INVASIVE ALIEN SPECIES OF INDIA

Compiled by

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Criteria adopted for designating an alien species as invasive

CEBPOL, NBA collected the readily available ecosystem-wise literature of invasive alien species and thoroughly analyzed. During the consolidation, we found that there were lots of confusions, wrong citations, biased definitions and information in most of the published lists of invasive alien species. For instance, some of the lists declare the naturalized species as invasive, and conversely some lists declare the invasive species as naturalized alien species. Besides, the accepted name and the synonym of a species were simultaneously reported in the same list and mentioned as different species. In a worst-case scenario, the native species has also been reported as invasive alien species. CEBPOL, NBA realized the need for avoiding this kind of ambiguity and at the same time felt the necessity for criteria to be adopted for declaring a species as invasive alien species.

The compiled list was primarily screened to confirm the alien status and invasiveness of the species based on a simple methodology developed by CEBPOL (details of the methodology are provided in Figure 1). After the initial filtration/confirmation, the confirmed list was placed in the NBA's invasive species expert committee for scrutiny.

The committee deliberated on the lists compiled by CEBPOL, NBA and suggested to include the invasive attributes on a graded scale for confirmation of the invasiveness of the species in India. After reviewing the available literature, the committee has suggested to adopt the important invasive attributes *viz.*, invasiveness, impacts, range of extension and others to designate the alien species as invasive in India (Table 1). Besides, the committee also took into account the personal experiences of the researchers and their view in declaring a species as invasive if there is non-availability/inadequate literature.

Based on the aforesaid criteria, the committee finalized a list of 170 invasive alien species in different ecosystems. The committee also felt the list might further be expanded. For example, when some species are designated as invasive based upon the specific criteria, there may be many more invasive species which may satisfy the above criteria, but due to lack of adequate information of the concerned species it is not included in the present lists. Keeping this aspect in view, the committee requested the NBA to host the lists on its website for public access and comments. Once adequate information is available on the new invasive species in Indian provinces, it may be included in the lists in the near future after due consultation with the expert committee.

Figure I. Flow chart devised to identify whether a given species can be considered as invasive or not

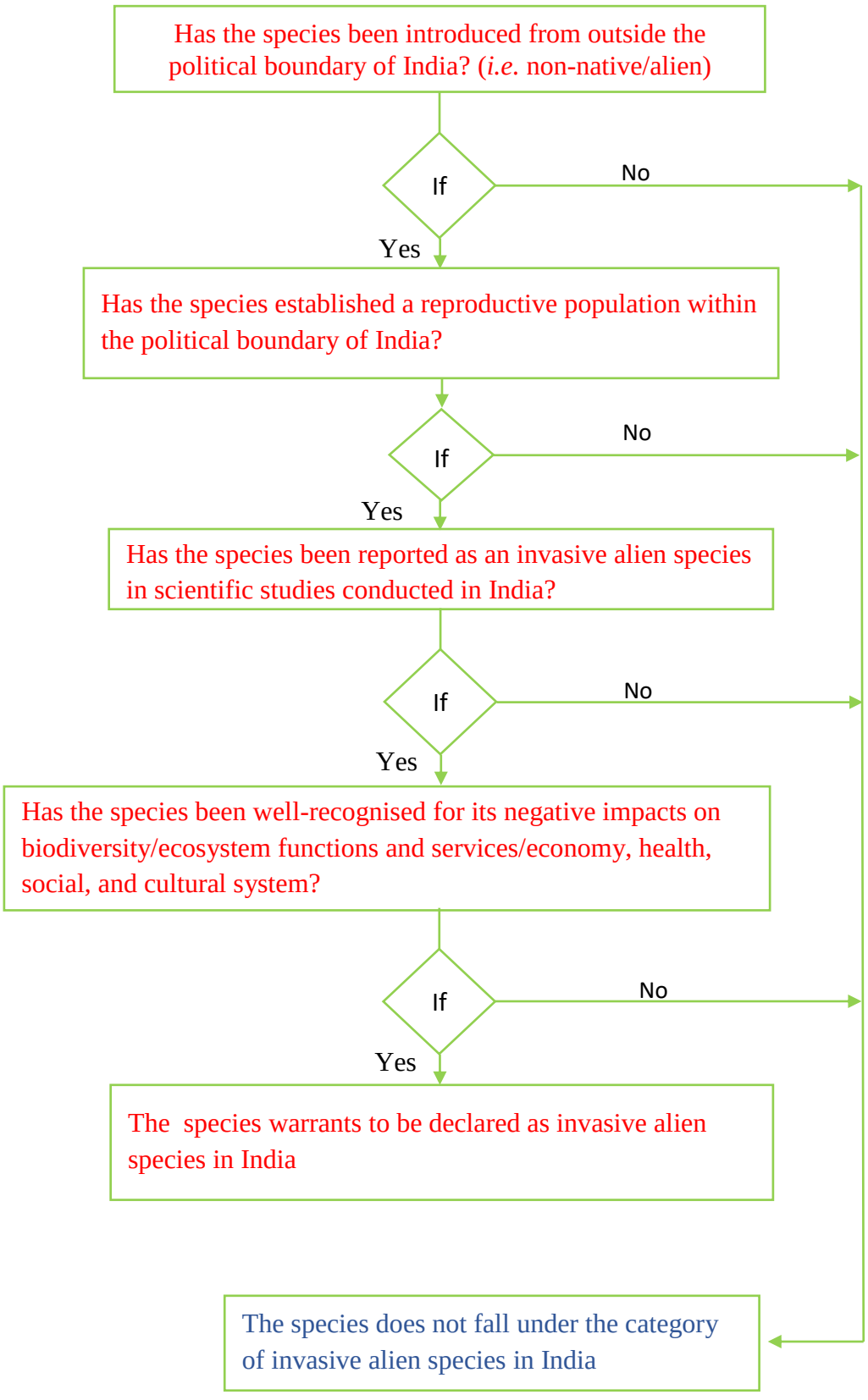

Table 1. Invasive attributes used to confirm the invasive status of the species reported in Indian ecosystems.

S. No	**Invasive attributes**
Invasiveness	
1.	**IE** – Invasive Elsewhere
2.	**RMS** – Rapid Multiplication and Spread in different ecosystems
3.	**MMR** – Multiple Modes of Reproduction
4.	**MMD** – Multiple Modes of Dispersion
Impacts	
1.	**B1** – Affecting ecosystem functions and services
2.	**B2** – Biodiversity loss
3.	**B3** – Economic loss and health hazard
Invasion areas (Continues spread)	
	RE – Range Extension

Terrestrial Invasive Alien Plant Species

S. No	Name of taxa	English Name	Invasiveness				Impacts			RE	References
			IE	RMS	MMR	MMD	B1	B2	B3		
1.	*Abutilon crispum* (L,) Bricicky	Bladder Mallow	✓	✓		✓	✓	✓		✓	Inderjit et al., 2018; Based on field observation by experts
2.	*Acacia auriculiformis* L. New name *Racosperma auriculiformis* (L) Benth.	Northern black wattle	✓	✓	✓	✓	✓	✓		✓	Based on field observation by experts
3.	*Acacia dealbata* Link	Silver wattle	✓	✓		✓	✓	✓		✓	Sekar 2012; Based on field observation by experts
4.	*Acacia mearsnii* De Willd.	Back wattle	✓	✓		✓	✓	✓	✓	✓	Sankaran et al., 2013; Naithani et al., 2017; Sekar 2012; Reddyet al., 2008.
5.	*Ageratina adenophora* (Spreng.)King & H. Rob.	Crofton weed or sticky snakeroot	✓	✓	✓	✓	✓	✓	✓	✓	Muniappan and Viraktamath1993; Based on field observation by experts
6.	*Ageratina riparia* (Regel)R. M.King & H. Rob.	Creeping croftonweed	✓	✓	✓	✓	✓	✓	✓	✓	Based on field observation by experts
7.	*Alternanthera bettzickiana (*Regel) G. Nichols	Red Calico plant	✓	✓	✓	✓	✓	✓	✓	✓	Sankaran et al., 2013; Based on field observation by experts
8.	*Alternanthera brasiliana* (L.) Kuntze	Brazilian joy weed	✓	✓	✓	✓	✓	✓		✓	Sankaran et al., 2013; Based on field observation by experts
9.	*Alternanthera ficoidea* P. Beauv.	Joseph's coat	✓	✓	✓	✓	✓	✓		✓	Based on field observation by experts
10.	*Alternanthera paronychioides* St. Hil.	Smooth joy weed	✓	✓	✓	✓	✓	✓		✓	Sekar 2012; Based on field observation by experts

S. No	Name of taxa	English Name	Invasiveness				Impacts			RE	References
			IE	RMS	MMR	MMD	B1	B2	B3		
11.	*Alternanthera pungens* Kunth.	Khaki weed	✓	✓	✓	✓	✓	✓	✓	✓	Naithani et al., 2017; Sekar 2012;
12.	*Alternanthera tenella* Colla	Calico plant	✓	✓	✓	✓	✓	✓		✓	Naithani et al., 2017; Sekar 2012;
13.	*Antigonon leptopus* Hook. & Arn.	Coral vine	✓	✓	✓		✓	✓		✓	Sekar 2012; Based on field observation by experts
14.	*Argemone mexicana* L.	Mexican poppy	✓	✓			✓	✓		✓	Sankaran et al., 2013; Naithani et al 2017;
15.	*Bidens pilosa* L.	Black Jack	✓	✓	✓	✓	✓	✓	✓	✓	Muniappan and Viraktamath1993; Sekar,2012;
16.	*Cabomba caroliniana* A. Gray	Carolina fanwort,	✓	✓	✓		✓	✓		✓	Based on field observation by experts
17.	*Cannabis sativa* L.	Hemp/ Marijuna	✓	✓		✓	✓	✓		✓	Based on field observation by experts
18.	*Centrosema molle* Benth.	Butterfly-pea	✓	✓			✓	✓		✓	Sankaran et al., 2013; Based on field observation by experts
19.	*Cestrum aurantiacum* Lindl	Orange cestrum	✓	✓	✓	✓	✓	✓	✓	✓	Sankaran et al., 2013; Based on field observation by experts
20.	*Chromolaena odorata* (L.) King & Robin.	Siam weed	✓	✓	✓	✓	✓	✓	✓	✓	Mahajan and Azeez2001. Sankaran et al., 2013; Naithani et al ., 2017
21.	*Cirsium arvense (L.)* Scop.	Canada thistle	✓	✓	✓	✓	✓	✓		✓	Based on field observation by experts
22.	*Coronopus didymus* Sm.	Lesser swinecress	✓	✓	✓	✓	✓	✓		✓	Based on field observation by experts

S. No	Name of taxa	English Name	Invasiveness				Impacts			RE	References
			IE	RMS	MMR	MMD	B1	B2	B3		
23.	*Cryptostegia grandiflora* R. Br.	Rubber vine	✓	✓		✓	✓	✓		✓	Naithani et al 2017; Sekar 2012; Reddyet al.,, 2008;
24.	*Cuscuta chinensis* Lam.	Dodder	✓	✓		✓	✓	✓		✓	Naithani et al., 2017; Sekar 2012;
25.	*Cytisus scoparius* (L.) Link	Scotch broom	✓	✓		✓	✓	✓		✓	Naithani et al., 2017
26.	*Dactylandra welwitschii* Hook. f.	Badi Aankh Phootani bel	✓	✓		✓	✓	✓		✓	Based on field observation by experts
27.	*Dinebra retroflexa* (Vahl) Panz.	Viper grass	✓	✓	✓	✓	✓	✓		✓	Naithani et al., 2017; Sekar, 2012;
28.	*Diplachne fusca* (L.) P.Beauv.	Brown flowered swamp grass	✓	✓	✓	✓	✓	✓		✓	Based on field observation by experts
29.	*Dysphania ambrosioides* Mosyakin & Clemants	Mexican tea	✓	✓		✓	✓	✓		✓	Sekar, 2012; Based on field observation by experts
30.	*Erigeron bonariensis L.,*	Horseweed / Butterweed	✓	✓	✓	✓	✓	✓		✓	Inderjit et al., 2018; Based on field observation by experts
31.	*Erigeron canadensis* L.	Canadian horseweed	✓	✓		✓	✓	✓		✓	Based on field observation by experts
32.	*Evolvulus nummularius* (L.) L.	Round leaf Bindweed	✓	✓		✓	✓	✓		✓	Naithani et al 2017; Sekar 2012;
33.	*Hyptis suaveolens* Poit.	Pig nut	✓	✓	✓	✓	✓	✓		✓	Sankaran et al., 2013; Sekar 2012;
34.	*Ipomoea eriocarpa* R. Br.	Purple morning glory	✓	✓		✓				✓	Naithani et al., 2017; Sekar 2012;
35.	*Ipomoea fistulosa* Mart. ex Choisy	Bush Morning Glory/ Shrub Ipomoea	✓	✓	✓		✓	✓		✓	Based on field observation by experts

S. No	Name of taxa	English Name	Invasiveness				Impacts			RE	References
			IE	RMS	MMR	MMD	B1	B2	B3		
36.	*Lantana camara* L.	Lantana	✓	✓	✓	✓	✓	✓	✓	✓	Chandrasekaran andSwamy 2001; Love et al 2009; Sundaramand Hiremath 2012. Sankaran et al., 2013;
37.	*Leucaena leucocephala* (Lam.) de Wit	False/Horse tamarind	✓	✓		✓	✓	✓		✓	Sankaran et al 2013; Naithani et al 2017;
38.	*Maesopsis eminii* Engl.	Umbrella-tree	✓	✓			✓	✓		✓	Sankaran et al., 2013
39.	*Mikania micrantha* Kunth	Mile-a-minute	✓	✓		✓	✓	✓		✓	Gogoi 2001; Sankaran andSrinivasan2001;Lahkar et al.,2011.
40.	*Mimosa diplotricha* C. Wight ex Sauvalle var.	Giant sensitive plant	✓	✓	✓	✓	✓	✓		✓	Based on field observation by experts
41.	*Mimosa pigra* L.	Cat claw mimosa	✓	✓	✓	✓	✓	✓		✓	Naithani et al., 2017; Based on field observation by experts
42.	*Muntingia calabura* L.	Jamaican cherry	✓	✓	✓	✓	✓	✓	✓	✓	Based on field observation by experts
43.	*Opuntia dillenii* Haw.	Prickly pear	✓	✓	✓	✓	✓			✓	Muniappan and Viraktamath1993; Sekar 2012;
44.	*Opuntia elatior* Miller	Prickly pear	✓	✓	✓	✓	✓			✓	Sekar, 2012; Based on field observation by experts
45.	*Parthenium hysterophorus* L.	Congress weed	✓	✓	✓	✓	✓	✓	✓	✓	Aneja, 1991; Gunaseelan,1998; Singh and Kaur, 1997; Sankaran et al 2013;
46.	*Pennisetum purpureum* Schumach.	Elephant grass	✓	✓		✓	✓	✓		✓	Naithani et al 2017; Sekar 2012;

S. No	Name of taxa	English Name	Invasiveness				Impacts			RE	References
			IE	RMS	MMR	MMD	B1	B2	B3		
47.	*Prosopis juliflora* (Sw.) DC.	Mesquite	✓	✓	✓	✓	✓	✓		✓	Dayal, 2007; Anoop, 2010; Kauret al.,2012.
48.	*Pueraria montana* var. lobata (Willd.) Sanjappa & Pradeep	Kudzu	✓	✓		✓				✓	Based on field observation by experts
49.	*Senna spectabilis* (DC.) Irwin & Barneby	Calceolaria shower	✓	✓			✓	✓		✓	Sankaran et al., 2013; Based on field observation by experts
50.	*Solanum elaeagnifolium* Cavanilles	Silverleaf nightshade	✓	✓			✓	✓		✓	Based on field observation by experts
51.	*Solanum mauritianum*Scop.	Bugweed	✓	✓			✓	✓		✓	Based on field observation by experts
52.	*Sphagneticola trilobata* (L.) Pruski	Singapore daisy	✓	✓			✓			✓	Sankaran et al., 2013; Based on field observation by experts
53.	*Typha angustifolia* L.	Lesser bulrush	✓	✓	✓	✓	✓	✓		✓	Sekar 2012; Naithani et al., 2017; Inderjit et al., 2018;
54.	*Ulex europeus* L.	Common gorse	✓	✓		✓	✓	✓	✓	✓	Naithani et al., 2017; Based on field observation by experts

Invasive Alien Terrestrial Plant species reported in India

Note: IE - Invasive Elsewhere; **RMS –** Rapid Multiplication and Spread in different ecosystems; **MMR** – Multiple Modes of Reproduction **MMD** – Multiple Modes of Dispersion; **Impacts** (**B1-** affecting ecosystem functions and services;**B2-**Biodiversity loss; **B3-** Economic loss and health hazard (human and wildlife)**RE -** Range Extension (Continues spread of the alien species)

Aquatic Invasive Alien Plant Species

S. No	Name of the Species	English Name	Invasiveness				Impacts			RE	Reference
			IE	RMS	MMR	MMD	B1	B2	B3		
1.	*Alternanthera philoxeroides* (Mart.) Griseb.	Alligator weed	√	√	√	√	√	√		√	Masoodi,and Khan, 2012; Masoodi, et al., .2013;Chatterjee, and Dewanji, 2012.
2.	*Eichhorniacrassipes* (Mart.) Solms	Water hyacinth	√	√	√	√	√	√	√	√	Kathiresan, 2000; Narayanan et al 2007; Patel, 2012
3.	*Ipomoea carnea* Jacq.	Pink morning glory	√	√	√	√	√	√	√	√	Chaudhuri et al 1994; Laxmappa. 2013; Laxmappa et al., 2014
4.	*Lemnaperpusilla* Torr.	Minute duckweed	√	√	√	√	√	√		√	Gopal , 1990. Khuroo,et al 2007
5.	*Lythrum salicaria* L.	Purple loosestrife	√	√	√	√	√	√		√	Based on field observation by experts
6.	*Marsilea quadrifolia*	Common Water Clover	√	√	√	√	√	√		√	Khuroo,et al 2007; Lolu,A.J. et al.2016
7.	*Myriophyllum aquaticum*(Vell.) Verdc.	Parrot's feather	√	√	√	√	√	√	√	√	Arshid, *et al*.2011; Shah, *et al*., 2014.
8.	*Salvinia auriculata* Aubl (syn. *S. molesta*)	Butterfly fern	√	√	√	√	√	√	√	√	Nair, and Pai, 1973; Thomas1979; Jayanth, 1987.

Note: IE - Invasive Elsewhere; **RMS –** Rapid Multiplication and Spread in different ecosystems; **MMR** – Multiple Mode of Reproduction **MMD** – Multiple Mode of Dispersion; **Impacts** (**B1**- affecting ecosystem functions and services; **B2**-Biodiversity loss; **B3**- Economic loss and health hazard (human and wildlife)**RE -** Range Extension (Continues spread of the species)

Inland Invasive Alien Species of Fishes

S. No	Name of the Species	English Name	Invasiveness				Impacts			RE	Reference
			IE	RMS	MMR	MMD	B1	B2	B3		
1.	*Clarias gariepinus*	African catfish	√	√	√	√	√	√	√	√	Krishnakumar et al. 2009, 2011, Laxmappa et al. 2015, Singh et.al. 2012; 2014; 2014a; 2015.
2.	*Cyprinus carpio*	Common carp	√	√	√	√	√	√	√	√	Singh et al. 2010; 2011; 2013, 2014; 2014a.
3.	*Gambusia affinis*	Western Mosquito fish/ Topminnow	√	√	√	√	√	√	√	√	Singh et al. 2011; 2013, 2014.
4.	*Gambusiaholbrooki*	Eastern Mosquito fish	√	√	√	√	√	√	√	√	Singh et al. 2011; 2013, 2014.
5.	*Mylopharyngodonpiceus*	Black carp	√	√	√	√	√	√	√	√	Singh et al. 2013a.
6.	*Oreochromis mossambicus*	Mozambique tilapia	√	√	√	√	√	√	√	√	Biju Kumar 2000: Laxmappa et al. 2015;, Singh et al. 2011; 2013, 2014;2014a
7.	*Oreochromis niloticus*	Nile tilapia	√	√	√	√	√	√	√	√	Laxmappa et al. 2015; Singh et al. 2013, 2014; 2014a
8.	*Poecillia reticulata*	Guppy	√	√	√	√	√	√	√	√	Biju Kumar, 2000; Singh an Lakra 2011; Singh et al. 2013b
9.	*Pterygoplichthysdisjunctivus*	Vermiculated sailfin catfish	√	√	√	√	√	√	√	√	Singh et al 2013 Biju Kumar et al. 2015
10.	*Pterygoplichthys multiradiatus*	Sucker mouth armored cat fish	√	√	√	√	√	√	√	√	Krishnakumar et al. 2009; Singh et al 2013a.
11.	*Pterygoplichthys pardalis*	Amazon sailfin catfish	√	√	√	√	√	√	√	√	Singh et al 2013a; Biju Kumar et al. 2015.
12.	*Pterygoplichthys anisitsi*	Paraná Sailfin Catfish	√	√	√	√	√	√	√	√	Singh et al 2013a.
13.	*Pygocentrus nattereri*	Red Piranha	√	√	√	√	√	√	√	√	Singh et al 2013a.
14.	*Aristichthys nobilis*	Bighead	√	√	√	√	√	√	√	√	Singh and Lakra, 2011. Based on field observation by experts

Note: Categories and Criteria adopted for listing Invasive alien Fishes in Inland Water IE - Invasive Elsewhere; **RMS –** Rapid Multiplication and Spread in different ecosystems; **MMR** – Multiple Mode of Reproduction **MMD** – Multiple Mode of Dispersion; **Impacts** (**B1**- affecting ecosystem functions and services; **B2**-Biodiversity loss; **B3**- Economic loss and health hazard (human and wildlife) **RE** - Range Extension (Continues spread of the species).

Marine Invasive Alien Species

S. No	Name of the Species	English Name	Invasiveness				Impacts			RE	Reference
			IE	RMS	MMR	MMD	B1	B2	B3		
Algae											
1.	*Kappaphycus alvarezii*	Elkhorn sea moss	√	√				√		√	Chandrasekaran et al. 2008; Kamalakannan et al. 2014
2.	*Monostorma oxyspermum*	Seaweed.	√							√	Untawale, et al 1980; Based on field observation by experts
Scyphozoa											
1.	*Phyllorhiza punctata* (Lendenfield 1884)	*Phyllorhiza puncta* Lendenfield, 1884	√	√	√	√	√	√		√	Saravanan, et al , 2016. Based on field observation by experts
2.	*Pelagia noctiluca* (Forsskal, 1775)	*Pelagia noctiluca* Forsskal, 1775	√	√	√	√	√	√		√	Kramp, 1961; Based on field observation by experts
Anthozoa											
1.	*Carijoa riisei*	Snowflake coral / Branched pipe coral	√	√	√	√	√	√	√	√	Raghunathan, et al ., 2013; Based on field observation by experts
2.	*Tubastrea coccinea (*Lesson, 1829)	Orange soft coral	√	√	√	√		√		√	Pillai, and Patel, 1988 Based on field observation by experts
Ctenophora											
1.	*Beroe ovata* (Bruguiere, 1789)		√	√	√	√		√		√	Chopra, 1960.; Based on field observation by experts
2.	*Beroe cucumis (*Fabricius, 1780)		√	√	√	√		√		√	Robin et al ., 2009; Based on field observation by experts
3.	*Vallicula multiformis* (Rankin, 1956)		√	√	√	√		√		√	Prasade, et al 2016; Based on field observation by experts
Bivalve											
1.	*Mytiloposis sallei* (Recluz, 1849)	Caribbean false mussel	√	√	√	√	√	√	√	√	Ganapati et al 1971; Based on field observation by experts
2.	*Perna perna (*Linnaeus, 1758)		√	√	√	√	√	√	√	√	Kesavan, et al 2009; Based on field observation by experts

Hydrozoa											
1.	*Ectoplura crocea* (Agassiz, 1862)	Pink-mouth hydroid	√	√	√	√	√	√	√	√	Mammen, 1963; Based on field observation by experts
Polycheates											
1.	*Ficopomatus enigmaticus* (Fauvel, 1923)	Australian tube worm	√	√				√	√	√	Chandramohan, and Aruna, 1994; Based on field observation by experts
2.	*Lumrineris japonica (*Marenzeller, 1879)		√	√				√	√	√	Gaonkar, et al 2010; Based on field observation by experts
Amphipods											
1.	*Jassa marmorata* Holemes, 1905		√	√		√	√	√		√	Anil, et al 2003; Based on field observation by experts
Decapods											
1.	*Penaeus vannamei* Boone, 1931		√	√				√		√	Dev Roy, 2007; Based on field observation by experts
Bryozoa											
1.	*Membranipora membranacea (*Linnaeus, 1767)	Coffin box	√	√		√	√	√	√	√	Shrinivaasu, et al., 2015; Based on field observation by experts
Ascidian											
1.	*Microcosmuscurvus (*Tokioka, 1954)	Scaly tunicate	√	√				√		√	Meenakshi,1997;Abdul Jaffar Ali et al,2009; Tamilselvi, et al., 2011.
2.	*Didemnum candidum* Savigny, 1816		√	√				√		√	Meenakshi, 2003; Abdul Jaffar Ali and Sivakumar, 2007; Abdul Jaffar Ali et al 2009 and 2014

Categories and Criteria adopted for listing Invasive alien Marine species

IE - Invasive Elsewhere; **RMS –** Rapid Multiplication and Spread in different ecosystems; **MMR** – Multiple Mode of Reproduction

MMD – Multiple Mode of Dispersion; **Impacts** (**B1**- affecting ecosystem functions and services; **B2**-Biodiversity loss; **B3**- Economic loss and health hazard (human and wildlife) **RE -** Range Extension (Continues spread of the species)

Invasive Alien Species / Strains of Microbes in Fresh water and brackish water ecosystems

S. No	Name of the Species	English Name	Invasiveness				Impacts			RE	References
			IE	RMS	MMR	MMD	B1	B2	B3		
Fungus											
1.	*Aphanomyces invedans*		√	√					√		Mohan and Shankar 1995; Based on field observation by experts
2.	*Enterocytozoon hepatopenaei*		√	√							Rajendran, et al, 2016; Based on field observation by experts
Bacteria											
1.	*Eswardsiella tarda*		√	√					√		Sahoo et al 2000; Based on field observation by experts
2.	*Flavobacterium* Sp		√	√					√		Verma and Rathore 2015; Based on field observation by experts
Virus											
3.	White spot syndrome Virus (WSSV)		√	√					√		Karunasagar et al **1997**; Based on field observation by experts
4.	Infectious Hypodermal Haematopoetic Necrosis Virus (IHHNV)		√	√					√		Sheela et al 1998; Based on field observation by experts
5.	Yellow head virus (YHV		√	√					√		Mohan et al 1998; Based on field observation by experts
6.	Infectious myonecrosis virus (IMNV)		√	√					√		Sahul Hameed, et al.,2017; Based on field observation by experts
7.	MonodonBaculovirus (MBV)		√	√					√		Vijayan et al 1995; Based on field observation by experts
8.	Hepatopancreatic parvovirus (HPV)		√	√					√		Manivannan, et al 2002; Based on field observation by experts
9.	Laem Singh Virus		√	√					√		Prakasha et al 2007; Based on field observation by experts
10.	Carp edema virus		√	√					√		Raja Swaminathan, et al 2016; Based on field observation by experts
11.	Cyprinid herpes virus 2		√	√					√		Sahoo, et al 2016; Based on field observation by experts

12.	Ranavirus		√	√					√		George et al. 2014; Based on field observation by experts
13.	Tilapia Lake virus		√	√					√		Behera,et al. 2018; Based on field observation by experts

The details of Categories and Criteria adopted for listing Invasive alien Microorganisms reported in Indian aquatic system

IE - Invasive Elsewhere; **RMS –** Rapid Multiplication and Spread in different ecosystems; **MMR** – Multiple Mode of Reproduction**MMD** – Multiple Mode of Dispersion; **Impacts** (**B1**- affecting ecosystem functions and services; **B2**-Biodiversity loss; **B3**- Economic loss and health hazard (human and wildlife)**RE -** Range Extension (Continues spread of the species).

Invasive Alien Spcies of Microboes /strains (other than plants) in Agriculture Ecosystems.

S. No	Species Name	Common Name	Invasiveness				Impacts			RE	Reference
			IE	RMS	MMR	MMD	B1	B2	B3		
Fungus											
1.	*Hemileia vastatrix*	Coffee rust	√	√					√		Kushalappa and Eskes 1989; Based on field observation by experts
2.	*Phytophthora infestans*	Late blight of potato	√	√					√		Butler 1918; Based on field observation by experts
3.	*Urocystis tritici*	Flag smut of wheat	√	√					√		Sydow and Butler, 1906; Based on field observation by experts
4.	*Puccinia carthami*	Rust of chrysanthemum	√	√					√		Sydow and Butler, 1906; Based on field observation by experts
5.	*Venturia inequalis*	Apple Scab	√	√					√		Rajak et al., 1974; Based on field observation by experts
6.	*Plasmopara viticola*	Downey mildew of grapes	√	√					√		CMI, 1988; Based on field observation by experts
7.	*Sclerospora phillipinensis*	Downey mildew of maize	√	√					√		Payak, and Renfro 1967; Based on field observation by experts
8.	*Pyricularia grisea*	Blast of paddy	√	√					√		Padmanabhan, 1965; Based on field observation by experts
9.	*Fusarium moniliforme*	Foot rot of Rice	√	√					√		Padmanabhan, 1959; Based on field observation by experts
10.	*Phyllachora sorghi*	Leaf spot of sorghum	√	√					√		Ramakrishnan, and Sundaram 1953; Based on field observation by experts
11.	*Oidium heavea*	Powdery mildew of rubber	√	√					√		Mitra M, Mehta PR. 1938; Ramakrishnan and Radhakrishna Pillay 1963.
12.	*Phytophthora nicotianae* var. *nicotianae*	Tobacco black shank	√	√					√		Govindarao and Koteswararao 1956..
13.	*Sphaeropsis* spp.	Canker of apple	√	√					√		Mundkur.; Kheshwala. 1943; Based on field observation by experts

14.	*Synchytrium endobioticum*	Potato wart	√	√					√		Ganguly and Paul. 1953; Based on field observation by experts
15.	*Fusariumoxysporum* f.sp *cubense* (TR4)	*Fusarium* wilt of Banana	√	√					√		Uma, et al, 2017; Based on field observation by experts
16.	*Plasmopara halstedii*	Downey mildew of sunflower	√	√					√		Mayee and Patil, 1986; Based on field observation by experts
Bacteria											
1.	*Xanthomonas campestris* p.v. *campestris*	Black rot of crucifers	√	√					√		Patel et al 1949; Based on field observation by experts
2.	*Agrobacterium tumefaciens*	Crown gall of apple/pear	√	√					√		Sharma, et al 2002; Based on field observation by experts
3.	*Agrobacterium rhizogenes*	Hairy root of apple/pear	√	√					√		Singh 1943; Based on field observation by experts
4.	*Erwinia amylovora*	Fire blight of pear	√	√					√		Papdiwal.; Deshpande. 1978; Based on field observation by experts
5.	*Xanthomonas oryzae* p.v. *oryzae*	Bacterial leaf blight of paddy	√	√					√		Srivastava and Rao, 1964; Based on field observation by experts
Virus											
1.	Banana Bunchy Top Virus (Babu virus)	Banana bunchy top	√	√					√		Verghese, 1945; Based on field observation by experts
2.	Sunflower necrosis illar virus	Sunflower necrosis	√	√					√		Prasada Rao et al 2000; Based on field observation by experts
3.	Peanut stripe virus	Bud necrosis	√	√					√		Singh, et al 1993; Based on field observation by experts
Nematode											
1.	*Globoderarostochiensis*	Potato golden nematode	√	√							Jones, 1961; Based on field observation by experts

The details of Categories and Criteria adopted for listing Invasive alien Microorganisms reported in Indian Agricultural System

IE - Invasive Elsewhere; **RMS –** Rapid Multiplication and Spread in different ecosystems; **MMR** – Multiple Mode of Reproduction. **MMD** – Multiple Mode of Dispersion; **Impacts** (**B1**- affecting ecosystem functions and services; **B2**-Biodiversity loss; **B3**- Economic loss/health hazard (human and wildlife) **RE** - Range Extension (Continues spread of the species)

Invasive Alien Insect species in Agricultural ecosystems

S. No	Name of the Species	English Name	Invasiveness				Impacts			RE	Reference
			IE	RMS	MMR	MMD	B1	B2	B3		
1.	*Aceria guerreroronis*Keifer	Coconut eriophyid mite	√	√		√			√	√	Navia et al. 2005; Desai et al. 2009Sarkar, 2011;
2.	*Aleurodicus dispersus* Russell	Spiralling white fly	√	√		√			√	√	Srinivasa et al 1999; Mani, 2010.
3.	*Aleurodicus rugioperculatus* Martin	Rugose spiraling whitefly	√	√		√	√		√	√	Sundararaj and Selvaraj, 2017.
4.	*Bemisia argentifolii* Bellows andPerring *Bemisia tabaci Biotype* B / M|EAM	Silver leaf whitefly	√	√		√			√	√	De Barro et al. 2005; Reddy et al 2006.;Sujay Yet al . 2010.
5.	*Eriosoma lanigerum (*Hausmann*)*	Woolly apple aphid	√	√	√	√			√	√	Thakur and Dogra. 2009.
6.	*Heteropsylla cubana*Crawford	Subabul psyllid	√	√		√			√	√	Singh et al. 1989; Veeresh, 1990.
7.	*Hypothenemus hampei* Ferrari	Coffee berry borer beetle	√	√					√	√	Kumar et al. 1990; Vijayalakshmi et al. 2013
8.	*Icerya purchasi* Maskell	Cottony cushion scale	√	√	√	√			√	√	Rao , 1951.
9.	*Leptocybe invasa*(Fisher and Lasalle)	Eucalyptus gall wasp/ Blue gum chalcid	√	√					√	√	Jacob et al. 2007; Senthilkumar et al 2013
10.	*Liriomyza trifolii* (Burgess)	American serpentine leaf miner	√	√		√			√	√	Virakthamath et al 1993; Hore, Garima et al 2017.
11.	*Orthezia insignis*Browne	Lantana bug	√	√						√	NBAIR, 2017; Nanjappa et al. 2005.
12.	*Paracoccus marginatus* Williams & Granara de Willink	Papaya mealybug	√	√	√	√	√	√	√	√	Mani et al 2012; Krishnan et al 2016
13.	*Phenacoccus madeirensis*	Madeira mealybug	√	√	√	√			√	√	Shylesha and Joshi 2012
14.	*Phenacoccus solenopsis* Tinsley	Cotton mealybug	√	√	√	√			√	√	Vennila et al. 2010; Maruthadurai, and Singh, 2015

15.	*Plutella xylostella*Linnaeus	Diamond back moth	√	√					√	√	Fletcher, 1914; Sujay et al 2010.
16.	*Pseudococcus jackbeardsleyi* Gimpel and Miller	Banana mealybug	√						√	√	Mani *et al.* 2013
17.	*Quadraspidiotus perniciosus* (Constock)	San Jose scale	√	√	√				√	√	Fotedar, R. 1941; Rawat, and Pawar,., 1991; Rawat, Sangal, et al., 1993.
18.	*Quadrastichus erythrinae* Kim	Erythrina gall wasp	√	√					√	√	Faizal, et al 2006.
19.	*Tuta absoluta* (Meyrick)	Tomato Pinworm	√	√		√			√	√	Sridhar et al. 2014; Sharma and Omkar Gavkare.2017
20.	*Pineus pini (*Macquart*)*	Pine woolly aphid	√	√						√	FAO, 2005; Sujay et al 2010.
21.	*Phthorimaea operculella* (Zeller)	Potato tuber moth	√	√					√	√	Lefroy, 1907; Chandel, et al 2005.

Categories and Criteria adopted for listing Invasive alien Insects reported in Indian Agricultural System

IE - Invasive Elsewhere; **RMS –** Rapid Multiplication and Spread in different ecosystems; **MMR** – Multiple Mode of Reproduction
MMD – Multiple Mode of Dispersion; **Impacts** (**B1**- affecting ecosystem services and functions; **B2**-Biodiversity loss; **B3**- Economic loss and health hazard (human and wildlife)**RE -** Range Extension (Continues spread of the species)

Invasive Alien Species of Major Islands

S. No	Species Name	Common Name	Invasiveness				Impacts			RE	Reference
			IE	RMS	MMR	MMD	B1	B2	B3		
Insects											
1.	*Citripestis eutraphera*	Mango borer	√	√					√	√	Soumyaet al. 2016.
2.	*Anoplolepis gracilipes*	yellow crazy ant	√	√						√	Bharti et al 2016; Sardarand Ghorai 2017.
Cnidaria											
1.	*Carijoa riisei*	Snowflake coral	√	√				√	√	√	Raghunathan, et al 2013; Venkataraman et al 2016
Mollusca											
1.	*Achatina fulica*	Giant African Snail	√	√						√	Mohanty et al 2018.
Fishes											
1.	*Oreochromis mossambiscus*	Mozambique tilapia	√	√					√	√	Rajan et al 2018.
2.	*Heteropneustes fossilis*	Asian stinging catfish	√	√					√		Rajan et al 2018.
Amphibian											
1.	*Hoplobatrachus tigerinus*	Indian bullfrog	√	√				√	√	√	Harikrishnan and Vasudevan. 2013; Mohanty et al 2018a
Reptile											
1.	*Calotes versicolor*	Garden lizard	√	√					√		Harikrishnan and Vasudevan. 2013
Birds											
1	*Acridotheoes tristis*	Common Myna	√	√						√	Rajan, and Pramod, 2013; Mohanty et al 2018.
2.	*Passer domesticus*	House sparrow	√	√						√	Rajan, and Pramod, 2013; Mohanty et al 2018.
Mammals											
1	*Axis axis*	Chital/Spotted deer	√	√				√	√	√	Ali and Pelkey 2013; Mohanty et al 2016.
2.	*Axis porcinus*	Indian Hog deer	√	√					√		Ali, R. 2004.
3.	*Muntiacus muntjak*	Indian muntjac	√	√					√		Ali, R. 2004.
4.	*Elephas maximus*	Asian elephant	√	√					√		Ali, R. 2004

Categories and Criteria adopted for listing Island invasive species

Note: IE - Invasive Elsewhere; **RMS –** Rapid Multiplication and Spread in different ecosystems; **MMR** – Multiple Mode of Reproduction **MMD** – Multiple Mode of Dispersion; **Impacts** (**B1**- affecting ecosystem services and functions; **B2**-Biodiversity loss; **B3**- Economic loss and health hazard (human and wildlife) **RE -** Range Extension (Continues spread of the species).

Details of the Invasive Alien species reported in India

S.NO	Details of the Species and Ecosystem	Total
Terrestrial Ecosystem		
1.	Terrestrial plants	**54**
	Total	**54**
Aquatic Ecosystem		
1.	Microorganism reported in freshwater and brackish water	**15**
2.	Aquatic plants (inland)	**8**
3.	Fishes	**14**
4.	Marine invasive species	**19**
	Total	**56**
Agriculture Ecosystem		
1.	Fungus	**16**
2.	Bacteria	**5**
3.	Virus	**3**
4.	Nematode	**1**
5.	Invasive Insects	**22**
	Total	**47**
Major Island Ecosystem		
1.	Insects	**2**
2.	Cnidaria	**1**
3.	Mollusca	**1**
4.	Fishes	**2**
5.	Amphibian	**1**
6.	Reptile	**1**
7.	Birds	**2**
8.	Mammals	**4**
	Total	**14**
	Terrestrial plants	**54**
	Aquatic Ecosystem	**56**
	Agriculture Ecosystem	**47**
	Island Ecosystem	**14**
	Overall Indian IAS species	**173**