Journal of Agriculture and Environment for International Development - JAEID 2018, 112 (1): 43-64
DOI: 10.12895/jaeid.20181.693

Expansive alien flora of Odisha, India

Taranisen Panda[1*], Nirlipta Mishra[2], Bikram Kumar Pradhan[1] and Raj Ballav Mohanty[3]

[1] *Department of Botany, Chandbali College, Chandbali, Odisha, India*
[2] *Department of Zoology, Chandbali College, Chandbali, Odisha, India*
[3] *Satya Bihar, Rasulgarh, Bhubaneswar, Odisha, India*

**Corresponding author: taranisenpanda@yahoo.co.in*

Submitted on 2017, 10 October; accepted on 2018, 17 June. Section: Research Paper

Abstract: The present paper documents the expansive alien flora of Bhadrak district, Odisha, India based on data obtained from field exploration and literature consultations. Eighty seven expansive alien species of 64 genera and 40 families are documented. Of these, 52 species are being used for medicinal purposes as reported by local inhabitants. Asteraceae is found to be most dominant family contributing 12 species to the list. Most of the expansive alien flora of the district belongs to American continent (70.1%) and African continent (17.2%). Growth form analysis shows herbs share 64 species(forbs 58 species and grasses 6 species) followed by shrubs (10 species), trees (5 species) and climbers (8 species) respectively. Out of 87 expansive alien species 13 have been introduced purposely while rest accidentally during import of food grains. *Ageratum conyzoides* L., *Eichhornia crassipes* (C. Martius) Solms., *Lantana camara*L. and *Mikania micrantha* Kunth. are spreading and covering the habitat faster than native species, exerting severe pressure on functioning of ecosystems as well as species diversity. A better planning in the form of early identification, reporting and control of the expansive alien flora of Bhadrak district is warranted.

Keywords: Biological invasions; list of expansive alien plants; nativity; uses

Introduction

Expansive alien species are exotic organisms that have been introduced by human beings intentionally for social or personal gain or accidentally from one region of the world to another from time immemorial (Levine, 1989; Pysek *et al*., 2004**).** Natural disaster such as flood and cyclone can also play the role to introduce alien species to a new habitat. The impact of expansive alien species on biodiversity and ecosystems could be a serious threat (Pearce, 2015; Paini *et al*., 2017; Ricciardi *et al*., 2017) next to direct habitat destruction (Hobbs and Humphries, 1995; Preston and Williams, 2003). Several characteristics of the species help them to be expansive like faster

growth rate, their higher competitive ability, higher reproductive efficiency producing large quantity of seeds in prolific rate having dispersal ability through air and water, vegetative reproduction, production of allelochemicals and rapid establishment that help them to adapt new habitats (Callaway and Aschehoug, 2000; Drake *et al.*, 2003; Simberloff *et al.*, 2005; Sharma *et al.*, 2005; Huang *et al.*, 2009). Once the expansive alien species has become dominant, reestablishment of native species is rarely successful (Davies and Shelley, 2011).The mode of speedy resource acquisition and consumption of the expansive alien species may cause drastic alteration in soil structure, its profile, rate of decomposition, nutrient dynamics and moisture availability (Walck *et al.* 1999; Vila and Weiner, 2004). Consequently its impact on the biodiversity and ecosystems become a serious hindrance for conservation and sustainable use of biodiversity.

At least 10% of the world's vascular floras (around 300,000) have the potential to invade other ecosystems and affect local biota in direct or indirect ways (Singh *et al.*, 2006). In the tens rule (Williamson and Fitter 1996) three stages of invasion are distinguished. Imported species are those brought into a country, while introduced are those found in the wild. Those forming self-sustaining populations are called established. The categories are nested: established are both introduced and imported, and introduced are also imported. Botanists have traditionally called species that are introduced, but not established, casuals; the established are called naturalized. The transition from imported to introduced, which can be called escaping, has a probability of around 10% in many cases, and the probability of establishing is also often about 10% (Williamson and Fitter, 1996). Recent studies have documented that expansive alien plant species may dislocate or harmfully affect indigenous species and wildlife habitats (Sax and Gaines 2000; Walther *et al.*, 2009; McGeoch *et al.*, 2010; Pysek *et al.*, 2011; Bellard *et al.*, 2016; Doherty *et al.*, 2016), negative impacts on ecosystem structure, function and hydrology (Sanders *et al.* 2003; Traveset and Richardson, 2006; Khanna, 2009; McGeoch *et al.*, 2010; Maguire *et al.*, 2011; Simberloff *et al.*, 2013; Foxcroft *et al.*, 2014), undesirable impact on animal health (Khanna, 2009; Sing and Peterson 2011), losses to economy (Pimentel *et al.*, 2001; Khanna, 2009) of the area they enter by force. The increase of international trade of ornamental and forage plants, human migration, climatic change, habitat destruction, industrialization and urbanization, fast economic development and population growth have only accelerated the invasive process (Meyerson and Mooney, 2007; Pysek *et al.*, 2008; Walther *et al.*, 2009; Bhatt *et al.*, 2012). Currently some investigations have centered on expansive alien species and their unconstructive role on ecosystem services in different countries of the world (Sax and Gaines 2000;Walther *et al.*, 2009; McGeoch *et al.*, 2010; Sing and Peterson, 2011). In this context, when the case of India is concerned about 18% of the flora of this country constitute aliens, of which 55% are

from American origin, 30% Asian as well as Malaysian and remaining 15% belongs to European and Central Asian countries (Nayar, 1977). But studies on this aspect are sporadic in India (Khanna, 2009; Bhatt *et al.*, 2012) and still lacking in Odisha. So the present study was planned and conducted for identification, documentation origin, diversity etc. of alien and expansive species of Bhadrak district, to focus on the threat and possible hazards they are creating on the native flora and fauna of this locality.

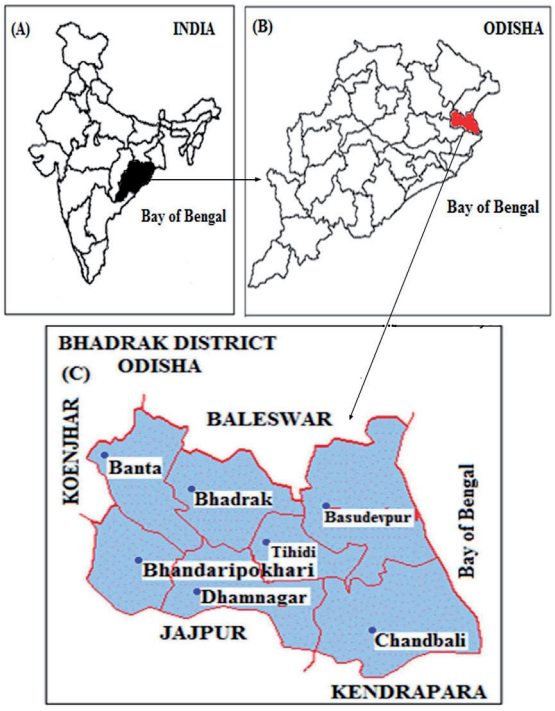

Fig. 1 - A) Location of Odisha state in the eastern region of India B) map of the Odisha state C) study area showing different blocks of the Bhadrak district

Materials and Methods

Study site

India has a characteristic geographic location at the junction of the three major biogeographic realms, namely the Indo-Malayan, the Eurasian and the Afro-tropical (6° 45' to 37° 6' latitude and 68° 7' to 97° 25' E longitude) with a land frontier of about 15,200 km and a coastline of 7,516 km. It is the seventh largest country in the world and the second largest in Asia; with human population of more than 1 billion. The

country is administratively divided into 29 States and 7 Union Territories. Due to the geographical vastness and topographical heterogeneity, the country experiences a tropical to sub-tropical climate with three distinct seasons i.e. hot summer (late April-late June), rainy monsoon (late June-mid September), and mild winter (mid November- late March). The bio-climatic diversity ranges from sea level to the highest mountain ranges; hot-arid conditions in the West to tropical evergreen forests in North-east and Western Ghats; cold-arid conditions in the trans-Himalayas to mangroves of Sunderbans; and freshwater aquatic to marine ecosystems (Negi, 1986).

Odisha is the ninth largest state of India by area and the eleventh largest by population. It is located in the east coast of India (17.48^0 – 22.34^0N and 81.24^0 – 87.29^0E) with the Bay of Bengal forming its eastern and south eastern frontiers. With the eastern Ghat range of hills, almost passing through the heart of the state, high Similipala hills on its north and around 480 kms of coast line on its east, Odisha having varied ecosystems from marine to semi-arid on the west provides 'niches' for diverse animal and plant communities (Patnaik 1996). The entire territory lies in the tropical zone as a result of which high temperature is recorded particularly during April-May. However, the sea exercises a moderating influence over the climate of the coastal belt whereas the hill tracts experience an extreme climate. The vegetation found in this region is tropical moist deciduous forest type (Champion and Seth 1968).

Bhadrak district (20° 43'–21° 13' N and 86° 6'–87° E) is located in Northeast Odisha. It spreads over 2505 km^2 having 1.507 million inhabitants (2011 Census). Four other districts namely Balasore, Kendrapara, Jajpur and Koenjher surround Bhadrak district while a part is bounded by the Bay of Bengal (Fig. 1). The district covers about 1.61 % of the total land area of the state and contributes 3.59 % of the state's population. About 86.66 % of the inhabitants are villagers and the people are engaged in agricultural practices as their primary occupation. Being situated in close proximity to Bay of Bengal, the district is characterized by periodic earth tremors, thunder storms in the rains and dust storms in April and May. Some of the flora which grow in abundance in the region are: *Acacia nilotica* (L.) Delile., *Anacardium occidentale* L., *Annona squamosa* L., *Artocarpus heterophyllus* Lam., *Averrhoa carambola* L. *Azadirachta indica* A. Juss., *Bambusa vulgaris* Schrad., *Bombax ceiba* L., *Borassus flabellifer* L., *Butea monosperma* (Lam.) Taub., *Cassia fistula* L., *Calophyllum inophyllum* L., *Crataeva nurvata* (Buch.) Ham., *Ficus benghalensis* L., *Ficus religiosa* L., *Gmelina arborea* Roxb., *Kigelia africana* (Lam.) Benth., *Mangifera indica* L., *Mimusops elengi* L., *Morinda citrifolia* L., *Phoenix sylvestris* (L.) Roxb., *Polyalthia longifolia* (Sonn.)Thw., *Pongamia pinnata* (L.) Pierre., *Pterocarpus marsupium* Roxb., *Samanea saman* (Jacq.) Merr. J. Wash., *Spondias mangifera* Willd., *Streblus asper* Lour., *Syzygium cumini* (L.) Skeels., *Tamarindus indica* L. and *Terminalia arjuna* (Roxb.ex DC.) Wight & Arn.

Data collection

Extensive field surveys (June 2013- May 2015) were carried out to document and enlist the expansive alien floras in diverse habitats, i.e. cultivated fields, waste lands, river banks, roadsides, water bodies, marshes, pathways, parks, private gardens and other relevant localities of the district following established and standard procedures (Jain, 1987; Martin, 1995). The information on the expansive alien plants was obtained through a combination of tools and techniques of structured questionnaires, complemented by free interviews and informal conversations (Martin 1995; Huntington 2000). The information regarding the expansive alien plant species has been gathered mostly from local farmers, elderly and knowledgeable persons. Personal interviews and group discussions carried out in the local language revealed specific information about the plants, which were further compared and authenticated by crosschecking (Cunningham, 2001).During field study, some of the field characters like habit, habitat, mode of spread and nature of expansiveness of alien species were examined. The economic uses of these species if any were discussed with the local people. Samples of recorded herbs, twigs of shrubs, climbers and trees were identified using relevant vegetation (Haines, 1925; Saxena and Brahmam, 1996).

The plant species are enumerated and arranged as per Angiosperm Phylogeny Group III Classification (APG III, 2009). During the investigation, some of the plants were also photographed. The voucher specimens were deposited in the herbarium of the Department of Botany, Chandbali College, Chandbali. Previously collected literatures by other scholars concerning nativity of species (Negi and Hajra, 2007; Reddy, 2008; Khanna, 2009; Singh *et al*., 2010; Khuroo *et al*., 2012) were consulted. The invasive plants were represented alphabetically according to their scientific names, habit, local name if any, family, nativity and uses.

Results

In the present study 87 expansive alien plants from 35 families belonging to 64 genera are documented from the study region as per APG III classification. (Table 1; Fig. 2). Among the reported plants, 27.6% of the taxa are recorded from the superorder Malvids, 25.3% from superorder Lamids, 27.2% from superorder Fabids, 13.8% from Companulids and 10.4% from superorder commelinids. Magnolids, Monocots and Eudicots account for about 5.7% of the species in the Bhadrak district. Asteraceae contributes the largest number of species (12 spp.) followed by Convolvulaceae, Fabaceae (6 sp. each), Amaranthaceae, Malvaceae, Poaceae, Solanaceae (5 sp. each), and Apocynaceae, Lamiaceae, Onagraceae (3 sp. each) (Fig. 3). Twenty families are represented by one species, contributing 57% of the total number families in the inventory. In terms of generic richness *Cassia, Ipomoea* and *Cleome* (4 sp. each)

ranked highest followed by, *Corchorus*, *Solanum* and *Ludwigia* (3 sp. each). With regard to the area of origin of expansive alien species, the contributions of different geographical regions are listed in figure 4 and Table 1. It is demonstrated that 70.1% of the expansive alien species of Bhadrak district were American followed by African (17.2%), Asian (3.5%), European (3.5%), Mediterranean (2.3%) and Australian (1.2%). Annuals comprise about 52.9% (46 sp.) and the remaining are perennials. Habit wise distribution analysis (Fig. 5) revealed that herbs were represented a higher proportion (64 species; forbs 58 species; 66.7% and grasses six species; 6.9%) followed by Shrubs (10 species; 11.5%), trees (five species; 5.7%) viz., *Annona reticulata* L., *Borassus flabellifer* L., *Kigelia africana* (Lam.) Benth., *Prosopis juliflora* (Sw.) DC. and *Ziziphus mauritiana* Lam. and eight climbers (9.2%) (Table 1 and Fig. 5). The plant species were classified through Raunkiaer (1934) classification. The Therophtes was the most dominant class with 44 plant species (50.6%) followed by Phanerophytes with 19 species (21.8%), Chemaephytes with 9 species (10.3%), Hydrophytes with 7 species(8.1%), Hemicryptophytes with 5 species (5.8%),Cryptophytes with 2 species (2.3%) and helophytes having one species (1.1%) respectively. In terms of habitat, we found that wastelands ranked highest (66.3%), followed by agricultural lands (11.2%), road sides (9.2%), aquatic (7.2%) and others (6.1%). The use of expansive alien species for different purposes as indicated by local people is same as the literature reviewed. *Alternanthera sessilis* (L.) DC., *Chenopodium album* L., *Ludwigia adscendens* (L.) Hara, *Oxalis corniculata* L. and *Portulaca oleracea* L. for instance are edible while *Borassus flabellifer* L. is being used for hand-held fan. Of 87 species, fifty species are used for medicinal purposes by the indigenous people while the uses of 24 species are unknown to local people. Out of 87 species, only 11 species namely, *Ageratum conyzoides*, *Cassia alata*, *Chenopodium album*, *Eichhornia crassipes*, *Ipomoea quamoclit*, *Lantana camara*, *Mirabilis jalapa*, *Passiflora foetida*, *Portulaca oleracea, Prosopis juliflora and Solanum nigrum* are introduced deliberately purposely; the rest accidentally during trade exchange including grain import. Further, it has been observed that few species like *Ageratum conyzoides, Eichhornia crassipes, Lantana camara*, *Mikania micrantha* and *Parthenium hysterophorus* are highly expansive and caused considerable ecological damages to indigenous floristic composition (Fig. 6). A questionnaire survey among the informants revealed that there were hardly any management programmes to control expansive alien plants such as *L. camara Mikania micrantha, Ageratum conyzoides* and *Parthenium hysterophorus* and many of them mentioned that alien species were cleared to raise plantations or clear-off roadsides. The only method that they knew for control was to manually cut and burn.

Table 1 - Expansive alien plant species of Bhadrak district, Odisha, India

Name of the Species	Family	Origin Area	LF	Habit	Life span	Habitat	Uses
Acanthospermum hispidum DC.	Asteraceae	Brazil	Th	Forb	Annual	Wasteland	Medicinal
Ageratum conyzoides L.	Asteraceae	Central America	Th	Forb	Annual	Wasteland	Medicinal
Alternanthera philoxeroides (Mart.) Griseb.	Amaranthaceae	Central America	Hyd	Forb	Perennial	Aquatic	Fodder
Alternanthera sessilis (L.)DC.	Amaranthaceae	Central America	Hyd	Forb	Perennial	Aquatic	Medicinal, Vegetable
Amaranthus spinosus L.	Amaranthaceae	Central America	Th	Forb	Annual	Cultivated field, Wasteland	Medicinal, Fodder
Annona reticulata L.	Annonaceae	Central America	Ph	Tree	Perennial	Cultivated field,Wasteland	Medicinal, Fruit edible
Antigonon leptopus Hook. & Arn.	Polygonaceae	Central America	Th	Climber	Perennial	Along roadside	Medicinal
Argemone mexicana L.	Papaveraceae	South America	Th	Forb	Annual	Cultivated field, Wasteland	Medicinal
Boerhavia diffusa L.	Nyctaginaceae	Tropical Africa	Th	Forb	Perennial	Wasteland	Medicinal
Blumea lacera (Burm. F.) DC.	Asteraceae	Central America	Th	Forb	Annual	Wasteland	Medicinal
Borassus flabellifer L.	Arecaceae	Tropical Africa	Ph	Tree	Perennial	Wasteland	Articrafts Medicinal
Calotropis gigantea (L.) R. Br.	Apocynaceae	Tropical Africa	Ph	Shrub	Perennial	Wasteland	Medicinal
Calotropis procera (Ait.) R. Br.	Apocynaceae	Tropical Africa	Ph	Shrub	Perennial	Wasteland	Medicinal
Cannabis sativa L.	Cannabaceae	Central Asia	Th	Forb	Annual	Wasteland	Medicinal
Cassia absus L.	Fabaceae	Central America	Th	Forb	Annual	Along roadside	Not Known
Cassia alata L.	Fabaceae	South America	Ph	Shrub	Perennial	Wasteland	Medicinal
Cassia occidentalis L.	Fabaceae	South America	Ph	Forb	Perennial	Wasteland	Medicinal
Cassia tora L.	Fabaceae	South America	Th	Forb	Annual	Wasteland	Medicinal
Catharanthus roseus L.	Apocynaceae	Central America	Th	Forb	Perennial	Wasteland	Medicinal

Chamaesyce hirta (L.)Millsp.	Euphorbiaceae	Central America	Th	Forb	Annual	Wasteland	Medicinal
Cissampelos pareira L.	Manispermaceae	South America	Ch	Climber	Perennial	Wasteland	Medicinal
Chenopodium album L.	Amaranthaceae	Europe	Th	Forb	Annual	Cultivated field	Vegetable
Chloris barbata (L.) Sw.	Poaceae	Central America	He	Grass	Perennial	Wasteland	Not Known
Cleome gynandra L.	Cleomaceae	Central America	Th	Forb	Annual	Wasteland	Medicinal
Cleome monophylla L.	Cleomaceae	Tropical Africa	Th	Forb	Annual	Along roadside	Not Known
Cleome rutidosperma DC.	Cleomaceae	Central America	Th	Forb	Annual	Along roadside	Medicinal
Cleome viscosa L.	Cleomaceae	Central America	Th	Forb	Annual	Wasteland	Medicinal
Corchorus aestuans L.	Malvaceae	Central America	Th	Forb	Annual	Wasteland	Medicinal
Corchorus tridens L.	Malvaceae	Tropical Africa	Th	Forb	Annual	Along roadside, Wasteland	Not known
Corchorus trilocularis L.	Malvaceae	Tropical Africa	Th	Forb	Annual	Wasteland	Not Known
Croton sparsiflorus Morong.	Euphorbiaceae	South America	Th	Forb	Perennial	Wasteland	Medicinal
Cuscuta reflexa Roxb.	Convolvulaceae	Mediterranean	He	Climber	Annual	Parasites	Medicinal
Cynodon dactylon (L.) Pers.	Poaceae	Tropical Africa	He	Grass	Perennial	Wasteland	Medicinal
Cyperus rotundus L.	Cyperaceae	Europe	He	Grass	Perennial	Wasteland	Medicinal
Datura metel L.	Solanaceae	Central America	Ph	Shrub	Perennial	Wasteland	Medicinal
Datura stramonium L.	Solanaceae	Central America	Ph	Forb	Annual	Along roadside, Wasteland	Medicinal
Echinochloa colona (L.) Link.	Poaceae	South America	Th	Grass	Annual	Moist places	Edible
Echinochloa crusgalli (L.) P. Beauv.	Poaceae	South America	Th	Grass	Annual	Moist places	Edible
Echinops echinatus Roxb.	Asteraceae	Afghanistan	Ch	Forb	Annual	Wasteland	Not Known
Eclipta alba (L.) Hassk.	Asteraceae	Central America	Th	Forb	Annual	Cultivated field	Medicinal

Eichhornia crassipes (C. Martius) Solms.	Pontederiaceae	Central America	Hyd	Forb	Perennial	Aquatic	Not Known
Euphorbia heterophylla L.	Euphorbiaceae	Central America	Th	Forb	Annual	Cultivated Field	Ornamental
Euphorbia hirta L.	Euphorbiaceae	Central America	Th	Forb	Annual	Cultivated Field	Medicinal
Evolvulus nummularius (L.) L.	Convolvulaceae	Central America	Th	Forb	Perennial	Wasteland	Not Known
Gnaphalium polycaulon Pers.	Asteraceae	Central America	Th	Forb	Annual	Wasteland	Not Known
Gomphrena serrata L.	Amaranthaceae	Central America	Th	Forb	Annual	Wasteland	Medicinal
Hyptis suaveolens (L.) Poit.	Lamiaceae	Central America	Ph	Forb	Annual	Wasteland	Not Known
Ipomoea carnea Jacq.	Convolvulaceae	Central America	Cr	Shrub	Perennial	Wasteland	Not Known
Ipomoea obscura (L.) Ker.-Gawal.	Convolvulaceae	Tropical Africa	Th	Climber	Perennial	Wasteland	Medicinal
Ipomoea pestigridis L.	Convolvulaceae	Tropical East Africa	Th	Climber	Annual	Cultivated Field Wasteland	Not Known
Ipomoea quamoclit L.	Convolvulaceae	Central America	Th	Climber	Perennial	Wasteland	Medicinal
Kigelia africana (Lam.) Benth.	Bignoniaceae	Rhodesia	Ph	Tree	Perennial	Garden	Medicinal
Lantana camara L.	Verbenaceae	Central America	Ph	Sub-shrub	Perennial	Wasteland	Medicinal
Leonotis nepetiifolia (L.) R. Br.	Lamiaceae	Tropical Africa	Th	Forb	Annual	Wasteland	Medicinal
Ludwigia adscendens (L.) Hara	Onagraceae	Central America	Hyd	Forb	Annual	Aquatic	Vegetable
Ludwigia octovalvis (Jacq.) Raven	Onagraceae	Tropical Africa	Hyd	Forb	Annual	Aquatic	Medicinal
Ludwigia perennis L.	Onagraceae	Tropical Africa	Hyd	Forb	Annual	Aquatic	Not Known
Malachra capitata (L.) L.	Malvaceae	Central America	Th	Forb	Perennial	Wasteland	Not Known
Mecardonia procumbens (Mill.) Small.	Plantaginaceae	North America	Ch	Forb	Annual	Wasteland	Not Known
Mikania micrantha Kunth.	Asteraceae	Central America	Ph	Climber	Annual	Wasteland	Not known

Mimosa pudica L.	Fabaceae	Brazil	Th	Forb	Perennial	Wasteland	Medicinal
Mirabilis jalapa L.	Nyctaginaceae	Peru	Th	Forb	Annual	Wasteland	Ornamental
Ocimum canum Sims.	Lamiaceae	Central America	Th	Forb	Perennial	Wasteland	Medicinal
Opuntia stricta (Haw.) Haw.	Cactaceae	Central America	Ph	Shrub	Perennial	Wasteland	Not Known
Oxalis corniculata L.	Oxalidaceae	Europe	Cr	Forb	Perennial	Cultivated Field Wasteland	Vegetable Medicinal
Parthenium hysterophorus L.	Asteraceae	North America	Th	Forb	Annual	Wasteland	Not known
Passiflora foetida L.	Passifloraceae	South America	Ph	Climber	Perennial	Wasteland	Medicinal
Pedalium murex L.	Pedaliaceae	Central America	Th	Forb	Annual	Wasteland	Not Known
Peperomia pellucida (L.) Kunth.	Piperaceae	South America	He	Forb	Annual	Wasteland	Not Known
Pistia stratiotes L.	Araceae	Central America	Hyd	Forb	Perennial	Aquatic	Medicinal
Plumbago zeylanica L.	Plumbaginaceae	Africa	Th	Forb	Perennial	Wasteland	Medicinal
Portulaca oleracea L.	Portulacaceae	South America	Ch	Forb	Annual	Wasteland	Medicinal Vegetable
Portulaca quadrifida L.	Portulacaceae	Central America	Ch	Forb	Annual	Wasteland	Vegetable
Prosopis juliflora (Sw.) DC.	Fabaceae	Central America	Ph	Tree	Perennial	Wasteland	Not Known
Saccharum spontaneum L.	Poaceae	Tropical West Asia	Hel	Grass	Perennial	Wastelan, River bed	Handicraft
Scoparia dulcis L.	Plantaginaceae	Central America	Ch	Forb	Perennial	Wasteland	Not Known
Sida acuta Burm.f.	Malvaceae	Central America	Th	Forb	Annual	Wasteland	Medicinal
Solanum nigrum L.	Solanaceae	Central America	Ph	Shrub	Annual	Cultivated Field, Wasteland	Medicinal
Solanum torvum Sw.	Solanaceae	Central America	Ph	Shrub	Perennial	Wasteland	Medicinal
Solanum viarum Dunal.	Solanaceae	Central America	Ph	Forb	Perennial	Wasteland	Medicinal
Sonchus oleraceus L.	Asteraceae	Mediterra-nean	Th	Forb	Annual	River bed	Not Known
Synedrella nodiflora (L.) Gaertn.	Asteraceae	Central America	Th	Forb	Annual	Wasteland	Not Known

Tribulus terrestris L.	Zygophyllaceae	Central America	Ch	Forb	Perennial	Wasteland	Medicinal
Tridax procumbens L.	Asteraceae	Central America	Th	Forb	Perennial	Wasteland Cultivated Field	Medicinal
Typha angustata Bory. &Choub.	Typhaceae	Central America	Ph	Forb	Perennial	Wasteland	Medicinal
Xanthium indicum Koenig.	Asteraceae	Central America	Ch	Shrub	Annual	Along roadside	Not Known
Ziziphus mauritiana Lam.	Rhamnaceae	Australia	Ch	Tree	Perennial	Wasteland	Medicinal, edible

Abbreviations: LF: Life form, Ch: Chamephyte, Cr: Cryptophyte, He: Hemicryptophyte, Ph: Phanerophyte, Tel: Helophytes, Hyd: Hydrophyte, Th: Therophyte.

Fig. 2 - a. Ageratum conyzoides *L.*
b. Antigonon leptopus *Hook. & Arn.*
c. Argemone Mexicana *L.*
d. Cassia alata *L.*
e. Chamaesyce hirta *(L.) Millsp.*
f. Cissampelos pareira *L.*
g. Croton sparsiflorus Morong.
h. Eclipta alba *(L.) Hassk.*
i. Eichhornia crassipes *(C. Martius) Solms.*
j. Evolvulus nummularius *(L.) L.*
k. Gomphrena serrata *L.*
l. Ipomoea carnea *Jacq.*
m. Kigelia africana *(Lam.) Benth. n.* Lantana camar*a L.*
o. Mikania micrantha *Kunth.*
p. Parthenium hysterophorus *L. q.* Pistia stratiotes *L.*
r. Sida acuta *Burm.f.*
s. Solanum viarum *Dunal.*
t. Typha angustata *Bory. & Choub.*

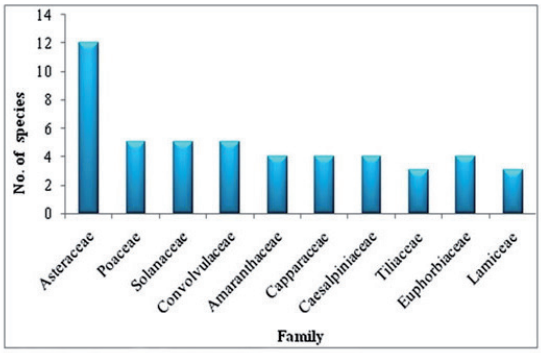

Fig. 3 - Ten dominant families of expansive alien species in Bhadrak district

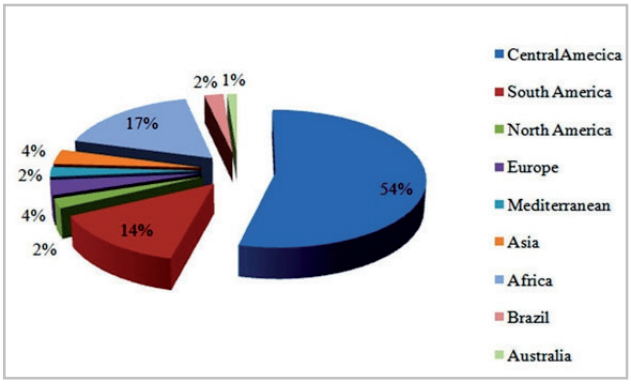

Fig. 4 - Contribution of different geographical areas to expansive alien species of Bhadrak district

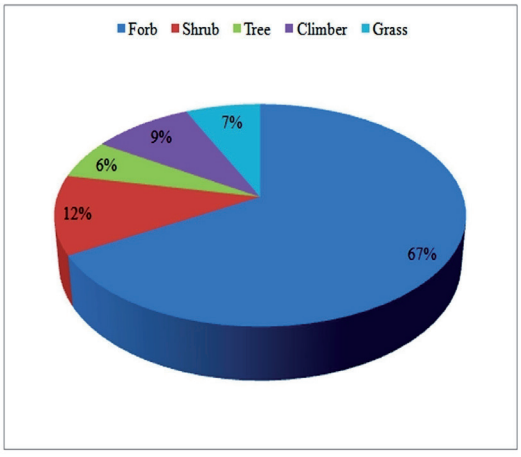

Fig. 5 - Habit wise distribution analysis

Fig. 6 - *a) Invasion of* Ageratum conyzoides *L. in agricultural field b)* Eichhornia crassipes *(C. Martius) Solms.in a pond c)* Mikania micrantha *Kunth.in* Aegle marmelos *(L.) Corr. d)* Carica papaya L.

Discussion

Lovers of biodiversity believe that biological invasions by alien species and recent species extinctions are closely linked process (Fritts and Rodda, 1998; Wilcove, 1998).The flourishing growth of these species is altering the terrestrial and aquatic communities worldwide (Gurevitch and Padilla, 2004). In this regard, India is worst affected, a country whose past history tells us about the introduction of expansive alien species from British, Portuguese, Spanish, French, from the Middle East and Central Asian countries (Pandey, 2000).The plants introduced during historical trade relationship include tropical American plants, a number of aggressive weeds and certain plants having economic value (Jenkins and Mooney, 2006). Many of the alien

species that are now known to be expansive in India have arrived in a variety of ways and for different purposes (Hiremath and Sundaram, 2013). Many such species were first introduced in to this country as garden ornamentals ((Hiremath and Sundaram 2013). They were also introduced purposely to fulfill the fuel-wood requirements, to prevent spreading of desert and some for commercial cultivation (Kohli *et al.* 2006; Muniappan *et al.*, 2009; Khuroo *et al.*, 2012; Kannan *et al.* ,2013). The history of expansive alien plants in Bhadrak district reveals that many species are introduced for economic purpose like timber, ornamental, and green coverage plantation of barren land and some were migrated to this region by transport of food grains from other regions. Climatic conditions of the region became suitable for them and they showed rapid proliferation to spread all over the district. All the species listed in this study are also reported as weeds in other countries and are included in the Global Compendium Weeds (Randall 2002). In fact, from the recorded 100 species of the world's worst expansive alien species (Lowe *et al.*, 2000), India harbours eleven plant species many of which are in Bhadrak district of Odisha. When the origin of expansive alien species is concerned, the contribution of American continent (70.1%) is noteworthy (Reddy 2008).The highest contributions of expansive alien species from American continent recorded in the present study are principally comparable with data from the studies of Kshirsagar (2005), Negi and Hajra (2007) and Khuroo *et al.* (2012). In fact, American continent has contributed majority of the noxious expansive alien plants found in Odisha and also in China (Kumar and Satpathy, 2015; Randall, 2002) and Taiwan (Wu *et al.* 2004). Of the reported species, the following species are common to China, Taiwan and Bhadrak district of Odisha, India: *Alternanthera philoxeroides, Ageratum conyzoides, Echinochloa crusgalli, Eichhornia crassipes* and *Mikania micrantha.* The historical trade routes discovered by Europeans to India, tropical climate are the possible causes for higher proportion of American weeds in India.

Families wise Asteraceae, or Poaceae are species-rich and higher numbers of expansive alien species belonging to these families are expected. But the predominance of members belonging to Asteraceae in this region is remarkable (Rao and Murugan 2006; Reddy 2008). This confirms other results from Europe (Lambdon *et al.*, 2008), South Africa (Heywood, 1989) and China (Wu *et al.*, 2010). During the present investigation maximum expansive alien plants are reported from the wastelands followed by agricultural fields and such an observation draws support from the studies of Singh *et al.* (2010). Expansive alien plant species are used for a variety of purposes. For example, *Amaranthus spinosus*, *Argemone mexicana, Calotropis gigantea, Cassia alata, Catharanthus roseus, Cissampelos pareira, Cynodon dactylon, Cyperus rotundus, Datura metel, Lantana camara Eclipta alba, Solanum nigrum and Tridax procumbens* is being used for medicinal purposes (Panda *et al.* 2012; Mishra *et al.* 2015 Panda *et al.* 2016).Similarly, *Alternanthera sessilis, Boerhavia diffusa, Annona reticulate, Ludwigia adscendens, Oxalis corniculata* and *Portulaca oleracea mauritiana* is being used for

both medicinal and edible purposes (Panda, 2014; Mishra *et al*., 2016; Panda *et al*., 2016) and *Borassus flabellifer* is used for writing, etching and making hand-held fans, (Panda *et al*., 2015). Moreover, the herbaceous plants are recorded as the dominant expansive alien flora (73.6%). The dominance of herbaceous expansive alien plants is also reported (Khuroo *et al* 2012). Higher number of annuals (46 species; 52.9%) of the expansive alien flora of Bhadrak district are comparable with the studies of Singh *et al*. (2010) and Adhikari *et al*. (2015), although perennials are more noxious (Huang *et al*. 2009; Xu and Qiang, 2004).

Individually, the invasion by *Ageratum conyzoides* L., *Eichhornia crassipes* (C. Martius) Solms., *Lantana camara* L., *Mikania micrantha* Kunth. and *Parthenium hysterophorus* L. are causing great concern in many parts of this district. Ageratum conyzoides L. is expanding at an alarming rate, especially in agricultural fields, road sides and even gardens. The weed is harmful to native species and has become a problem in agroecosystems (Negi and Hajra 2007). Freshwater species like *Eichornia crassipes* (C. Martius) Solms., introduced from Brazil during AD 1914–1916, is of most nuisance as it causes hindrance by choking all possible water bodies and reducing their utility. Because of its rapid growth rate, water hyacinth is able to outcompete native aquatic plants by utilising the available nutrients in the water, and successfully competing for space and sunlight (Cilliers, 1991). Similarly *Lantana camara* L. as one of the most ubiquitous expansive alien land species, which was introduced to Calcutta Botanical Garden as an ornamental shrub during AD 1809–1810 (Thakur *et al*. 1992; Kannan *et al*. 2013), is spreading fast all over the district due to its better competitive ability and allelopathic effect (Gentle & Duggin 1997; Hiremath and Sundaram 2005; Sundaram and Hiremath 2012). Previously, studies of Iyengar (1933) on forest ranges in North Salem, southern India reported a range of spread at the rate of 600–1,280 ha per year. Hakimuddin (1930) reported a range of spread at the rate of more than 2 km/year between 1911 and 1930 in the Himalayan foothills. Similarly, Sharma *et al*. (2005) and Love *et al*. (2009) have drawn attention to the rapid spread of Lantana throughout India. Prasad (2012) noted the rapid spreading of *Lantana camara* in Bandipur Tiger Reserve in southern India and concluded that it suppressed grass cover and indigenous tree sapling density. Recently, Kannan *et al*. (2013a) stated that the Western Ghats and Eastern Himalayas are highly infested by at least one of these three expansive alien plants i.e. *Lantana camara, Mikania micrantha* and *Parthenium hysterophorus*, and their spread and negative impacts are increasing. The perennial *Mikania micrantha* Kunth. which is a fast growing species, is covering the habitats of the district and suppressing the growth of agricultural crops as well as natural vegetation through competition and allelopathic effects (Sankaran and Srinivasan 2001; Huang *et al*. 2009). An example of an accidentally introduced species that has become expansive is *Parthenium hysterophorus* L., a dominant weed of the study area, especially wastelands, roadsides, railway tracks and foot paths. This noxious weed

is an aggressive colonizer spreading rapidly suppressing native herbaceous flora. This weed is reported to be allergenic causing respiratory problems, dermatitis and asthma (Raghubanshi *et al*., 2005).The method of control of expansive alien species in the present study is manual removal. This method is still practiced in developing countries (Julien *et al*., 1999). Moreover, this method of control is effective only for small infestations, as it is labour-intensive and offers only a short-term solution because the long-lived seeds are able to germinate and hence reinflux occurs rapidly (Kannan *et al*., 2013a).

Conclusion

As a final remark, it would suffice to say that from the earlier descriptions of negative impacts in other ecosystems, and the observation of the proliferation of expansive alien species within this district, it appears that these species may significantly alter the functioning of ecosystems here. These expansive alien species are spreading rapidly thereby exerting considerable pressure on local plant diversity. Since the expansive alien species have strong adaptability, they may replace the native species in the district. There is a major need to reconcile taxonomists, ecologists and environmental scientists for early and detailed detection as well as developing some effective control measures to eradicate the problems created by the expansive alien flora in the district.

Acknowledgments The authors wish to convey their sincere gratitude to the people concerned for their help in field work.

References

APG III. 2009. An update of the angiosperm phylogeny group classification for the orders and families of flowering plants. Botanical Journal of the Linnaean Society, 161(2), 105–121.

Adhikari D., Tiwary R., Barik S.K. 2015. Modelling hotspots for invasive alien plants in India. PLoS ONE, 10(7), 134665

Bellard C., Cassey P., Blackburn T.M. 2016. Alien species as a driver of recent extinctions. Biology Letters, 12, 20150623.

Bhatt J.R, Singh J.S, Singh S.P., Tripathi R.S., Kohli R.K. 2012. Invasive Alien Plants: An Ecological Appraisal for the Indian Subcontinent. Vol. 1. Wallingford, UK: CABI.

Callaway R.M., Aschehoug E.T. 2000. Invasive plants versus their new and old neighbors: a mechanism for exotic invasion. Science, 290, 521-523.

Cilliers C.J. 1991. Biological control of water hyacinth, Eichhornia crassipes (Pontederiaceae), in South Africa. Agriculture Ecosystems and

Environment, 37, 207-218.
Champion H.G., Seth S.K., 1968. A revised survey of the forest types of India. New Delhi: Manager of Publications, p.16-17.
Clinton W.J., 1999. Executive Order 13112: Invasive Species; Presidental Documents. The White House: Washington, DC, USA.
Cunningham A.B., 2001. Applied ethnobotany: People, wild plant use and conservation. London, UK: Earthscan Publishing Ltd.
Davis K.W., Sheley R.L., 2011. Promoting native vegetation and diversity in exotic annual grass infestations. Restoration Ecology, 19, 159-165.
Doherty T.S., Glen A.S., Nimmo D.G., Ritchie E.G., Dickman C.R., 2016. Invasive predators and global biodiversity loss. Proceedings of National Academy Sciences, 113, 11261–11265.
Drake S.J., Weltzin J.F,. Parr P., 2003. Assessment of non-native invasive plant species on the United States Department of Energy Oak Ridge National Environmental Research, Australia. Castanea, 68, 15–30.
Fritts T.H., Rodda G.H., 1998.The role of introduced species in the degradation of island ecosystems: a case history of Guam. Annual Review Ecology System, 29, 113–140.
Foxcroft L.C., Pysek P., Richardson D.M., 2014. Impacts of alien plant invasions in protected areas. In: Foxcroft LC, Pysek P, Richardson DM, Genovesi P (eds). Plant invasions in protected areas: patterns, problems and challenges. Springer, Dordrecht, pp. 19-41.
Gentle C.B., Duggin J.A., 1997. Allelopathy as a competitive strategy in persistent thickets of Lantana camara L. in three Australian forest communities. Plant Ecology, 132, 85-95.
Haines, H.H., 1925. The Botany of Bihar and Orissa. London: Adland and Son,West Newman Ltd.
Gurevitch J., Padilla D.K. 2004. Are invasive species a major cause of extinctions? Trends in Ecology and Evolution, 19, 470–474.
Hakimuddin M. 1930. Lantana in northern India as a pest and its probable utility in solving the
cowdung problem. Indian Forester, 56, 405–410.
Heywood V.H. 1989. Patterns, extents and modes of invasions. In: Biological Invasion: A global prospective (eds Drake J.A.). New York: JohnWiley, p. 31-60.
Hiremath A.J.B., Sundaram B., 2005. The fire-Lantana cycle hypothesis in Indian forests. Conservation and Society 3, 26-42.
Hiremath A.J.B., Sundaram B., 2013. Invasive plant species in Indian protected areas: conserving biodiversity in cultural landscapes. In: Foxcroft L.C. et al. (eds.). Plant Invasions in Protected Areas: Patterns, Problems and Challenges, Invading Nature. Springer Series in Invasion Ecology 7, pp.241-246.

Hobbs R.J., Humphries S.E., 1995. An integrated approach to the ecology and management of plant invasions. Conservational Biology, 9, 761-770.

Huang Q.Q., Wu J.M., Bai Y.Y., Zhou L., Wang G.X., 2009. Identifying the most noxious invasive plants in China: role of geographical origin, life form and means of introduction. Biodiversity Conservation, 18, 305–316.

Hulme P.E., 2009. Trade, transport and trouble: managing invasive species pathways in an era of globalization. Journal of Applied Ecology, 46, 10–18.

Huntington H.P., 2000. Using traditional ecological knowledge in science: Methods and applications. Ecological Application, 10, 1270–1274.

Iyengar AVV. 1933. The problem of the Lantana. Current Science, 21, 266–269

Jain S.K., 1897. Glimpses of Indian Ethnobotany. New Delhi: Oxford and IBH Publishing Co,.231-241.

Jenkins P.T., Mooney H.A., 2006. The United States, China, and invasive species: species: present status and future prospects. Biological Invasions, 8, 1589-93.

Jha C.S., Dutt C.B.S., Bawa K.S., 2000. Deforestation and land use changes in Western Ghats, India. Current Science, 79, 231–237.

Julien M.H., Griffiths M.W., Wright A.D., 1999. Biological control of water hyacinth. The weevils Neochetina bruchi and N. eichhorniae: biologies, host ranges, and rearing, releasing and monitoring techniques for biological control of Eichhornia crassipes. Monograph No. 60. Australian Centre for International Agricultural Research (ACIAR), Canberra, pp. 87

Kannan R., Shackleton C.M., Uma Shaanker R., 2013. Reconstructing the history of introduction and spread of the invasive species, Lantana, at three spatial scales in India. Biological Invasions, 15, 1287–1302.

Kannan R., Shackleton C.M., Uma Shaanker R., 2013a. Playing with the forest: invasive alien plants, policy and protected areas in India. Current Science, 104(9), 1159-1165.

Khanna K.K., 2009. Invasive alien angiosperms of Uttar Pradesh. Biological Forum - An International Journal, 1, 41–46.

Khuroo A.A., Reshi Z.A., Malik A.H., Weber E., Rashid I., Dar G.H., 2012. Alien flora of India: taxonomic composition, invasion status and biogeographic affiliations. Biological Invasions, 14, 99–113.

Kohli R.K., Batish D.R., Singh H.P., Dogra K.S., 2006. Status, invasiveness and environmental threats of three tropical American invasive weeds (*Parthenium hysterophorus* L.*, Ageratum conyzoides* L., *Lantana camara* L.) in India. Biological Invasions, 8, 1501–1510.

Kshirsagar S.R., 2005. Origin, present status and distribution of exotic plants in south Gujarat. Indian Journal of Forester, 28, 136-143.

Kumar N.S., Satapathy K.B., 2015. Diversity uses and origin of invasive alien plants

in Dhenkanal district of Odisha, India. International Research Journal of Biological Science, 4(2), 21-27.

Lambdon P.W., Pysek P., Basnou C., Hejda M., Arianoutsou M., Essl F., Jarosık V., Pergl J., Winter M., Anastasiu P., Andriopoulos P., Bazos I., Brundu G., Celesti-Grapow L., Chassot P., Delipetrou P., Josefsson M., Kark S., Klotz S., Kokkoris Y., Kuhn I., Marchante H., Perglova I., Pino J., Vila M., Zikos A., Roy D., Hulme P., 2008. Alien flora of Europe: species diversity, temporal trends, geographical patterns and research needs. Preslia, 80,101-149.

Levine S.A., 1989. Analysis of risk for invasions and control program. In: Drake JA, Mooney HA, Di Castri F, Grooves RH, Druger FJ, Rejmanek M, Williamson M. (Eds.). Biological invasion: A Global Perspective. New York: John Wiley & Sons, pp. 425– 435.

Love A., Babu S., Babu C.R., 2009. Management of Lantana, an invasive alien weed in forest ecosystems in India. Current Science, 97, 1421–1429.

Lowe S., Browne M., Boudielas S,. De Poorter M., 2000. 100 of the World's worst invasive alien species. A selection fromthe Global Invasive Species Database. The Invasive Species Specialist Group (ISSG) of the World Conservation Union (IUCN), Switzerland.

Mack R.N., Lonsdale W.M., 2001. Humans as global plant dispersers: getting more than we bargained for. Bioscience, 51, 95–102.

Martin G.J., 1995. Ethnobotany: A methods manual. London, UK: Chapman and Hall, 102-104.

McGeoch M.A., Butchart S.H.M., Spear D., Marais E., Kleynhans E.J., Symes A., Chanson J., Hoffmann M., 2010. Global Indicators of Biological Invasion: Species Numbers, Biodiversity Impact and Policy Responses. Diversity and Distributions, 16(1), 95-108.

Maguire D., Sforza R., Smith S.M., 2011. Impact of herbivory on performance of Vincetoxium spp. invasive weeds in North-America. Biological Invasions, 13, 1229-1240.

Meyerson L.A., Mooney H.A., 2007. Invasive alien species in an era of globalization.
Frontiers in Ecology and the Environment, 5(4), 199-208.

Mishra N., Panda T., Mohanty R.B., Kishore A., Singh R.R., 2015. Traditional phytotherapy in Bhadrak district of Odisha, India. Life Science Leaflets, 60, 26-40.

Mishra N., Panda T., Pradhan B.K., Rout S.D., Mohanty R.B., Kishor A., Singh R.R. 2016. Indigenous knowledge in utilization of wetland plants of Bhadrak district, Odisha, India. Indian Journal of Natural Products and Resources, 7(1), 82-89.

Muniappan R., Raman A. Reddy G.V.P., 2009. *Ageratina adenophora* (Sprengel) King and Robinson (Asteraceae). In: Muniappan R, Reddy GVP, Raman A.

(eds). Biological control of tropical weeds using arthropods. Cambridge: Cambridge University Press, 63–73.

Nayar M.P., 1977. Changing Patterns of the Indian Flora, Bulletin of Botanical Survey of India, 19(1-4), 145-155.

Negi S.S., 1986. Geo-botany of India. New Delhi, India: Periodical Expert Book Agency, pp. 1–7.

Negi P.S., Hajra P.K., 2007. Alien Flora of Doon Valley, North West Himalaya. Current Science, 92(7), 968-978.

Panda T., 2014. Traditional knowledge on wild edible plants as livelihood food in Odisha, India. Journal of Biology and Earth Sciences, 4 (2): B144-B159.

Panda T., Das M., Mishra N., Mohanty R.B., 2012. Traditional knowledge used in anti-diabetic herbal therapy of Odisha, India. The Journal of Ethnobiology and Traditional Medicine. Photon, 117, 204-213.

Panda T., Tripathy B.K., Mishra N., Mohanty R.B., 2015. A note on the traditional use of palm leaf as writing and etching medium in Odisha. ENVIS Newsletter, 20(2), 6-7.

Panda T., Mishra N., Pradhan B.K., 2016. Folk knowledge on medicinal plants used for the treatment of skin diseases in Bhadrak district of Odisha, India. Medicinal and Aromatic Plants, 5, 262.

Pandey D.S., 2000. Exotics–introduced and natural immigrants, weeds, cultivated, etc. In: Singh, NP, Singh DK, Hajra PK, Sharma BD. (eds). Flora of India (introductory volume, Part II). Kolkata, India: Botanical Survey of India, pp. 266–301.

Paini D., Sheppard A.W., Cook D.C., De Barro P.J., Worner S.P., Thomas M.B., 2017. Global threat to agriculture from invasive species. Proceedings of National Academy Sciences, 113, 7575–7579.

Pearce F., 2015.The new wild: why invasive species will be nature's salvation. Boston: Beacon press.

Pimentel D., McNair S., Janecka J., Wightman J., Simmonds C., O'Connell C., Wong E., Russel L., Zern J., Aquino T., Tsomondo T., 2001. Economic and environmental threats of alien plant, animal, and microbe invasions. Agriculture, Ecosystems and Environment, 84, 1–20.

Preston G., Williams L., 2003. Case Study: The working for Water Programme: Threats and successes. Service Delivery Review. 2(2), 66-69.

Patnaik S.R., 1996. Orissa Today. Nayapalli, Bhubaneswar: An Annual Survey (Eds.), Sun Times, pp. 4.

Prasad A.E., 2012. Landscape-scale relationships between the exotic invasive shrub Lantana camara and native plants in a tropical deciduous forest in southern India. Journal of Tropical Ecology, 28, 55-64.

Pysek P., Richardson D.M., Rejmánek M., Webster G.L, Williamson M., Kirschner J.,

2004. Alien plants in checklists and floras: towards better communication between taxonomists and ecologists. Taxon, 53 (1), 131–143.

Pysek P., Jarosık V., Hulme P.E., 2011. A global assessment of invasive plant impacts on resident species, communities, and ecosystems: the interaction of impact measures, invading species' traits, and environment. Global Change Biology, 18, 1725–1737.

Raghubanshi A.S., Rai L.C., Gaur J.P., Singh J.S., 2005. Invasive alien species and biodiversity in India. Current Science, 88(4), 539-540.

Randall R.P., 2002. A Global Compendium of Weeds. Shannon Books, Australia.

Rao R.R., Murugan R., 2006. Impact of exotic adventives weeds on native biodiversity in India: Implications for Conservation. In: Rai LC, Gaur, JP. (Eds.). Invasive Alien Species and Biodiversity in India. Varanasi, India: Banaras Hindu University, pp. 93-109.

Raunkiaer C., 1934. The life forms of plants and statistical plant geography. Oxford: Oxford University Press.

Reddy C.S., 2008. Catalogue of invasive alien flora of India. Life Science Journal, 5(2), 84-89.

Ricciardi A., Blackburn T.M., Carlton J.T., Dick J.T.A., Hulme P.E., Iacarella J.C. Jeschke J.M., Liebhold A.M., Lockwood J.L., MacIsaac H.J., Pysˇek P., Richardson D.M., Ruiz G.M., Simberloff D., Sutherland W.J., Wardle D.A. Aldridge D.C., 2017. Invasion science: a horizon scans of emerging challenges and opportunities. Trends in Ecology and Evolution, 32, 464–474.

Sankaran K.V., Srinivasan M.A., 2001. Status of Mikania infestation in the Western Ghats. In: Sankaran KV, Murphy ST, Evans HC (eds.) Alien weeds in moist tropical zones: banes and benefits. KFRI/CABI Bioscience, Kerala/Ascot, pp. 67–76.

Sax D.F., Gaines S.D., 2008. Species invasions and extinction: the future of native biodiversity on islands. Proceedings of the National Academy of Sciences, 105, 11490–11497.

Saxena H.O., Brahmam M., 1996. The Flora of Orissa. Vol. I-IV, Bhubaneswar: Orissa Forest Development Corporation.

Sharma G.P., Singh J.S., Raghubanshi A.S., 2005. Plant invasions: emerging trends and future implications. Current Science, 88, 726–734.

Sharma J.R., Singh D.K., 2000. Status of plant diversity in India: an overview. In: Roy PS, Singh S, Toxopeus AG. (eds). Biodiversity and environment. Dehra Dun, India: Indian Institute of Remote Sensing, pp. 69–105.

Simberloff D., Parker I.M., Windle P.M., 2005. Introduced species policy, management and future implications. Frontiers Ecology & Environment, 3, 12–20.

Simberloff D., Martin J.L., Genovesi P., 2013. Impacts of biological invasions: what's what and the way forward. Trends Ecology & Evolution, 28, 58–66.

Singh J.S., Singh K.P., Gupta S.R., 2006. Ecology, environment and resource conservation. New Delhi: Anamaya Publishers.

Singh K.P., Shukla A.N., Singh J.S., 2010. State-level inventory of invasive alien plants, their source regions and use potential. Current Science.99 (1), 107-114.

Sing S.E., Peterson R.K.T., 2011. Assessing environmental risks for established invasive weeds: Dalmatian (Linaria dalmatica) and yellow (L. vulgaris) toadflax in North America. International Journal Environment Research and Public Health, 8, 2828–2853.

Sundaram B., Hiremath A.J., 2012. *Lantana camara* invasion in a heterogeneous landscape: patterns of spread and correlation with changes in native vegetation. Biological Invasion, 14, 1127–1141.

Thakur M.L., Ahmad M., Thakur R.K., 1992. Lantana weed (*Lantana camara* var. aculeata Linn.) and its possible management through natural insect pests in India. Indian Forester, 118, 466-486.

Traveset A., Richardson D.M., 2006. Biological invasions as disruptors of plant reproductive mutualisms. Trends in Ecology & Evolution, 21(4), 208–216.

Vila M., Weiner J., 2004. Are invasive plant species better competitors than native plant species? Evidence from pair-wise experiments. Oikos, 105, 229–238.

Walck J.L., Baskin J.M., Baskin C.C., 1999. Effects of competition from introduced plants on establishment, survival, growth and reproduction of the rare plant Solidago shortii (Asteraceae). Biological Conservation, 88, 213–219.

Walther G.R., Roques A., Hulme P.E., Sykes M.T., Pysek P., Kühn I., 2009. Alien species in a warmer world: risks and opportunities. Trends in Ecology & Evolution, 24, 686–693.

Wilcove D.S., 1998. Quantifying threats to imperiled species in the United States. Bioscience, 48, 607–615.

Williamson M., Fitter A., 1996.The varying success of invaders. Ecology, 77, 1661-1666.

Wu SH, Hsieh CF, Rejmanek M. 2004. Catalogue of the naturalized flora of Taiwan. Taiwania, 49, 16-31.

Wu S.H., Sun H.T., Teng Y.C., Rejmanek M., Chaw S.M., Yang T.Y.A., Hsieh C.F., 2010. Patterns of plant invasions in China: taxonomic, biogeographic, climatic approaches and anthropogenic effects. Biological Invasions, 12, 2179–2206.

Xu H.G., Qiang S., 2004. Inventory alien species in China. Beijing: China environmental science publication.