

# Invasive alien fauna in Sri Lanka: National list, impacts and regulatory framework

B. Marambe<sup>1</sup>, P. Silva<sup>1</sup>, S. Ranwala<sup>2</sup>, J. Gunawardena<sup>3</sup>, D. Weerakoon<sup>2</sup>, S. Wijesundara<sup>4</sup>, L. Manawadu<sup>2</sup>, N. Atapattu<sup>5</sup>, and M. Kurukulasuriya<sup>1</sup>

<sup>1</sup>Faculty of Agriculture, University of Peradeniya, Sri Lanka. <pradeepas@pdn.ac.lk>. <sup>2</sup>Faculty of Science, University of Colombo, Sri Lanka, <sup>3</sup>Stanley Thilakarathne Mawathe, Nugegoda, Sri Lanka, <sup>4</sup>Royal Botanic Garden, Peradeniya, Sri Lanka, <sup>5</sup>Canadian High Commission, Colombo, Sri Lanka.

**Abstract** In Sri Lanka, 12 invasive alien species (IAS) of animals are nationally listed, 10 of which are vertebrates (seven species of fresh water fishes, two species of rodents, and one species of large mammal) and two are invertebrates (two species of molluscs). The list was created after a risk assessment based on the potential ecological and socio-economic impacts, invasive potential, distribution and the management options of the candidate species. Of the IAS where information on the year of introduction is available, four were introduced before 1978 (the year of introduction of open economic policies) and three thereafter. The main impacts of IAS on native species have been through direct destruction, competitive exclusion, and hybridisation. Four main legal enactments and three national policies are aimed at the control of entry and spread of invasive alien fauna in Sri Lanka. Despite many sectoral policies, laws and regulations touching on IAS, the regulatory framework still remains unclear, piece-meal, overlapping and largely un-enforced. A well-coordinated institutional mechanism for an effective eradication/control IAS in the country is urgently needed.

**Keywords:** Sri Lanka, risk assessment, predation, competition, hybridisation, eradication

## INTRODUCTION

Sri Lanka is an island nation with a land area of 65,610 km<sup>2</sup>, additional territorial waters and an Exclusive Economic Zone (EEZ) of 517,000 km<sup>2</sup>. The country is biologically diverse, due to variations in topography and climate. Natural ecosystems and habitats include forests and grasslands, freshwater and marine wetlands, rivers, streams, mangroves, and coral reefs.

Together with the Western Ghats of India, Sri Lanka was identified by Conservation International (CI) as one of 34 global biodiversity “hotspots”, with a high concentration of endemic species, and the loss of over 75% of the primary vegetation (Mittermeier *et al.* 2005). Myers *et al.* (2000) identified this region as one of eight biodiversity hotspots based on the number of endemic plants and vertebrates, their density, and remaining primary vegetation relative to the original extent. Birdlife International (BI) has identified Sri Lanka as one of the world’s 356 endemic bird areas ([www.birdlife.org](http://www.birdlife.org)). Sri Lanka’s lowland rainforests, montane rainforests and south-western rivers and streams are listed in WWF’s Global 200 eco-regions as one of the most biologically distinct terrestrial, freshwater, and marine eco-regions of the planet, and are considered priorities for conservation ([www.worldwildlife.org/science/ecoregions/global200.html](http://www.worldwildlife.org/science/ecoregions/global200.html)).

Invasive alien species (IAS) have resulted in major impacts on biodiversity at a global scale, where at least 39 per cent of the species extinctions during the past 400 years are due to IAS ([www.indiaenvironmentportal.org.in/node/38152](http://www.indiaenvironmentportal.org.in/node/38152)). In Sri Lanka, many alien species imported for agriculture have established in the wild in low numbers, often with few recorded effects on local ecosystems. A small proportion of intentional and accidental introductions have become serious problems that have destroyed or displaced crops or indigenous species. The contribution of IAS to habitat degradation is second only to the direct negative impact caused by humans.

Sri Lanka has now recognised IAS as a major threat to the native biodiversity (IUCN and MENR 2007). These threats have become more significant over the past two or three decades due to more liberalised economic policies facilitating international trade, travel and transportation movement (Marambe *et al.* 2003), and natural and man-made disasters supporting the free movement of

international aid. The IUCN Invasive Species Specialist Group’s (ISSG) Global Invasive Species Database lists 82 potentially invasive species as present on the island. More than 60 of these are known to have become invasive (40 plants and 20 animals, including 23 of “100 of the world’s worst”). The rapid spread of these species in a multitude of environments makes control difficult as options applied one ecosystem may be difficult to apply in another.

Previous studies have focussed on invasive alien flora rather than on fauna (Marambe 1999, 2000, 2008) for which lists were based on limited literature, popular articles, and observations and perceptions of scientists/environmentalists. No formal risk assessment process has been undertaken to determine their invasiveness. This paper provides the most recent overview of the status and impact of invasive alien fauna in Sri Lanka, plus a review of the existing regulatory framework and strategies adopted to overcome threats from these species.

## INVASIVE ALIEN FAUNA IN SRI LANKA

Bambaradeniya (2000, 2002) listed twenty species of invasive alien fauna spreading in the natural and semi natural ecosystems in different bioclimatic zones of Sri Lanka. This included nine species of freshwater fish, one of reptile, five of mammals, and five of molluscs. Ten of these species are included in the list of 100 of the world’s worst IAS (IUCN-ISSG 2001). Excluding Northern and Sabaragamuwa Provinces, there are published provincial lists based on observations by scientists (Table 1), but not all of these species have been through a risk assessment process.

A risk assessment protocol for assessing the invasive alien fauna has been developed and is accepted by the Biodiversity Secretariat (BDS) of the Ministry of Environment of Sri Lanka (MESL). It evaluates invasive fauna according to stratified criteria identified under four thematic areas: potential ecological and socio economic impacts; invasive potential; distribution; and management of the candidate species (Ranwala 2010).

The national list of invasive alien fauna (Table 2) identified from this risk assessment includes seven species of freshwater fish, two species of rodents, one species

**Table 1** Distribution of invasive alien fauna in the seven provinces of Sri Lanka\* P = recorded as present (Adopted from: Silva and Kurukulasuriya 2010).

Invasive Alien Fauna	NW	NC	UP	WP	CP	EP	SP
Clown knifefish ( <i>Chitala ornata</i> )	P	P	-	P	-	-	P
Plecostomus catfish ( <i>Hypostomus plecostomus</i> )	P	-	-	P	-	-	-
Walking catfish ( <i>Clarias batrachus</i> )	P	-	-	P	-	-	-
Guppy ( <i>Poecilia reticulata</i> )	P	-	-	P	-	-	P
Western mosquitofish ( <i>Gambusia affinis</i> )	P	-	-	P	-	-	-
Mosambique tilapia ( <i>Oreochromis mossambicus</i> )	P	P	P	P	P	-	P
Carp ( <i>Cyprinus carpio</i> )	-	-	-	P	-	P	-
Snakeskin gouramy ( <i>Trichogaster pectoralis</i> )**	-	-	-	-	-	-	-
Red eared slider turtle ( <i>Trachemys scripta</i> )	-	P	-	P	-	-	-
House mouse ( <i>Mus musculus</i> )	-	-	-	P	-	-	-
Ship rat ( <i>Rattus rattus norvegicus</i> )	-	-	-	P	-	-	-
Feral cat ( <i>Felis catus</i> )	-	-	-	P	-	-	-
Feral dog ( <i>Canis familiaris</i> )	-	-	-	P	-	-	-
Feral buffalo ( <i>Bubalus bubalis</i> )	P	-	P	-	-	-	P
Apple snail ( <i>Pomacea diffusa</i> )	-	-	-	P	-	-	P
Giant African snail ( <i>Lissachatina fulica</i> )	-	-	-	P	-	-	-
Field slug ( <i>Laevicaulis alte</i> )	-	-	-	P	-	-	-
Rainbow trout ( <i>Oncorhynchus mykiss</i> )**	-	-	-	-	-	-	-
Garden slug ( <i>Deroceras reticulatum</i> )**	-	-	-	-	-	-	-
Garden slug ( <i>Deroceras caruanae</i> )**	-	-	-	-	-	-	-

\*NW – North Western Province, NC – North Central Province, UP – Uva Province, WP – Western Province, CP – Central Province, EP – Eastern Province, SP – Southern Province.

\*\* These species have not been recorded in any of the above provinces despite been listed in the previous national lists (Bambaradeniya 2000, 2002; Marambe *et al.* 2001; Wijesekera and Bambaradeniya 2007)

of large mammal, and species of molluscs. In addition, 16 species have been identified as alien fauna with a potential to become invasive and eight species listed by Bambaradeniya (2002) lack recent records (see Table 1).

## IMPACTS OF INVASIVE ALIEN FAUNA IN SRI LANKA

Threats posed by IAS to native species include direct exploitation or destruction, competition for resources, hybridisation and the other impacts. The following section illustrates with specific examples the likely impacts of IAS in Sri Lanka, under the above impact categories.

### Direct exploitation/destruction of native species

The clown knifefish (*Chitala ornata*) is a large predator introduced in 1994. Subsequently, there have been decreases in the abundance of native fish such as *Aplocheilichthys dayi*, *A. parvus*, *Horadandia athukorali*, *P. vittatus*, *P. bimaculatus*, *R. daniconius* and *Amblypharyngodon melettinus* (Gunawardena 2002). The predatory walking catfish (*Clarias batrachus*) also has direct effects on native species (Weerawardane and Dissanayake 2005).

The guppy (*Poecilia reticulata*) was introduced to control mosquito larvae based on its larvivorous feeding habits, but its efficacy as a bio-control agent is now questionable. Research by Shirantha *et al.* (2008) showed that guppy feeding habits have become more carnivorous and the species is now feeding on the eggs of amphibians (Bambaradeniya 1999).

Feral populations of cats (*Felis catus*) and dogs (*Canis familiaris*) prey on wild reptiles, birds and small mammals ([www.sundaytimes.lk/030615/funday/2.html](http://www.sundaytimes.lk/030615/funday/2.html)). Feral dogs have been seen attacking wild animals in Bundala National Park (Bambaradeniya *et al.* 2002) and the dogs also avidly search for and feed on the eggs of marine turtles in coastal areas (De Silva 1999, Ilangakone 2000, Bambaradeniya *et al.* 2002). De Silva (2007) has documented domestic cats destroying herpetofauna in home gardens.

### Superior competitors for resources

In Sri Lanka, Mosambique tilapia (*Oreochromis mossambicus*) is non-selective in its diet and breeds prolifically, enabling it to colonise tanks, reservoirs and slow flowing rivers while displacing native inhabitants such as *Labeo porcellus* and *L. dussumieri* (Pethiyagoda 1999). The diet of small tilapia comprises zooplankton, which are food resources for indigenous fish. The endemic red-fin labeo (*L. lankae*) overlaps in distribution with tilapia and has been driven to near extinction, possibly due to this competition (Pethiyagoda 1999, 2006).

Mozambique tilapia also occupies the same habitats as the indigenous cichlid *Etilapia suratensis*, and the two species probably compete for nesting space (Ahamed and Dharmaretnam 2008). The listing of Mozambique tilapia as an IAS was challenged by aquaculture specialists who claimed that endemic fish species do not exist in the reservoirs where tilapias are abundant (Amarasinghe *et al.* 2006). Populations of Mozambique tilapia that established in some non-flowing habitats showed little significant dietary overlap with indigenous fish species (Amarasinghe *et al.* 2008). These contradictory views indicate that the impact of co-occurring populations of tilapia and indigenous fish is not clear and further assessment is warranted.

The tank cleaner (*Hypostomus plecostomus*) can out-compete native biota. The species is an omnivore with a diet varying from plankton to plant matter and invertebrates. Further invasion to inland waters may pose a threat to endemic fish species (Wijethunga and Epa 2008). The scrape feeding habits of the tank cleaner could change habitat quality, leading to detrimental effects on co-occurring species (Amarasinghe *et al.* 2006).

In the dry zone, feral buffaloes (*Bubalus bubalis*) compete for food with herbivores such as deer (*Rusa alfredi*), sambur (*R. unicolor*) and elephants (*Elephas maximus*). Their wallowing muddies aquatic habitats, which deters their use by other animals such as elephants (Bambaradeniya 2000). In Sinharaja rainforest, exotic

**Table 2** The National List of Invasive Alien Fauna and their summary status in Sri Lanka.

Species	Mode of Introduction	Spread	Nature of threat	Control
Plecostomus catfish/ Tank cleaner/ Sucker mouth catfish ( <i>Hypostomus plecostomus</i> )	1994; Negligence; Ornamental fish trade	Coastal flood plain, mainly around Colombo, Gampaha, Kandy and Kalutara districts	Superior competitors for resources Scrape feeding habits-change the habitat quality	Not available
Mosambique tilapia ( <i>Oreochromis mossambicus</i> )	1952; Deliberate; commercial fishery	Island wide	Superior competitors for resources	Not available
Clown knifefish ( <i>Chitala ornata</i> )	1994; Neglect; Ornamental fish trade	Coastal flood plain Streams and reservoirs - wet zone	Direct exploitation or destruction of native species	Not available
Ship rat ( <i>Rattus rattus</i> )	Accidental; Ships	Island wide distribution in natural and managed terrestrial habitats	Agricultural pest; hybridisation with the native biota; vector for leptospirosis virus	Chemical control – poisonous baits
Apple snail ( <i>Pomacea diffusa</i> )	1980; Negligence; Ornamental fish trade	Colombo, Kalutara, Kandy, Galle, Rathnapura, Gampaha, and Matara	Destruction of aquatic plants	Not available
Guppy ( <i>Poecilia reticulata</i> )	1930; Deliberate; mosquito control	Lowland wet zone, and more riverine areas - upper catchments of Mahaweli & Kelani rivers	Direct exploitation or destruction of native species	Not available
Walking catfish ( <i>Clarias batrachus</i> )	Negligence; Ornamental fish trade	Marshes and streams - lowland wet zone	Direct exploitation or destruction of native species	Not available
Feral buffalo ( <i>Bubalus bubalis</i> )	Deliberate; Animal husbandry	Island wide - Forests	Superior competitors for resources; hybridisation with native biota; facilitate the spread of invasive alien plants	Not available
House mouse ( <i>Mus musculus</i> )	Accidental; Ships	Island wide distribution in natural and managed terrestrial habitats	Agricultural pest; hybridisation with the native biota; vector for leptospirosis virus	Chemical control – poisonous baits
Western mosquito fish ( <i>Gambusia affinis</i> )	Deliberate; mosquito control	Marshes, ditches and streams of the lowland wet zone	Not known	Not available
Carp ( <i>Cyprinus carpio</i> )	1915; Deliberate; commercial fishery	Headwater streams 1500m a.s.l. elevation	Superior competitors for resources; feeding habits- change the habitat quality; direct exploitation or destruction of native species	Not available
Giant African snail ( <i>Lissachatina fulica</i> )	1840; Negligence, Research/Hobby	Island wide distribution in natural and managed terrestrial habitats	Pest of agricultural landscapes	Chemical control - metaldehyde

ship rats (*Rattus rattus*) appear to suppress numbers of the endemic *Srilankamys ohiensis*, which suggests competition between the two species of rats for resources (Bambaradeniya 2000).

#### Hybridisation with native species

Domestic buffaloes have interbred with the native wild water buffaloes (*Bubalus arnee*) to form a hybrid feral population (Bambaradeniya 2002). This has probably led to the local extinction of genetically pure populations of the wild water buffalo in locations such as the Wilpattu National Park (Deraniyagala 1964). The three subspecies of ship rat (*R. rattus rattus*, *R. r. alexandrianus* and *R. r. rufescens*), which were accidentally introduced to Sri Lanka, have probably interbred with the two local subspecies (*R. r. kandianus* and *R. r. kelaarti*) to form hybrid populations (Bambaradeniya 2000). The extent of

hybridisation in buffaloes and the rats needs to be verified by further study.

#### Other impacts

Some invasive alien fauna have indirect influences on native biodiversity. Feral buffalo feed on the pods of the invasive alien mesquite (*Prosopis juliflora*) and facilitate the spread of this plant in the arid zone. They also disturb natural habitats allowing the establishment of invasive alien plants such as *Lantana camara* (Bambaradeniya 2000). Ship rats spread leptospirosis virus, and feral cats and dogs are vectors of rabies ([www.sundaytimes.lk/030615/funday/2.html](http://www.sundaytimes.lk/030615/funday/2.html)). Increased fishery pressure and the adoption of harmful fishing practices (i.e. small-meshed gill nets) to catch exotics such as tilapia and carp (*Cyprinus carpio*) have impacted non-target species such as freshwater turtles in the dry zone reservoirs (Pethiyagoda 1999).

**Table 3** The main legal instruments found in Sri Lanka to deal with invasive alien fauna.

Ordinance/Act	Intention	Applications	Problems in implementation
Fauna and Flora Protection Ordinance (No. 02 of 1937, as amended)	protection, conservation, and preservation of fauna and flora of Sri Lanka and the commercial exploitation of them	Import of any animal, spawn, eggs, or larvae of any animal can only be done under the authority of a permit [Section 37(1)]; applies to all species of animals except those domestic animals - cattle, sheep, goats, horses, asses, mules, dogs, cats, domesticated pigs and domestic fowl reared as poultry; these provisions have the same effect as if they were part of the Customs Ordinance	No provisions to deal with a species already brought in under a permit, where it has subsequently become an invasive or is likely to become invasive; this Act does not apply to plants.
Fisheries and Aquatic Resources Act (No. 02 of 1996, as amended)	to manage, regulate, conserve and develop the fisheries and aquatic resources	Minister in Charge of Fisheries and Aquatic Resources, and the Minister in Charge of Trade, can prohibit or regulate the import of fish or aquatic resources. 24 species of fishes are prohibited from being imported.	No provisions to deal with a species that has become or is likely to become an invasive in the country.
Plant Protection Act (No. 35 of 1999)	to prevent the introduction and spread of any organism injurious or harmful to plants or destructive to plants found in Sri Lanka	To prevent entry of any plant or animal that may become a pest or invasive, or potential threat to plant life. When there is reason to believe that a pest is being harboured in any premises, the D G of Agriculture can direct an inspection to ascertain the situation. The Minister of Agriculture can prohibit entry of Quarantine Pests (a pest of potential economic or environmental importance that is not yet present or present but not widely distributed and being officially controlled).	The Act does not make provisions to control an introduced species or a species with a potential to be introduced that could be harmful to animals
Marine Pollution Prevention Act (No. 35 of 2008)	to prevent, control and reduce pollution in the territorial waters.	Provisions can be used to bring in necessary regulations to control and regulate the release of ballast waters in the seas of Sri Lanka or to treat them in a specified way before releasing into the waters.	Regulations are still to be made for the implementation of the Act

## EFFORTS TO OVERCOME THE THREATS OF INVASIVE ALIEN FAUNA TO THE SRI LANKAN ECOSYSTEMS

### Legal Instruments

Sri Lanka is a signatory to international and regional agreements related to trade, such as World Trade Organization (WTO) Agreements, South Asian Free Trade Area (SAFTA) Agreement, and to international conventions related to IAS such as Convention on Biological Diversity (CBD), International Plant Protection Convention (IPPC), and International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). Sri Lanka has also enacted many ordinances/acts to impose laws governing import of fauna and flora to the country. Key ordinances and government agencies include: 1) the BDS of the MESL, which serves as the focal point for the implementation of the CBD; 2) the Department of Agriculture (DOA) of the Ministry of Agriculture (MA) of Sri Lanka, which is the focal point for IPPC related activities; 3) the Marine Environment Protection Authority (MEPA) of the MESL

is the focal point for implementation of MARPOL 73/78 Convention.

The main legal enactments that have directly assisted in eradicating and controlling the entry and spread of invasive alien fauna in Sri Lanka are given in Table 3, in the chronological order of enactment.

### Legal instruments and policies

Existing legislative enactments provide considerable legal support for actions against the introduction of IAS (Table 3). However, these laws can only be used in relation to specific types of invasive species. No single enactment deals with all the different types of invasive species. Approval has now been granted to develop a new act to prevent the entry of IAS and control of those already present.

The Constitution of the Democratic Socialist Republic of Sri Lanka, states that “The state shall protect, preserve and improve the environment for the benefit of the

**Table 4** National level policies directly dealing with IAS

National Policy	Implementing organisation	Relevant statements for IAS control
National Wildlife Policy of 2000	Department of Wildlife Conservation	To promote ecosystem-based management of protected areas, including the eradication of alien and invasive species, subject to thorough consideration of the environmental impacts. To regulate the importation of alien organisms, including genetically-modified organisms, so as to minimise risks to the integrity of Sri Lanka's biodiversity
National Environmental Policy of 2003	Ministry of Environment	Environmental management systems will be encouraged to be flexible so as to adapt to changing situations (e.g., climate change, invasive species and living, genetically-modified organisms) and adopt the precautionary principle
National Agriculture Policy of 2007	Ministry of Agriculture	Strictly adhere to plant protection regulations to prevent alien weeds, insect pests and diseases from entering the country

community". This governs the activities of all state, private sector and non-governmental organisations and individuals in protecting the environment. Several government institutions have developed policy statements or working mechanisms to tackle issues related to IAS (Table 4). However, key stakeholder organisations have as yet failed to create policies related to IAS, especially those that should focus on eradication.

### Action plans relevant to dealing with IAS

The BDS of the MESL, as the national authority for addressing issues related to biodiversity conservation, has taken steps to formulate a National Action Plan for the Control of IAS in protected areas, as a component of the Addendum to 'Biodiversity Conservation in Sri Lanka: a framework for action' (MENR 2007). Further, the secretariat has taken an initiative to appoint a National Experts' Committee on IAS to deal with the threats of alien invasions.

The Addendum to the Biodiversity Conservation Action Plan (BCAP) in Sri Lanka (MENR 2007) listed as high priority recommendations: 1) establish an invasive species specialist group; 2) prioritise invasive alien species including GMOs, terrestrial and aquatic species; 3) prepare a national database on IAS; 4) provide funding for research on methods to control the spread of the prioritised IAS; 5) establish a national biodiversity information management committee to implement the computerised networking and establishment of meta-data base (including invasive species); and 6) strengthen human resources, technical capacity and infrastructure of the BDS of the MENR, so as to provide capacity to coordinate and monitor a comprehensive set of biodiversity indicators and programmes (including invasive species).

The need for appropriate structures and indicators for monitoring biodiversity components and coordination of action plans is recognised as an integral part of implementing commitment to the CBD (Atapattu *et al.* 2006). There is little information about monitoring activities and evaluating success of locally organised projects. A monitoring mechanism is in place for many national and international projects. However, there is almost no evaluation of the success and failures of IAS management activities. For an effective monitoring and evaluation to take place, development and use of indicators is imperative. The Addendum to the BCAP in Sri Lanka – A Framework for Action (MENR 2007) and the relevant chapter report (Atapattu *et al.* 2006) lists indicators to be used in evaluating the impact of IAS related activities.

### CONCLUSIONS

There has been a significant increase in research on specific invasive alien fauna over the past five years but there is no institution/committee assigned to oversee and coordinate research and management actions. Eradicating or managing IAS requires a coordinated strategy based on cooperation among all land managers (Marambe 2001). A National Strategy and Action Plan (NSAP) was proposed for effective management of IAS by Marambe (2001) as the existing institutional design and coordinating mechanism is insufficient or ineffective in tackling IAS issues at national and regional levels.

In Sri Lanka, the regulatory framework for IAS control remains unclear, piece-meal, overlapping and largely un-enforced, despite many sectoral policies, laws and

regulations. This situation has facilitated the entry to, and spread of, IAS through new pathways created as a result of expanding international trade, tourism, and transport. Different organisations are mandated to implement policies and laws governing IAS control, planning and implementation, but at present each group addresses their own institutional concerns with little consideration for overall national priorities.

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