accident or purpose and which have colonized or invaded their new home. Today in many continental areas 20% or more of the plant species are non-indigenous.

On many islands the proportion of non-indigenous plant species is 50% or more. The spread of these alien species is creating complex and far reaching challenges that threaten both the natural biological riches of the earth and the well being of its citizen. Some protected areas established to conserve native species have been profoundly affected by introduced species⁷. At the global scale, commercial trade propels rising annual and cumulative rates of invasion due to the development of new source and recipient regions, trade routes, and markets, as well as new products, larger and faster ships, and increased air transport^{8,9}. These species are transported intentionally as object of trade (e.g exotic animals for the pest trade, horticulture plants and livestock's) and unintentionally as contaminants (e.g plant disease introduced on crop germplasm and transport of aquatic species in ballast tanks of intercontinental ships. Alien species have often been or have carried human diseases and parasites^{10, 11}. As ecosystems become more connected by human activities the number of alien species continue to grow. Alien species have also been spread through the provision of humanitarian emergency food aid. Invasive weeds have faster rates of growth and biomass production compared to native species, high competitive ability, high reproductive efficiency including production of a large number of seeds, efficient dispersal, vegetative reproduction, rapid establishment and other traits that help them adapt to new habitats. Many of these species have allelopathic potential and possess high tolerance to different abiotic conditions. These invasive alien species are a major concern for National development and economic planning. Jammu is situated on a hillock, on the bank of river Tawi and also serves as base camp for the religious tourism attracting people from nation and world. The breathtaking landscape of this biodiversity rich region has attracted people of all walks of life, and also from far off regions of the world and its promotion as a global tourist destination, the region has witnessed intentional or unintentional introduction of varying faunal and floral elements from different phytogeographical regions of the world. Such anthropogenic influences along with pollution of freshwater ecosystems has promoted invasion of these disturbed habitats by non- native species. Taking note of the importance of studies on the aquatic alien invasive species, particularly in areas of high anthropogenic interference, present study is aimed at compiling the first ever documentation of aquatic flora of Jammu region along with supplementation of each species with information on origin, spread, habit and impact on local ecosystem.

Material and Methods

Study area

The State of Jammu & Kashmir is the northernmost and sixth most largest state of India covering an area of 2,22,236 sq.km. The state lies between 32°15' to 37°05' North latitude and 72°2'35' to 83°20' East latitude. The state ranks 6th in area and 17th in population among the states and Union Territories of India. Jammu is one of the three regions comprising India's northernmost area and is mirrored in the rugged beauty and unique culture of the people who live in their shadow of Jammu. Jammu region is sandwiched between the Vale of Kashmir to the north and the Daman Koh Plains to the south, the Shivalik Range comprises most of the region of Jammu. The Pir Panjal Range, the Trikuta Hills and the low-lying Tawi River of the branch Chenab River basin add beauty and diversity to the terrain of Jammu. Jammu's altitude ranges from 300 meters to 4200 meters. Jammu district falls in sub-mountainous region at the foothills of Himalayan Mountains. Shivalik Hills rises gradually in the north part of the district and merges with the Indo-Gangetic plain in the south. Jammu city is at an elevation of 1,030 feet above the sea level. Jammu district has a sub-tropical climate with hot and dry climate in summer; a warm and humid monsoon; and dry and cold climate in winter. Being in the foothills of the mountains, nights are generally cooler than the neighbouring areas of the Punjab. Minimum and Maximum temperature is around 4 degree Celsius and 47 degree Celsius respectively. Rainy season usually starts from the end of June or the beginning of July. Average rainfall in the district is about 1,246 mm. A large part of the State forms part of the Himalayan Mountains. Due to extreme whether in summers and winters it is also known as the City of Rocks. Owing to the vast variety of edapho-climatic and physiographic heterogeneity; the district harbours diverse habitats, including swamps, marshes, rivers, streams, cultivated fields, orchards, wetlands and lakes which support equally diverse faunistic and floristic elements.

Methods

There is an apparent need for a regional and national authentic database on invasive plants for monitoring the spread and impact in various regions and for devising appropriate management strategies. In Jammu, comprehensive studies on aquatic invasive species and plant invasions are still missing. In view of this, the present study attempted to focus on the invasive species in flora of Jammu. Intensive field studies were conducted in a planned manner repeatedly in different seasons in order to get maximum representation of aquatic invasive species in different habitats, *i.e.* Lakes, Rivers, Wetlands, Ponds, Nallahs, Swampy areas, etc in different parts of Jammu. Almost the entire geographical area (5 districts) was surveyed *viz.* District Jammu, District Kathua, District Samba and District Poonch. Plant samples were collected from natural habitats, streams, village ponds, agricultural fields, riverine system, nallahs, wetlands, marshy lands, lakes etc to document almost all the floristic components of Jammu region. The survey and data collection on the aquatic invasive species of Jammu district was carried out from March, 2011 - April, 2012. The study followed a random sampling method so that no bias is introduced. The field books were maintained to note down information's regarding the collection number, date of collection, local name, family, habit, habitat & impacts on ecosystem. The species were collected systematically and preserved for identification. The plant material collected during each visit was carried to the laboratory and was properly preserved and herbarium sheets were made using conventional methods of processing and drying. After an extensive review of literature on global invasive species ^{12,13,14,15,16,17,18,19,20,21} and of India and their spread based on history, species origin, species behaviour and field observations, a list of species of plant invasion was prepared. The websites were also examined extensively for background information. The nativity of the aquatic invasive plants was recorded from the published literature.

Results

Preliminary botanical exploration of Jammu region revealed this region to be quite rich so far as aquatic and marshy plants are concerned and also found to be more susceptible for the invasion of alien species. During the course of investigations, species have been recorded from various waterbodies including two major Lakes *viz.* Lake Mansar, Lake Surinsar along with big and small rural and urban ponds, nallahs, wetlands, streams, agricultural fields and agricultural water canals. Among the 55 collected species belonging to 24 families recorded from Jammu region (**Table 1**), maximum contributing families are Potamogetonaceae and Cyperaceae with (7 sp. each) followed by Hydrocharitaceae (5 sp.), Menyanthaceae, Poaceae and Alismataceae (3 sp. each) Amaranthaceae, Ceratophyllaceae, Polygonaceae, Convolvulaceae, Typhaceae, Najadaceae, Ranunculaceae, Brassicaceae and Characeae with (2 sp. each) and least contributing families are Pontederiaceae, Cabombaceae, Salviniaceae, Isoetaceae, Marsileaceae, Aplanaceae, Juncaceae, Azollaceae and Plantaginaceae with (1 sp. each). Habit wise analysis shows herbaceous species share 65% (36 sp.), followed by graminoid 20% (11 sp.), sedges 5.45% (3 sp.), algae 3.6% (2 sp.), Shrub, climber and fern share 1.8% (1 sp. each). A total of 15 different geographic regions in terms of nativity are recorded in the present study. Among these, about 90% are contributed by four major geographical regions, *viz.*, continent of America (26 sp.), Europe (18 sp.), Africa (17 sp.) and Mediterranean (3 sp.). The American continents contributed majority (48%) of aquatic invasive plant species. The Africa and Europe contribute 32% and 30% respectively. Herbs constitute 65% (36 plants), graminoid 20% (11 plants). Three sedges recorded as an invasive species namely, *Scirpus acutus*, *S.articulatus* and *S.subterminalis* whereas 1 fern sp. *viz.* *Azolla pinnata*., 1 climber sp. *viz.* *Ipomea aquatica* and 1 shrub sp. *viz.* *Ipomea carnea* have been recorded apart from 2 algal sp. *viz.* *Chara braunii* and *Chara fragallis*. (**Figure 1**). The aquatic invasive species were found to dominate in almost all the water bodies. When present in a habitat, they were also observed to reduce the occurrence of associated species leading to a serious damage to the native biodiversity by harming both the flora and the associated faunal content. They were also observed to possess more than one mode of reproduction.

Discussion

While a number of lists of invasive plant species are in worldwide circulation, criteria used in these listings often are not documented clearly. Surveys have shown that more than half of exotic plant species currently spreading naturally were intentionally introduced, and that most of the exotic species that endanger India's native ecosystems were first introduced for horticultural purposes. Thus reducing the intentional use of high-risk exotic plants could reduce the spread and impact of invasive plants in the country. All these species reported here, were reported as weeds in other countries or invasive alien plants in most of the regions. These invasive are widely distributed in all kinds of ecosystems throughout the world, and include all categories of living organisms. In Jammu region, comprehensive studies on aquatic invasive species and plant invasions are still missing. In view of this, present study was aimed at compiling the first ever documentation of the aquatic alien flora of Jammu region. Such documentation will help in monitoring of invasion. These listed aquatic invasive alien species will serve as basic information for future research towards the conservation of endemic and natural vegetation of the region. Almost 80% of the aquatic invasive alien plant species were introduced from Neotropics. Of these, some species may have invaded only a restricted region, but have a huge probability of expanding, and causing great damage. Other species may already be globally widespread and causing cumulative but less visible damage. Of the 60 species listed as invasive alien species in Jammu, 75% are herbs, 10% shrubs, 5% grasses, 4% trees and 3% climbers and sedges. Maximum contribution to the invasive alien species is from American region. Although IAS is a growing reality in India, they are still largely ignored and unnoticed, thus getting a good opportunity to expand all over the country. A very few isolated accounts of IAS in India are available: ^{22,23,24,25,26,27,28,29,30,31,32} Jammu is situated on a hillock, on the bank of river Tawi and also serves as base camp for the religious tourism attracting people from nation and world. Jammu is also the Railhead of the state. The breathtaking landscape of this biodiversity rich region has attracted people of all walks of life, and also from far off regions of the world and its promotion as a global tourist destination, the region has witnessed intentional or unintentional introduction of varying faunal and floral elements from different phytogeographical regions of the world. Taking note of the importance of studies on the aquatic alien invasive species, particularly in areas of high anthropogenic interference, a better planning is needed for early detection and reporting of infestations of spread of new and naturalized weeds by creation of plant detection network. This is the first report of aquatic Invasive alien species in Jammu region (J&K). With further research the addition of new invasive alien species would be made to the list.

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Table 1: Aquatic Invasive species of Jammu Region

SN	Name of Species	Family	Habit	Nativity
1.	<i>Eicchornia crassipes</i>	Pontederiaceae	Herb	Trop.America,W.Brazil
2.	<i>Camboba caroliana</i>	Cabombaceae	Herb	S.Brazil
3.	<i>Hydrilla verticilla</i>	Hydrocharitaceae	Herb	Asia,Africa,Australia
4.	<i>Vallisneria americana</i>	Hydrocharitaceae	Herb	Asia,Australia,U.S,Canada
5.	<i>Vallisneria spiralis</i>	Hydrocharitaceae	Herb	Southern Europe
6.	<i>Elodea canadensis</i>	Hydrocharitaceae	Herb	N.America
7.	<i>Egeria densa</i>	Hydrocharitaceae	Herb	S.America
8.	<i>Alternanthera piloxeroides</i>	Amaranthaceae	Herb	S. America
9.	<i>Alternanthera sessiles</i>	Amaranthaceae	Herb	Australia,Asia
10.	<i>Ceratophyllum demersum</i>	Ceratophyllaceae	Herb	N.America
11.	<i>Ceratophyllum submersum</i>	Ceratophyllaceae	Herb	Africa,Asia and America
12.	<i>Salvinia molesta</i>	Salviniaceae	Herb	N.Argentina,S.E Brazil
13.	<i>Polygonum glabrum</i>	Polygonaceae	Herb	S.America,S.E U.S
14.	<i>Polygonum barbatum</i>	Polygonaceae	Herb	E.Asia,Australia,Trop.Africa
15.	<i>Isoetes lacustris</i>	Isoetaceae	Graminoid	Europe,N.America,Canada
16.	<i>Marsilia quardiflora</i>	Marsileacea	Herb	Europe,S.Asia
17.	<i>Ipomea carnea</i>	Convolvulaceae	Shrub	S.America
18.	<i>Ipomea aquatica</i>	Convolvulaceae	Vine/Climber	Central to S.China
19.	<i>Potamogeton natans</i>	Potamogetonaceae	Herb	Northern hemisphere
20.	<i>Potamogeton crispus</i>	Potamogetonaceae	Herb	N.America,Australia,Eurasia,Africa
21.	<i>Potamogeton pectinatus</i>	Potamogetonaceae	Herb	N.America,Europe,Africa
22.	<i>Potamogeton perfoliatus</i>	Potamogetonaceae	Herb	N.America Australi,Eurasia,Africa
23.	<i>Potamogeton lucens</i>	Potamogetonaceae	Herb	South & mid-east England
24.	<i>Potamogeton Nodusus</i>	Potamogetonaceae	Herb	N.America,Australia,Eurasia,Africa
25.	<i>Potamogeton pusillus</i>	Potamogetonaceae	Herb	Florida
26.	<i>Scirpus acutus</i>	Cyperaceae	Sedge	N.America
27.	<i>Scirpus articulatus</i>	Cyperaceae	Sedge	N.America
28.	<i>Scirpus subterminalis</i>	Cyperaceae	Sedge	N.America
29.	<i>Cyperus difformis</i>	Cyperaceae	Graminoid	S.Europe,Africa,Asia,Australia
30.	<i>Cyperus tenuispica</i>	Cyperaceae	Graminoid	Africa,Asia
31.	<i>Cperus iria</i>	Cyperaceae	Graminoid	E.Africa,C.Asia,Australia,Japan
32.	<i>Eleocharis plantagineum</i>	Cyperaceae	Graminoid	S & E.Asia,Polynesia
33.	<i>Caldesia parnassifolia</i>	Alismataceae	Herb	Europe,Africa,China,Australia
34.	<i>Saggitaria subulata</i>	Alismataceae	Herb	S.America
35.	<i>Alisma plantang aquatica</i>	Alismataceae	Herb	Africa
36.	<i>Azolla pinnata</i>	Azollaceae	Fern	Africa,S.E Asia,Australia
37.	<i>Typha angustata</i>	Typhaceae	Graminoid	Australia,New-Zealand

38.	<i>Typha aria</i>	Typhaceae	Graminoid	Trop.America
39.	<i>Najas graminea</i>	Najadaceae	Herb	S.Europe,Eastern Asia
40.	<i>Najas minor</i>	Najadaceae	Herb	Europe,Asia
41.	<i>Arundo donax</i>	Poaceae	Graminoid	E & S.Asia,Australia
42.	<i>Hymenachne amplexicaulis</i>	Poaceae	Graminoid	N.America,S.America,Asia,Australia
43.	<i>Paspalidium germinatum</i>	Poaceae	Graminoid	Africa,Asia,N.America,S.America
44.	<i>Nymphoid indica</i>	Meayanthaceae	Herb	Pantropical Africa
45.	<i>Nymphoid aquatica</i>	Meayanthaceae	Herb	N.America
46.	<i>Nymphoid Cristata</i>	Meayanthaceae	Herb	Trop.& Temp.Asia
47.	<i>Ranunculus arvensis</i>	Ranunculaceae	Herb	Europe
48.	<i>Ranunculus sclerata</i>	Ranunculaceae	Herb	N.America,Eurasia
49.	<i>Veronica anagallis aquatica</i>	plantaginaceae	Herb	Europe,Africa,Temp.Asia
50.	<i>Nausturtium officinal</i>	Brassicaceae	Herb	Europe,Asia
51.	<i>Cardamine hirsuta</i>	Brassicaceae	Herb	Europe, N.Africa, South-east Asia
52.	<i>Chara braunii</i>	Characeae	Green algae	Europe,N.America
53.	<i>Chara fragallis</i>	Characeae	Green algae	Australia,India
54.	<i>Oenanthes crocata</i>	Apiaceae	Herb	Europe, Africa
55.	<i>Juncus articulatus</i>	Juncaceae	Graminoid	Europe, Australia

Fig 1:Aquatic invasive alien plant

