National Symposium on Invasive Alien species

21-22 May, 2009
Browns Beach Hotel, Negombo

ABSTRACTS

Organized by

Biodiversity Secretariat, Ministry of Environment and Natural Resources

in collaboration with
Agriculture Education Unit (AEU) of University of Peradeniya
Institute of Biology (Sri Lanka)

Sponsored by
GEF/ UNDP funded project 'Strengthening Capacity to Control the Introduction and Spread of Invasive Alien Species' and
South Asia Co-operative Environment Programme (SACEP)

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National Symposium on Invasive Alien Species

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Program - Inaugural Session (21 May 2009)	
08.30 - 09.30	Registration of participants
09.30 - 09.40	Traditional Lighting of the Oil Lamp
09.40 - 09.50	Welcome Address and Introductory Remarks - **MARD Jayathilake**, Secretary/Ministry of Environment and Natural Resources
09.50 - 09.55	Address by: **Prof. Buddhi Marambe**, Team Leader/GEF-UNDP IAS Project
09.55 - 10.00	Address by: **Mr. Ananda Mallawathanthri**, Assistant Resident Representative, UNDP
10.00 - 10.10	Address by: **Hon. Champika Ranawaka**, Minister of Environment and Natural Resources
10.10 - 10.15	Vote of Thanks: **Mr. WM Wijesuriya**, Additional Secretary/Ministry of Environment and Natural Resources
10.15 - 10.45	**Tea**
Program - Plenary Session	
Keynote Address and Guest Lecturers (Chairperson: Mr. Sarath Fernando, Conservator General of Forests, Forest Department)	
10.45 - 11.05	Keynote Address: Marine Invasive Species in South Asian Seas (**R. Venkatesan,** SASP Coordinator, South Asian Seas Programme of South Asia Co-operative Environment Programme (SACEP)
11.05 - 11.20	Integrated Parthenium Weed Management Technology adopted in India (**M. Mahadevappa**)
11.20 - 11.30	Invasive Alien Species - Definitions (**Siril Wijesundara**)
11.30 - 11.45	Invasion - a Tool of Evolution (**T. Jayasingham**)
Position Papers (Chairperson: Mr. Ananda Mallawatantri, Assistant Resident Representative, UNDP)	
11.45 - 12.00	Institutional Arranagement, Policy and Legal instruments to deal with Invasive Alien Species in Sri Lanka (**Buddhi Marambe** & **Jagath Gunawardana**)
12.00 - 12.15	Invasive Alien Flora in Sri Lanka (**Siril Wijesundara**)
12.15 - 12.30	Invasive Alien Fauna in Sri Lanka: Present Scenario (**Pradeepa Silva** & **Maheshika Kurukulasuriya**)
12.30 - 12.45	Impact Analysis and Information Needs for Management of Invasive Alien Species in Sri Lanka (**Sudheera Ranwala**, **Nihal Atapattu** & **Lasantha Manawadu**)

12.45 - 01.00	Education and Awareness on IAS in Sri Lanka (**Devaka Weerakoon**)
01.00 - 02.00	**LUNCH**
Invited Papers (Chairperson: Mr. Ananda Wijesuriya, Director General/Department of Wildlife Conservation)	
02.00 - 02.15	Invasive species on Sri Lankan agriculture – Impacts, Management and Policy Implications (**DH Muthukudaarachchi & W M D H Kulathunga**)
02.15 - 02.30	Aquatic and Marine Invasives – Issues and Concerns and Policy Directives (**R. Kularatne**)
02.30 - 02.45	Forest invasive species in Sri Lanka (**NDR Weerawardena**)
02.45 - 03.00	Invasive alien species – Policy Directives and Implementation through Department of Wildlife (**S.R.B Dissanayake**)
03.00 - 03.15	Entry of invasive alien species to Sri Lanka - Role of Sri Lanka Customs (**Samantha Gunasekara**)
03.15 - 03.45	**TEA**
Invited Papers (Chairperson: Prof. Buddhi Marambe, Dean/Faculty of Agriculture, University of Peradeniya)	
03.45 - 04.00	Knowns and unknown of invasive behaviour and impact of invasive alien flora (**IAUN Gunatillake**)
04.00 - 04.15	Role of NGOs in management of IAS in Sri Lanka (**Sarath Ekanayake**)
04.15 - 04.30	Role of the Private Sector (**Sumith Abeysiriwardena**)
04.30 - 04.45	Role of Plant Quarantine in preventing entry of IAS to Sri Lanka (**RSY Silva**)
04.45 - 05.00	**BREAK**
Invited Papers (Mr. Gamini Gamage, Director/Biodiversity Secretariat, Ministry of Environment and Natural Resources)	
05.00 - 05.15	Management of *Salvinia molesta* in Sri Lanka (**PT Bandara**)
05.15 - 05.30	Control of Water hyacinth in Sri Lanka (**Lakshman Amarasinghe**)
05.30 - 05.45	Animal Quarantine – a measure to tackle invasive alien fauna in Sri Lanka (**A. Hewakoparage**)
05.45 - 06.00	Importance of identifying biodiversity signatures in implementation of article 8(h) in the Convention on Biological Diversity (**R. Senanayake**)
06.00 - 06.15	Impact and policy interventions on IAS in relation to aviation industry (**C. Widanapathirana**)
07.00 onwards	**FELLOWSHIP and DINNER**

National Sympoisum on Invasive Alien Species

21-22 May 2009, Browns Beach Hotel, Negombo

Program - Technical Sessions (22 May 2009)

Time & Venue

Auditorium - A

Risk Assessment and Ecology of IAS (Chairperson: Prof. I A U N Gunatilleke, University of Peradeniya)

08.30 - 08.50	Assessment of invasiveness of alien species: a statistical approach (**DKNG Pushpakumara, RO Thattil, B Marambe, GLLP Silva, ARSB Athauda, & D Weerakoon**)
08.50 - 09.10	Predicting invasiveness of fishes: An ecomorpholgical approach (**WS Welianga**)
09.10 - 09.30	Status, Ecology, and Management of the Invasive Plant *Miconia calvescens* DC (Melastomataceae) in Sri Lanka (**SH Bandumala**)

IAS in Forest Ecosystems (Chairperson: Mr. A Sathurusinghe, Deputy Conservator General of Forests/Forest Department)

09.30 - 09.50	Allelopathic effects of *P. juliflora* and its impact on some Sri Lankan dry forest species (**GAD Perera, GAN Suranjith, & RMUK Gunarathne**)
09.50 - 10.10	Factors affecting invasion of *Clidemia hirta* (L.) D. Don into Lowland Rain Forests of Sri Lanka: A case study from the Sinharaja Forest Dynamics Plot (**IAUN Gunatilleke, CVS Gunatilleke, T Chambers, IM Ambagahaduwa, KK Hushumnong, DFRP Burslem, PE Hulme, & RD Harrison**)
10.10 - 10.30	Preliminary study on the distribution of *Austroeupatorium inulifolium* in the Knuckles Conservation Area (**I Piyasinghe, D Wickremarathne, SM Weerasinghe, & J Gunatillake**)

Auditorium - B

Biology of IAS (Chairperson: D H Muthukudaarachchi, Director/Seed Certification & Plant Protection Centre/Department of Agriculture)

08.30 - 08.50	Morphological plasticity and competitive ability of *Austroeupatorium inulifolium* plant species (**I Piyasinghe, SM Weerasinghe, & J Gunatillake**)
08.50 - 09.10	Life history and feeding behaviour of a natural enemy of *Mimosa pigra* in Sri Lanka (**RRAR Shirantha & NK Ranawaka**)

09.10 - 09.30	Competitive ability of *Lantana camara* with *Urena lobata* (**I Piyasinghe, SM Weerasinghe, & J Gunatillake**)

IAS in Agriculture Ecosystems (Chairperson: Professor Rohan Rajapaksha, Executive Director/Council for Agricultural Research Policy)

09.30 - 09.50	Community based management of *Achatina fulica* (Férussac, 1821) populations in an agricultural landscape (**S Lelwala, T Ranasinghe, S Wijesundera, K Karunasena,& C Bambaradeniya**)
09.50 - 10.10	*Harmalia heitensis otho* Fennah 1975 (Hemiptera: Delphacidae) - An new pest of *Altenanthara sessilis* (L.) (Amaranthaceae) in Sri Lanka (**R Gnaneswaran & CA Wiraktamath**)
10.10 - 10.30	Invasive Alien Species of Agricultural Importance: Have we managed them properly? (**A Wijesekera**)
10.30 - 11.00	**TEA**

Auditorium - A

IAS in Aquatic Ecosystems (Chairperson: Ms. K T R Prathapasinghe, Director General/National Aquatic Resources Research and Development Agency)

11.00 - 11.20	Distribution of Aquatic weeds and their impacts in Ampara district (**ASLE Corea**)
11.20 - 1140	Effects of accidentally introduced sucker mouth tank cleaner (*Pterygoplychthys multiradiatus*) on the fishery in Polgolla reservoir at the Central Province of Sri Lanka (**UPK Epa & KVSN Bandara**)
11.40 - 12.00	Ontogenetic dietary shifts in accidentally introduced Clown Featherback *Chitala ornata* (Osteichthyes, Notopteridae) and its potential impact on freshwater fauna of Sri Lanka (**RRAR Shirantha & US Amarasinghe**)
12.00 - 12.20	Is Tilapia becoming and invasive fish in Sri Lanka? (**ARSB Athauda**)

Auditorium - B

IAS in Wetlands, Grasslands and Lagoons (Chairperson: Prof. C V S Gunatilleke, University of Peradeniya)

11.00 - 11.20	Policy Interventions for Managing IAS within Protected Area Systems of Sri Lanka – A Case Study from Bundala National Park (**SW Kotagama, N Perera, & KD Sunandalal**)
11.20 - 1140	Plant Invasions: A case study from Uduwaka Oya stream cathement in Attanagalla, Sri Lanka (**WS Welianga**)
11.40 - 12.00	Mis-identification of *Pteridium revolutum* (Blume) Nakai as an invasive alien [*Pteridium aquilinum* (L) Kuhn] in Sri Lanka (**RHG Ranil, DKNG Pushpakumara, CR Fraser-Jenkins, & DSA Wijesundara**)

12.00 - 12.20	Nest parameters of endemic cichlids and exotic cichlid in the Batticaloa lagoon of Sri Lanka (**AMR Ahamad & N Dharmaretnam**)
12.20 - 12.40	Factors affecting the invasion of *Prosopis juliflora* in the Bundala National Park (**RMUK Gunaratne & GAD Perera**)
12.20 - 01.30	**LUNCH**
Auditorium - A	
Social and economic Aspects of IAS (Prof. Gamini Senanayake, Deputy Vice Chancellor/University of Ruhuna)	
01.30 - 01.50	A Humanistic Approach for Combating Biological Invasions (**M Udugama & L Randeni**)
01.50 - 02.10	Commercial usage of Invasive Alien Species (IAS) as a consummative to control their distribution (**PM Perera & K De Alwis**)
02.10 - 02.30	Economics of Managing Invasive Alien Species (**K Wickremasinghe & A Senaratne**)
02.30 - 02.50	Ecology, biology and socio-economic features of *Pterygoplichthys multiradiatus* (Osteichthyes; Loricaridae) in the Mahaweli middle catchment of Sri Lanka (**RRAR Shirantha**)
Auditorium - B	
Introduction and Spread of IAS (Dr. Siril Wijesundara, Director General/Department of Botanic Gardens)	
01.30 - 01.50	The role of cattle, grey langur and elephant in seed dispersal of the invasive alien plant *Prosopis juliflora* (Mesquite) **Sandanayake & DK Weerakoon**)
01.50 - 02.10	Is Caribbean Pine invading grasslands in the Knuckles Region of Sri Lanka? (**WWMAB Medawatte, KU Tennakoon, PE Hulme, CVS Gunatillake, & IAUN Gunatillake**)
02.10 - 02.30	Long term observations on escaped ornamental aquatics in the wet zone of Sri Lanka (**K Yakandawala**)
02.30 - 02.50	Invasion of alien plankton to Sri Lanka through ballast water of cargo ships (**WU Chandrasekera & MAST Fernando**)
02.50 - 03.10	Research on Invasive Alien Plants in Sri Lanka: An analysis of past work (**DLMB Jayaraathne & SMW Ranwala**)
03.10 - 03.20	**Summing Up** - Mr. Gamini Gamage, Director/Biodiversity Secretariat, Ministry of Environment and Natural Resources
03.20 -	**Tea and Departure**

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Contents

THEME: BIOLOGY AND IMPACT OF INVASIVE ALIEN FAUNA

THEME: RISK ASSESSMENT OF BIOLOGICAL INVASIONS

THEME: INVASIVE BEHAVIOR: FLORA

THEME: INVASIVE BEHAVIOR: FAUNA

THEME: INVASIVE ALIEN SPECIES: POLICY, PATHWAYS OF INTRODUCTION, EDUCATION AND TRAINING

National Symposium on Invasive Alien Species, 21-22 May, 2009, Browns Beach Hotel, Negombo, Sri Lanka, Organized by Biodiversity Secretariat, Ministry of Environment and Natural Resources, in collaboration with Agriculture Education Unit (AEU) of University of Peradeniya and Institute of Biology (Sri Lanka)

A Humanistic Approach for Combating Biological Invasions

M. Udugama[1] and L. Randeni[2]*

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Ecosystems maintain their equilibrium by sustaining perpetual motion due to which, no biological organism can become invasive. Hence the presence of biological invasions is a sign of an external gap created by the only external organism; human being. This paper proposes a theoretical framework to internalize external behavior of human beings in invasive driven ecosystem degradation process.

The case study discussed in this paper recognizes the occurrence of aquatic invasive flora as a mixture of market and policy failure. Market is the universally accepted mean of commodity exchange. In contemporary era of economic globalization, if not intervened by the superior power it can cause ecosystem degradation. But if sources of market failure are not addressed correctly by the superior power it causes policy failure leading aquatic ecosystem to degrade further. This paper argues the inability to combat "human alien" as a primary cause for over all failure.

Alternatively, a humanistic approach was proposed as a novel mean for non-market intervention based on the theoretical revelations by Abraham Maslow (1908 – 1970). An assumption is that the human needs identified form a hierarchy that ranged from physiological and safety needs, through belonging and esteem needs to the highest level labeled self actualization needs. Each need is a motivation to move up in the hierarchy.

Adopting Maslow's theory into the management of aquatic floral invasions, following conclusions were made. A majority of the people suffer from basic needs such as food and shelter. People heading toward self actualization, once transcendent will lead the individuals of the rest of the community towards an eco-self. Maslow stressed on each individual's drive or potential to realize an "ideal self"- the essence of human existence.

Individuals with higher level needs would play leadership roles satisfactorily. Ecological restoration programmes need to be formulated in such way that individuals are internalized addressing their felt needs to assure commitment. The livelihoods need to be promoted in a way to revitalize the natural ecosystem for continued sustainability. Religious beliefs of the peripheral community contained similar concepts of Maslow's ideal self. If development practitioners are innovative they can find ways to bridge different epistemologies for meaningful social out come.

Acknowledgement: This paper stems from a field research funded by the National Science Foundation on "Economic Prospects for Tank Habitats: a case of Eco-restoration of tanks degraded by Invasive Alien Aquatic flora (Grant No: RG/2006/EPSD/04).

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Commercial usage of Invasive Alien Species (IAS) as a consummative to control their distribution

P. M. Perera and K. De Alwis

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Invasive Alien Species (IAS) is one of the major environmental threats to Sri Lankan native biota. Due to lack of awareness, people ignore these environmental depleters. Researchers take much effort to provide solutions, yet most are costly. It is wiser to promote usage of such species for commercial purposes; thereby control could be brought about.

Consumers show less interest in environment, yet if they get value for money, marketing is not difficult. Therefore targets were set to produce stationary and home décor using IAS. Stationary such as paper, file covers, letterheads visiting cards and wrapping paper as well as home décor such as wall hangers and vases could be made using IAS. In some cases small quantities of used paper could also be added creating a tendency towards recycling.

Consumers should be educated about the necessity of using these products. Up to now "3R" is used in most countries, yet none of them has come forward with invasive species in commercial purposes. Consumers should be aware that everything comes directly by killing invasive species that destroys native environment. This would encourage buyers and make them take responsibility for environment sustainability. This may also lead for self employment opportunities or feed Corporate Social Responsibilities (CSR) to companies on new projects.

A pilot project was carried out by using plant material obtained from 65%- 70% of invasive plant species (*Clidemia hirta*- 'Nylon Bovitia') which have shown a high fiber content(No added external chemicals). Upon small scale, hand – made, paper becomes brittle when 100% IAS material was used as raw material. However, at industrial scale, adoption of technologies could overcome this problem.

For home décor arrangements hard plant stems such as Valentine- *Clerodendrum quadriloculare* (Verbenaceae) and *Lantana camara* were used. Pathways to use IAS from national parks, reservoirs and sanctuaries should be facilitated under careful supervision. If such alternatives develop it would be the beginning of an end to the spread of invasive alien species.

Community based management of *Achatina fulica* (Férussac, 1821) populations in an agricultural landscape

S. Lelwala[1], T. Ranasinghe[1], S. Wijesundara[2], K. Karunasena[2] and C. Bambaradeniya[1]

[1]Ecosystems & Livelihoods Group, IUCN Asia. No.4/1, Adams Avenue, Colombo 4
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The Giant African Snail - *Achatina fulica* (Férussac, 1821), one of the world's worst invasive alien species was introduced to Sri Lanka around mid 1840s. It was initially restricted to the wet zone of the island, but gradually expanded its spread into the dry zone. The spread of this species in Hambanthota District was noticed three years ago. A collaborative project aimed at managing the spread of *Achatina* in the Kurudana village of the Hambanthota district was initiated by the IUCN and CARE in 2008.

A rapid assessment was carried out in April 2008 to determine the population density, distribution and socioeconomic implications of this species to the rural farmer community in Kurudana. The density of this species in Kurudana was estimated at approximately 9825 individuals per acre, and was a severe pest affecting a variety of vegetable and fruit crops in Kurudana. The cost of *Achatina* on the household economy of Kurudana included foregone benefits due to crop damage and additional expenditure to control this pest. The overuse of broad spectrum pesticides in Kurudana to manage this pest was also a major environmental concern. Subsequently, a systematic strategy was prepared to manage the spread of this species in Kurudana. The main components of this management strategy included prevention of further spread, early detection and warning, and a combination of control methods. A compendium of indicators was designed to monitor the progress of the management strategy on a regular basis. The implementation of the management strategy was undertaken by the villagers, under the technical guidance of IUCN and CARE. In September 2008, *Achatina* snails found in home gardens (five acres in extent) were collected and counted by the farmers. Since then some farmers have collected snails regularly in their farmlands, while others have not done any follow up action since the initial round of collection. A re-assessment of *Achatina* populations in 5m x 5m replicate quadrats was carried out in farmlands under both these management categories in April 2009. The microhabitat conditions in the quadrates were also recorded. As expected, a significantly lower snail density was recorded in farmlands where snails were collected regularly (mean ±SD = 3424±4681) compared to farmlands where collection was done only once (mean ±SD = 21664±2347).

A statistically significant positive linear relationship was observed between population density of snails and percentage of garbage present in plots. Further, a statistically significant positive linear relationship was observed between population density of snails and percentage of weeds present in plots (grass+herbs). A considerably high snail density was recorded in the banana cultivated areas. Therefore, these results indicate that regular collection and good sanitation in the farmland are vital practices in controlling *Achatina fulica* populations.

Economics of Managing Invasive Alien Species

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Invasive alien species (IAS) have become a significant environmental problem in certain ecosystems in Sri Lanka as revealed by a number of research studies. Introduction and spread of IAS in an ecosystem could bring about both environmental and economic costs. The nature of costs caused by IAS could be either direct or indirect. Management of IAS involves asymmetry of costs and benefits thereby implicating characteristics of a public good. Therefore government intervention is usually imperative for controlling IAS and comprehensive policies are required to manage IAS.

Although a number of research studies have been conducted on biological and ecological aspects of IAS in Sri Lanka, economic and policy studies on IAS are rare to found. From the economic point of view, there are two main aspects which need to be considered in IAS management; namely, identification and quantification of benefits and costs of IAS management and formulate most effective policies that help to generate economically efficient and environmentally sustainable solutions. The objective of the present study is to analyze the economic benefits of management of IAS in Sri Lanka, using the total economic value framework. Based on the outcome of this analysis, it attempts to develop criteria and guidelines that should be used in selection of policies for managing IAS in Sri Lanka.

Life history and feeding behaviour of a natural enemy of *Mimosa pigra* L. in Sri Lanka.

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Mimosa pigra is a well-known noxious alien plant occupied in an extensive area of the Mahaweli river catchments of Sri Lanka. It's attesting over populated condition is mainly due to lack of natural enemies. In 2007, we were able to record an insect enemy that brings destructive damage to seeds of *M. pigra*. In a four months study period, *M. pigra* in flowering stage were allowed for particular insect attack to study insect life history (at room temperature 29 -31°C) and feeding pattern. The specific objective was to quantify the effect of host plant.

The insect enemy was a Lepidopteran belongs to Trotriciniae tribe of the Family Trotricidae. It oviposited on small flower buds and tender leaves. Incubation period was 5 to 7 days. Larva was residence in a silk formation made itself by netting the leaves. Larval period was 7 to 10 days. Pupatation occurred in a brown coloured cotton construction hangs on the branches. This period was ended in 10 to 12 days.

Larvae exclusively fed (feeding efficiency was about 5 seed/day) on soft parts of the seeds and pods resulting punctures. Since the damaged seeds were easily prone to wither it is severe enough to lessen or limit seed production. One to three larvae were able to destroy a single pod completely in a day. It seems that this insect can possibly bring severe damage to seeds of *M. pigra*.

Though there was several other leguminous species in the studied area no any other host plant species were recorded. It is not among the common insect pests so far recorded in Sri Lanka. As such there is a possibility in developing this insect as a bio-control agent for *M. pigra* in Sri Lanka. However, it is extremely necessary to have further comprehensive studies in this regards and to quantify its suitability.

Acknowledgement: Research facilities provided by University of Kelaniya, Kelaniya, Sri Lanka is greatly acknowledged.

Status, Ecology, and Management of the Invasive Plant, *Miconia calvescens* DC. (Melastomataceae) in Sri Lanka

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Miconia calvescens (Melastomataceae), reported to confine its spread to montane forests of Sri Lanka is now invading low land wet forests of the country. This species had been introduced to Sri Lanka in late 1888 for horticultural interest. Today it threatens much of the biological diversity in native forests receiving 1800–2000 mm or more annual rainfall.

Miconia calvescens is a small tree, growing up to15 m tall. It has the ability to form a monoculture stand providing complete canopy closure and dense shade in moist conditions. Flowering and fruiting of *Miconia calvescens* begins when the plant is 4–5 years old and can take place several times during a year. Each fruit contains up to 200 seeds. Because of its attractive foliage, *Miconia calvescens* has been subject to spread via gardeners. Its spread from gardens has mainly occurred via fruit-eating birds. Seed may also be spread via mud sticking to vehicles, footwear and animals. Pulling out of seedlings is the most effective control method of the species.

The role of cattle, grey langur and elephants in seed dispersal of *Prosopis juliflora* (Sw) DC. (Mesquite)

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The invasive alien plant species, *Prosopis juliflora* (Mesquite; Kalapu Andara) has been introduced to the Hambantota District in 1953. During the last few decades *Prosopis* started spreading rapidly within the Hambantota District threatening many natural ecosystems as well as human habitations and their croplands. The main objective of this study was to determine the role of Cattle, Grey langur and Elephant in the dispersal of seeds of *Prosopis juliflora,* as these are the three species of animals that mainly feed on pods of this plant.

Prosopis juliflora seeds were found in the dung of all three species. The percentage of seeds recorded in each animals dung were, 60%, 90%, and 12% for Cattle, Grey langur and Elephants respectively. During *in situ* germination trials, the highest germination potential was observed in the seeds present in Cow dung while the least germination potential was observed in the seeds present in grey langur dung. Ex situ germination conducted under eight different conditions indicated that the best conditions for germination are when the dung is broken and kept in the shade with watering. The best germination potential was observed in seeds present in cow dung. Seeds present in the dung of grey langur did not show germination under any of the conditions provided. However, when the *Prosopis juliflora* seeds were removed from dung and planted in sterile soil, germination was observed in seeds removed from all three species. The highest germination potential was observed in cow dung (86.7%) followed by elephants (65%) and grey langur (29.3%). Removal of seed coat was necessary for germination of seeds of *Prosopis juliflora* and therefore passage of seed through the gut of these three species may aid germination by removal of seed coat due to digestion.

The results of this study clearly indicate that both cattle and elephants can function as seed dispersal agents of *P. juliflora*. The elephant has a large home range (50-150 sq.km.) compared to cattle. However, cattle and their dung are transported by man over long distances. Therefore, cattle pose even a bigger threat than elephants in dispersing seeds of this invasive plant.

Impacts of Plant Invasions: A case study from Uduwaka Oya stream cathement in Attanagalla, Sri Lanka

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Acacia and *Pines* are two "brutal" plant species that control the growth of native plants, change ecosystem functions and also miminise the land productivity. Both plant species had been introduced in differernt parts of the country after clearing parts of the natural forest patches. Introduction of foreign plants in a different environment not only affects the very land where they have been planted, but the social and cultural practices of the local residence, ecology of the surrounding areas and more over the economy and ecology of the country. The effect of introductions usually cannot be predictable in the short term. Ecologist use varios terms to describe the effects, one of which are called "Frankeistein effect"; the unpredictabilty. This study was done during the Archaeolgical Excavations carried out at the Alawala Cave Temple from 1st December 2008 till 10th April 2009 under the auspisous of Postgraduate Institute of Archaeology of the University of Kelaniya, Sri Lanka. Investigaions were done in the Uduwaka Oya stream catchment in Sri Lanka, which is a tributary to the Attanagalla Oya River. Field observations and interviews were made to gather data. Two tributaries of the Uduwaka oya stream have completely dried out and disappeared after the introduction of the alien plants to the catchment, mainly due to the lack of restock of the under ground aquifires. The water level of the Uduwaka Oya Stream have dropped considerably. Other than that many plants and animals have change their way of behaviour and have affecting on the socio and economical aspects of the villageres. Basket weiwing industry in which almost all villagers economy is based on, also has severaly affected due to the less availability of bamboo plants. Ecosystem services provided by the native forests for sustaining the life of the man and the animals have shrinked dramatically. It is important to take vise and neccesary actions immediately to manage these alien plants effectively in the native landscape in order to restore the natural ecosystems.

Alleopathic effects of *Prosopis juliflora* (Sw) DC and its impact on some Sri Lankan dry forest species

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Prosopis juliflora is becoming a threat to natural habitats in many costal dry areas of Sri Lanka. It is also invading some inland agroecosystems especially in Vavunia forming dense thickets. Most of the native dry forest plant species are not regenerated in such thickets. Allelopathic compounds present in *P. juliflora* may be one reason for this. This study examines the allelopathic effects exert by different parts of *P. juliflora* plants and assesses how these chemicals influence in the regeneration of two native dry forest species, *Catunaregam spinosa* and *Manilkara hexandra*.

Allelopathic effects imposed by different parts of *P. juliflora* plants were detected by a bioassay using seeds of *Vigna radiata*. Root extracts of *P. juliflora*, soil extracts from natural forest and *Prosopis* stand were separately added to petridishes containing seeds of *C. spinosa* and the number of seeds germinated and, the radical and hypocotyle lengths were measured. Soils from a natural forest and a *Prosopis* stand were collected and mixed with activated charcoal. Germination and establishment of *C. spinosa* on these soils were detected. Root extracts of *P. juliflora* were added to seedlings of *M. hexandra* at different ages and the growth performance was measured.

Results reveled that the seedlings of *V. radiata* were affected by extracts of all flowers, leaves, pods and roots of *P. juliflora* but the impact was the greatest with root and pod extracts. Then, the elongation of both radical and hypocotyle was adversely affected but seed germination was not affected. Similarly, root extracts of *P. juliflora* suppressed the establishment of *C. spinosa* but not affected to the germination of its seeds. Soils from *Prosopis* stands may contain allelopathic chemicals and hence inhibit the establishment of native species such as *C. spinosa*. Root collar diameter and height increment in mature seedlings of *M. hexandra* that treated with root extracts of *P. juliflora* were comparatively lower.

Thus it is evident that allelopathic chemicals produce from roots of *P. juliflora* may impose a threat on native species. Very young seedlings of native plant species die due to the suppression of the growth of the radical and the hypocotyle while in mature seedlings, declining of the growth performance may take place.

Competitive ability of *Lantana camera* L. with *Urena lobata* L.

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Invasions by invasive alien species (IAS) are a global phenomenon and identified as the second major reason for biodiversity loss. IAS can cause irreversible changes in community structure and ecosystem function. *Lantana camara* is included in the global invasive database as one of the worst 100 IAS. *Lantana camara* is currently invading many ecosystems of Sri Lanka including Udawalawe national park causing tremendous damage to the ecosystem. Attention has been paid to control their spread mainly through chemical and physical practices. The present study aims to investigate the competitive ability of *L. camara* when grown with a non-invasive, native *Urena lobata* using a pot experiment.

A pot experiment was conducted under glasshouse conditions, at the Department of Botany, University of Peradeniya. Seedlings of *Lantana camara* were raised and transplanted in the center of each pot (n=6). *Urena lobata* seedlings were planted as 1:0, 1:2, 1:4, 1:6 densities (*Lantana:Urena*) keeping *L. camara* as the target plant. After 7 weeks of growth *Lantana* plants were harvested and the results were statistically analyzed using Minitab 14.3.

The height growth of *L. camara* is significantly lower in high density (1:6) compared to lower density levels (1:0, 1:2, and 1:4) at the time of the harvest. Total biomass of *Lantana* at higher densities (1:4 and 1:6) showed significantly lower value than the 1:0 treatment. Shoot and root biomass at 1:6 is significantly lower than in the 1:0. However, Root weight ratio (RWR) showed no significant difference between treatments indicating relatively similar biomass allocation pattern under all 4 treatments. Growth rate of *L. camara* at 1:4 and 1:6 is significantly lower than in plants exposed to no competition (1:0).

The results emphasize that plant performance decreases due to inter-specific competition with *U. lobata*. Further studies are recommended in order to explore their inter-specific competition with other native, non-invasive plants, as this information can use in managing *Lantana* biologically.

Morphological plasticity and competitive ability of *Austroeupatorium inulifolium*

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Alien plants are invading the natural and semi natural ecosystems causing much damage to the biodiversity. For the past few years, *Austroeupatorium inulifolium* has invaded aggressively within the Knuckles Conservation Area. This species is still not been identified as an invasive plant in Sri Lanka and hence no data available on their impacts on the ecosystem. The baseline information on the ecology of *A. inulifolium* is important to undertake future management practices successfully. In the present experiment we investigated morphological plasticity when exposed to different nutrient pulses and also their competitive ability. This information is essential to understand their invasive ability and also can be used in management strategies.

Two pot experiments were set up at glasshouse conditions, at the Department of Botany, University of Peradeniya. In the first experiment, seedlings were transplanted as one plant/pot and nutrients were added to create spatial, temporal and homogeneous pulses for five weeks. After 8 weeks of growth plants were harvested. In the second experiment, seedlings were exposed to 3 densities (intra-specific) with 1, 2, and 4 seedlings/pot (n=10). Plants were harvested after 9 weeks. Results were statistically analyzed using Minitab 14.3.

Plants showed higher total, shoot and root biomasses when exposed to temporal pulses compared to homogenous pulses. It shows that plants respond to temporal nutrient pulses more efficiently through plastic responses than to spatial and homogeneous pulses. However, the root weight ratio (RWR) shows no significant difference between treatments indicating *Austroeupatorium* showed a better growth under temporal pulses by adjusting physiologically but not morphologically.

Total, shoot and root biomass at high density (x4) seems to be significantly lower than the lower density levels (x1, x2). The relative height ratio and growth rate of *A. inulifolium* seems to be significantly higher in lower densities (x1 and x2) compared to high density level. Further studies are progressing in order to explore their competitive ability when *A. inulifolium* is exposed to inter-specific competition with some native, non-invasive plants.

Distribution of Aquatic weeds and their impacts in Ampara district

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A survey was carried out in the Ampara district during 2005 – 2007 period to study the aquatic plant distribution and ecology in these areas. During the survey a total of 142 perrenial and seasonal reservoirs and 57 sites in irrigation canals & streams in the Ampara district were studied.

The major aquatic weeds observed were *Eichornia* and *Hydrilla. Eichornia* was found in 40% of the reservoirs while *Hydrilla* was found in 22% of the reservoirs. *Salvinia* was recorded only from 18% of the reservoirs. The major problems were caused by the invasion of *Nelumbium* in the seasonal and perennial reservoirs of the Ampara district. This species had totally covered 5% of the small seasonal reservoirs while it had partially covered 12% seasonal reservoirs and 4% major perennial reservoirs. The other weeds observed in the district were *Azolla, Pistia, Typha* and *Najas* . In the irrigation canals , *Hydrilla* was the major weed observed; and was found in 60% of the sites. *Potamogeton* was found in 7% of the sites visited. Six sites in streams were covered with *Eichornia* and *Salvinia.*

The major problem in the Ampara district was to manage the fast spread of *Nelumbium* as it affected the fishery activities in perennial reservoirs. The siltation caused by the decaying leaves was also reported as a problem by the fishery societies as it increased the silt layer. *Typha* created problems to the water users from the reservoirs. The irrigation canals were affected by the *Hydrilla* spread and in some places it reduced the natural water flow of these canals while it also hindered laying of any fishing nets. Ceratophyllum was observed in 5 locations of irrigation canals where the paddy farmer associations expressed their concerns in reduced water flow due to the spread of this species.

Mis-identification of *Pteridium revolutum* (Blume) Nakai as an invasive alien [*Pteridium aquilinum* (L) Kuhn] in Sri Lanka

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Two Pteridophytes, namely *Salvinia molesta* D.S. Mitchell and *Pteridium aquilinum* (L.) Kuhn. (Bracken fern) have been reported as Invasive Alien Species (IAS) in Sri Lanka by many authors. The invasiveness of *S. molesta* and its impact upon biodiversity is well known, including in Sri Lanka. However, no studies have been conducted on the invasiveness of *P. aquilinum* in Sri Lanka. The objective of this study was to identify the taxonomic status, distribution and invasiveness of *P. aquilinum* in Sri Lanka based on current information and field-assessments. Our study reveals that the genus Pteridium consists of a single taxon in Sri Lanka, *P. revolutum* (Blume) Nakai, which has been misidentified as *P. aquilinum*. *Pteridium aquilinum* sensu stricto is a well known invasive, though not alien species which occurs only in Africa and Europe and is absent from the Indian subcontinent. *P. revolutum* is significantly different in morphology from *P. aquilinum* in its markedly stiffer fronds with more convex pinnae and the segments more densely hairy beneath. It also has a different vernation with the pinnae uncurling more quickly and completely than the frond-apex. In contrast to *P. aquilinum* in Europe, *P. revolutum* is not particularly invasive, nor in general does as much damage to natural plant communities. It is not an adventive alien but is indigenous to Sri Lanka where it is locally known as 'Werella', 'Monara kekilla' and 'An kekilla'.

Similar to *P. aquilinum*, *P. revolutum* is a pioneer species, and common in burnt areas of patana grassland, open areas and roadside banks and may thus be used as an indicator-species for recognising forest clearings created by fire. According to the records of the National Herbarium, Peradeniya (PDA), and other herbaria (BM, K, G, GH, NY and US), the past distribution of *P. revolutum* on the island was limited to three administrative districts: Kandy, Nuwara Eliya and Badulla, at mid (600 m) to higher elevations (2,300 m). The present field assessments have also revealed that *P. revolutum* is common in the same localities where it was observed in the past. Its widest areas of distribution occur in some parts of Nuwara Eliya district including Horton Plains. Because of the controversial claims of its invasion, monitoring of populations of *P. revolutum* in selected areas to identify its potential as invasive species is and removal of this native species from the list of IAS in Sri Lanka are suggested.

Ecology, biology and socio-economic features of *Pterygoplichthys multiradiatus* (Osteichthyes; Loricaridae) in the Mahaweli middle catchment of Sri Lanka

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Pterygoplichthys multiradiatus, native to Latin America is a well known aquarium fish species that has become a naturalized notorious fish in Sri Lanka. Therefore, present study (March 2005 to March 2009) was carried out to study its ecology, biology and socio economic features to quantify its invasiveness in the Mahaweli reservoir area.

The ventrally flatten body with sucker mouth, strongly spinous pectoral fines, powerful tail region and coarsely keeled scales are convince for its benthic and grazing habit. It was found in reservoirs and riverine habitats of sandy to muddy substrate over the Mahaweli zone occasionally reporting extra large sizes (> 60 cm in length). It found to tolerate ranges of DO (2.5 -5.8 mg/l), pH (5.8 -9.4) and temperature (18 - 31 $^{\circ}$C).

It was found to show high reproductive potential; fecundity varied from 380 to 520, male showed parental care and excavated nesting tunnels, bred through out the year with peak spawning season in August to October. Its mean relative gut length was 5.23 (>1.0). It showed 85% food niche over laps with *Garra ceylonensis* and *G. philipsi* and moderate overlaps with other sympatric fish species. So far no any record of natural predator.

The study of socio economic features showed *P. multiradiatus* cause heavy siltation, choke hydro power tunnels and irrigation canals and damage fishing gears. The aquarium fish trade was identified as accountable for its introduction and colonization. It has a very little demand as a food fish due to hideous appearance and ethical and religious influences. Since live fish were locally fetched as aquarium fish there is a possibility to exploit for export market. As it found to expand range of occurrence very rapidly hereby it is suggested to implement proper management action to prevent it.

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Effects of accidentally introduced sucker mouth tank cleaner (*Pterygoplychthys multiradiatus*) on the fishery in Polgolla reservoir at the Central Province of Sri Lanka

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Pterygoplychthys multiradiatus is one of the invasive fish species introduced by ornamental fish trade in to the natural environment of Sri Lanka. Present study was carried out with an objective of investigating effects of *P. multiradiatus* on the fishery in Polgolla reservoir, a lentic water body in the Central province, Sri Lanka.

The study was conducted from January to March 2009 at Nawayalathenna fish landing site. Selected site was biweekly visited and fish catch data and net damages due to *P. multiradiatus* were recorded. Fishing time, type of nets used, net soaking time and number of fishermen employed were also recorded on sampling days. Fishermen used 50m long nylon gill nets with 5cm mesh size to catch fish. They set nets in the afternoon and collect the catch in the following morning. Net soaking time varied from 12 – 15hrs.

Catch per unit effort at Nawayalathenna fish landing site varied between 0.95 – 2.25 kg/boat/hr. Fish catch was mainly consisted of *P. multiradiatus*, *Oreochromis niloticus* and *O. mossambicus*. *Puntius sarana*, *P. filamentosus* and *Ompok bimaculatus* were also caught in small amounts. The fish yield ratio between *P. multiradiatus* and other fish species in the selected fish landing site was 3 : 1 in the present study. This clearly shows the dramatic increase of *P. multiradiatus* population in the Polgolla reservoir in the last few years. All the fishing nets were damaged due to entanglement of different sizes of *P. multiradiatus* during the sampling period and damaged area varied from 320 - 880 cm^2/net/day.

Accidentally introduced *P. multiradiatus* has negatively affected the existing fishery in the Polgolla reservoir mainly by increasing their proportion in the fish catch and by significantly damaging the fishing nets. *P. multiradiatus* caught in the nets are presently thrown back into the reservoir as there is no demand for this fish in the market as a food fish. Larger fish caught by the gill nets are also not marketable in the ornamental fish trade. Therefore, fishing mortality does not play a significant role in reducing the number of *P. multiradiatus* in the Polgolla reservoir. It is essential to find out ways to exploit this nuisance fish species as an animal feed or for any other use before they do further harm to freshwater fishery in Sri Lanka.

Nest parameters of endemic and exotic cichlids (*Etroplus* spp) in the Batticaloa lagoon of Sri Lanka

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Etroplus suratensis and *Etroplus maculatus* are indigenous cichlids found in Sri Lanka. *Oreochromis mossambicus* was introduced to enhance inland fisheries. This species has now established in inland waters and also in brackish water systems. The two *Etroplus* species are sympatric and show segregation of habitats. The impact of the introduced cichlid on the indigenous cichlids has not been investigated. As all three species are ground nesting it is expected that there will be some degree of competition between the three species during reproduction.The aim of this study was to investigate the interactions of indigenous and exotic cichlids using nest parameters including diameter, depth and water depth. Quantitative nest parameter data were collected during a period of one year from an inlet of the Batticaloa Lagoon, Sri Lanka.

There was a significant difference for the water depth of the nests with Species and Months as factors (F_{25}=6.71 p=0.0001); interaction was not significant ($F_{15,26}$=1.39, p=0.1486). There was a significant effect of: Months ($F_{8,26}$=4.92, p=0.0001) and Species ($F_{2,26}$=53.79, p=0.0001). *Etroplus maculatus* nests were found in shallower areas with a mean water depth of (28.08±8.43 m). Water depths of nests of *O. mossambicus* (39.13±11.54) *and E. suratensis* (37.14 ±7.07 cm) were more than that of *E. maculatus* (DMRT). There was a significant difference for the diameter of the nests of three species in the different months ($F_{25, 26}$ = 6.85, p= 0.0001). The factors Months and Species and the interaction were significant; Months ($F_{8,26}$ =2.49, p=0.0124); Species ($F_{2,26}$ =55.14, p=0.0001); interaction ($F_{15,26}$ =2.74, p=0.0006) (Two way ANOVA). The mean diameter of nests of *O. mossambicus* was higher than that of other two *Etroplus* spp (DMRT) (38.24 ±12.98) cm. Mean diameter of nest of *E. suratensis* was 34.27 (±9.33) cm and it ranged from 22.00 cm to 60.00cm. Mean diameter of nests of *E. maculatus* was the lowest (24.37 ±9.21 cm). It ranged from 9.00 cm to 60.00 cm. There was significant difference on the depth of the nests with three species and months ($F_{25,26}$ = 6.39, p= 0.0001); Months ($F_{8,26}$=2.45, p=0.0139); Species ($F_{2,26}$=53.22, p=0.0001); Interaction ($F_{15,26}$=2.25, p=0.0050). The mean depth of the nests of *O. mossambicus* was higher than that of other two cichlids). Mean depth of nest of *O. mossambicus* was 9.59 (±3.00) cm and it ranged from 5.00 to 20.00 cm. The nest depth of *E. suratensis* was higher than that of *E. maculatus* (DMRT). Mean depth of nest of *E. suratensis* was 7.97 (±3.10) cm and it ranged between 4.00 to 22.00 cm. Mean depth of nest of *E. maculatus* was 5.78 (±1.72) cm and it ranged between 3.00 and 10.00 cm.

This study showed habitat segregation between the two *Etroplus* species. *E. maculatus* nests were found in shallower areas whereas *O. mossambicus* and *E. suratensis were* similar depth. Since both occupy identical environment and the same habitat, and the nest sizes (diameter and nest depth) were larger in *O. mossambicus* probably inducing a competition for nesting space with other territorial animals in the lagoon including the two *Etroplus* species.

Harmalia heitensis otho Fennah 1975 (Hemiptera: Delphacidae) – An new pest of *Altenanthara sessilis* (L.) (Amaranthaceae) in Sri Lanka

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Altenanthara sessilis (L.) is considered as a medicinal herb and consumed as leafy vegetable in Asia, specially in Sri Lanka. known as '*Ponnangcarni*' or '*Mukunuvenna*'. It is extensively cultivated in Jaffna district occupying an area of 7.5 hectares. During January, 2009, there was a sudden out break of a delphacid planthopper population was noticed for the first time in Sri Lanka on *Altenanthara sessilis* (L.) in all cultivated fields in southeast Valigamam region (9 ^{0} 72' N, 79 ^{0} 99' E) of Jaffna District (Low Country Dry Zone) and caused total (90- 100%) crop loss.

The planthopper was identified as belonging to a species of *Harmalia* by the first author and later confirmed as *Harmalia heitensis otho* (Fennah) by Dr M.R. Wilson, Department of Biodiversity and Systematic Biology, National Museum of Wales, Cardiff, U.K. This is the first report of a delphacid becoming a serious pest of a dicotyledonous crop in Sri Lanka.

The planthopper is uniformly dark brown to black measuring 3.1-3.4 mm long. Fennah (1975) described the subspecies for populations of the species collected from eastern, northern and western Sri Lanka during 1962. However, its host plants were not known so far. Since its original description, its existence was not noticed until this outbreak. *Harmalia heitensis otho* and *Alternanthara sessilis* are wet land inhabitants.

Both brachypterous and macropterous forms were found in the field. The population was very high (70-80 adults/sweep) and the macropterous forms dominated at the time of observation (50-60 adults/sweep). Both adults and nymphs sucked the sap from the plant, resulting in drying of the affected plant. Initially round patches of dried crop was seen scattered in the field, as is the case with brown planthopper, *Nilaparvata lugens* (Stål) on rice. Entire crop in the fields dried within a week.

Jaffna was severely affected by flood after 50 years, due to the cyclone "Nisha" in December 2008. Sudden floods might have been the reason for the invasion of this particular species from its native habitat such as bunds of temporary ponds to cultivated land. In the absence of natural enemies and favourable environmental factors, the pest might have developed enormous populations leading to this outbreak.

Assessment of invasiveness of alien species: a framework using statistical approach

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Plant and animal invasions are considered as a threat to biodiversity and its conservation, second only to man-made habitat loss and fragmentation. Based on literature, it is clear that biological, ecological, climatological and social aspects of invasive alien species (IAS) have certain characteristics that make them more likely to become invaders. Some countries have used qualitative criteria to develop a numerical index, which allows to group invasive species based on selected criteria to facilitate the decision-making process and prioritization of species for actions. However, in Sri Lanka, a scientifically valid qualitative or quantitative assessment of invasiveness of plant or animal species has not taken place. Consequently, this paper develops a framework on identification of biological, ecological, social and climatological characters of IAS, using a statistical approach, which consists of regression, ranking and development of an index using multivariate statistics. The approach identifies the level of invasiveness so that the alien species can be grouped into such categories. The potential of using this knowledge in policy and decision making is discussed

Predicting invasiveness of fishes: An ecomorpholgical approach

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All animals or plants that are introduced with intent or inadvertently do not successfully colonize in the new environment. This is particularly due to lack of the perfect niche. They require all suitable conditions and minimum competition to survive. Since late 19th century till today, about 26 fish species have been introduced to Sri Lanka in less than a decade. There could be more others as well which have not yet been discovered. Not all of them have successfully colonized in Sri Lanka. According to the available records about 20 out of the 25 introductions have successfully invaded the native habitats. Less than 10 species have not able to maintain their populations' naturally in Sri Lanka which includes 5 Cyprinids also. They cannot be considered as "true colonizers" but they can make an impact on the nature and the ecosystem as a whole. Little information is available on the ecological impact of introduced fish species on the local fish fauna, ecosystem functions and goods and services provided. This article is an attempt to show the possibility of invasiveness through body shapes and ecology of the fish. This also can be considered as an eco-morphological approach to predict the invasiveness. Body morphology of fish can be measured using various methods as vertical and horizontal distances. Location of body organs, their shapes and the orientation or the direction from the center of the body can be considered as mensural measurements. Height, length and the width of the body indicate important aspects of the ecology of fish. Proportions of the height, length and width are important parameters to show the ecomorphology of fish. Gross Body shapes that can be defined as P1 (= Height of the body/ Width of the body) and P2 (= Total length/ Height of the body) are known to be useful to predict the niche of the fish, particularly food habits and the ecology. The present analysis is based on the P1 and P2 values obtained from about 35 Sri Lankan freshwater fish. According to the P1 and P2 values native carnivorous freshwater fish in Sri Lanka have dorso-ventrally flattened slender, long-bodies (low P1 and higher P2) whereas herbivores have short, deep bodies (high P1 and low P2). *C.ornate* (family; Notopteridae) *is* an accidentally introduced exotic fish and has a short and deep body (high P2 and low P1). According to the gross body morphology, *C.ornata* would share a niche that would belong to native herbivore, and segregate niche with native carnivores. In two ecological dimensions *C. ornata* is showing its positive invasiveness with less competition. *C.ornata* is a voracious piscivorous fish representing an outlier in the P1 and P2 relationship of freshwater fish community in Sri Lanka. This "outlier nature" is the success of the *C.ornata*. It can be concluded that *C.ornata* will further invade the freshwater bodies and if it raided the reservoirs there *C.ornata* would be a major threat for the littoral herbivores, and eventually to the freshwater fishing industry based on the exotic Tilapia. Therefore strict controlling measures are needed to prevent range expansion of this invasive alien fish species in Sri Lankan freshwaters.

Factors affecting the invasion of *Prosopis juliflora* (Sw) DC in the Bundala National Park

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Prosopis juliflora, a small tree which introduced to dry coastal areas of Sri Lanka as a shade tree has invaded in areas surrounding lagoons and in salt marsh ecosystems in Bundala National Park. The species seems to be thrive well in areas adjacent to lagoons and forms dense thickets but, towards the forest interior, the density of individuals of the species declines. Natural forests after about 500m from lagoons forests seem to be much healthier with no or few scattered individuals of *P. juliflora*. Present study examines the distribution pattern and factors affecting for the invasion of *P. juliflora* in Bundala National Park.

Seventeen 20x20m^2 experimental plots were established on the terrestrial land at the south of Embilikala and Malala lagoons and the vegetation was enumerated. A belt transect was established from lagoons towards south direction and 120 soil samples were collected from different distances from the lagoon. Water samples from Embilikala and Malala lagoons were collected. Both soil and water samples were chemically analyzed to detect some physico chemical parameters (pH, Salinity, Conductivity, total Nitrogen, Nitrate nitrogen, total phosphorus, available Phosphorus, Sodium, Potassium, Calcium and Magnesium).

It was evident that heavy loads of agrochemicals containing high amounts of Nitrogen and Phosperous are drained into Embilkala and Malala lagoons. These nutrients seep through the soil resulting in a zonation of abiotic factors. Heavy evaporation in the area would lead to concentrate nutrient levels in the terrestrial land and to increase soil salinity. These conditions may directly promote the establishment of *P. juliflora*. It was also found that the total Nitrogen:total Phosphorus ratio in the soil is very low and this indicates Nitrogen limitation in the soil. Thus, a legume like *P. juliflora* thrives well in such a nitrogen limited terrestrial ecosystem. Disturbances prevailing in the ecosystem also make more resources available for the establishment of *P. juliflora* and thereby indirectly support the invasion of the species in the area.

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Factors affecting invasion of *Clidemia hirta* (L.) D. Don in to Lowland Rain Forests of Sri Lanka: A case study from the Sinharaja Forest Dynamics Plot

1.
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Clidemia hirta, a neotropical shrub invasive over much of the Old World tropics, has aggressively colonized the rain forest habitats and associated degraded lands in the SW Sri Lanka, spreading initially along old logging trails and foot paths. It is widespread and abundant in the 25 ha long-term forest dynamics plot (all stems ≥1 cm dbh enumerated) located in the primary forest in the Sinharaja World Heritage Site.

Using the plot data for topography and distribution of other plants, we studied spatial distribution, population structure and the factors that may affect the forest invasion by *C. hirta* in the plot. We found that the abundance of *C. hirta* was highly correlated with topographical microhabitats and positively associated with the amount of light at the ground level. It was inversely correlated with species richness of other plants (<50 mm dbh) in the 5 x 5 m sample plots. The highest abundance of *C. hirta* occurred in valley habitats which are continually moist and have high light conditions as a result of wind-throws and also in steep slopes subjected to landslides.

The results indicate that the floristic richness and other microhabitat features, reproductive biology of *C. hirta*, and both animal and anthropogenic influences contribute to the spread of *C. hirta* in to the primary forest area and as such, its management requires a sound understanding of underlying ecological processes that contribute to the health of the rain forest ecosystem.

Is Caribbean Pine invading grasslands in the Knuckles Region of Sri Lanka ? If, so, can it be managed?

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Since 1967, about 25,000 ha of *Pinus caribaea* Morelet plantations have been established in abandoned tea lands, scrublands and fern lands in the wet and intermediate lowlands and lower montane areas in Sri Lanka with a view to reforest degraded lands and to meet the long-fibre requirement of the paper industry. Since its introduction, the natural spread of *P. caribaea* has not been reported in the island although this exotic species has been listed in the Global Invasive Species Database. Recent studies by us have shown that populations of seedlings, saplings and even mature trees have established in grasslands abutting *P. caribaea* plantations in the Knuckles (Dumbara) Range (KR). An understanding of the invasive potential of *P. caribaea* into different vegetation types in the KR and research in to the management of Caribbean pine invasion are of critical importance at this crucial stage of its natural spread.

Our preliminary investigations have revealed that the grasslands adjoining eight *P. caribaea* plantations in two agro-ecological zones (AEZ) *viz.*, i) intermediate mid country 1b (IM1b) and ii) wet mid country 3b (WM3b) around the KR were more vulnerable to *P. caribaea* regeneration compared to that in scrublands and forests in the respective zones.

In two separate pilot studies carried out in Caribbean pine plantations, (near the NW boundary of the Sinharaja World heritage Site [WM1] and in Lower Hantana in the Peradeniya campus [WM2]), we have demonstrated that pine plantations can be successfully replaced with native and naturalized plant species of ecological and economic significance to rural communities. These studies provide insights in to (i) the manipulation of the stand structure of established pine plantations to create suitable above ground environments favourable for establishment of native species, and (ii) to match suites of plant species to appropriate sites in different agro-ecological regions. These models could also be extended in to the naturally regenerating *P. caribaea* populations. However, for successful conversion of Caribbean pine plantations and invading pine populations into mixed, native species stands, a sound ecological understanding of the regeneration ecology of native and naturalized species is essential.

Long term observations on escaped ornamental aquatics in the wet zone of Sri Lanka

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Biological invasions are considered as global threats to native biodiversity and ecosystem function and ornamental plant trade has been implicated as a significant pathway of plant introductions into new regions. In Sri Lanka, ornamental aquatic plant industry has grown substantially during the last decade. They are one of the essential components in aquaria and aquatic landscapes and both sectors require new plants to maintain the viability of the industry. Therefore, alien aquatic plants are imported to the country. Once escaped, certain alien plants have the potential to invade into the aquatic ecosystems and cause detrimental damage to the biodiversity, agriculture and recreation. Many such events have been encountered globally as well as locally and these plants are listed under invasive alien plants. Early detection and treatment of new infestations is considered as an effective and ecologically sound management approach. Therefore, long term observations were made on two alien aquatic plants *Ludwigia sedioides* and *Mayaca fluviatilis* in the Gampaha district from 2006 to 2009.

Ludwigia sedioides is a submerged plant with floating leaves while *M. fluviatilis* is a submerged plant. Both plants are not recorded as naturally occurring plants in Sri Lanka. However, *L. sedioides* was observed as naturally occurring in two water bodies in 2006 while *M. fluviatilis* was recorded in a single water body. In 2009, *L. sedioides* was observed in 10 other water bodies while *M. fluviatilis* was spread only into an adjacent water body. The presence of large number of artificial water masses created by brick manufacture industry support the existence of *L. sedioides* and it occurs as a monoculture in 80% of the water bodies. Seasonal flooding in the area and the ability to survive on wet soils during dry spells have helped *L. sedioides* to spread rapidly. On the other hand as *M. fluviatilis* is a submerged plant, it is not visible at once hence can spread further silently. Most invasive alien plant management programmes identify the problem many years later hence considerable amount of money have to be spent for remedial measures including providing funds to control after the plant concerned has cause an extensive damage. Therefore, with early detection and correct identification, it is important to control these plants spread further by using ecologically sound method and this study highlighted the importance of strict monitoring and controlling of commercial aquatic plant nurseries in Sri Lanka.

Preliminary study on the distribution of *Austroeupatorium inulifolium* in the Knuckles Conservation Area

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Alien plants are invading the natural and semi natural ecosystems causing much damage to the biodiversity. For the past few years, *Austroeupatorium inulifolium* has invaded aggressively within the Knuckles Conservation Area. *A. inulifolium* is still not been identified as an invasive plant in Sri Lanka and hence no data available on their impacts on the ecosystem. The baseline information on the ecology of *A. inulifolium* is important to undertake future management practices successfully. In the present experiment we investigated morphological plasticity when exposed to different nutrient pulses and also their competitive ability. This information is essential to understand their invasive ability and also can be used in management strategies.

Two pot experiments were set up at glasshouse conditions, at the Department of Botany, University of Peradeniya. In the first experiment, seedlings were transplanted as 1 plant/pot and nutrients were added to create spatial, temporal and homogeneous pulses for five weeks. After 8 weeks of growth plants were harvested. In the second experiment, seedlings were exposed to 3 densities (intra-specific) with 1, 2, and 4 seedlings/pot (n=10). Plants were harvested after 9 weeks. Results were statistically analyzed using Minitab 14.3.

Plants showed higher total, shoot and root biomasses when exposed to temporal pulses compared to homogenous pulses. It shows that plants respond to temporal nutrient pulses more efficiently through plastic responses than to spatial and homogeneous pulses. However, the root weight ratio (RWR) shows no significant difference between treatments indicating *Austroeupatorium* showed a better growth under temporal pulses by adjusting physiologically but not morphologically.

Total, shoot and root biomass at high density (x4) seems to be significantly lower than the lower density levels (x1, x2). The relative height ratio and growth rate of *A. inulifolium* seems to be significantly higher in lower densities (x1 and x2) compared to high density level. Further studies are progressing in order to explore their competitive ability when *A. inulifolium* is exposed to inter-specific competition with some native, non-invasive plants.

Ontogenetic dietary shifts in Clown Featherback *Chitala ornata* (Osteichthyes, Notopteridae) and its potential impact on freshwater fauna of Sri Lanka

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Chitala ornata (Ostiechthyes, Notopteridae) has been accidentally introduced to several freshwater habitats in the western province, possibly through the ornamental fish trade. Food and feeding biology of *C. ornata* in a riverine habitat in Sri Lanka were investigated from March 2003 to July 2004. *C. ornata* shows morphological adaptations for carnivorous feeding habits. The stomach contents of *C. ornata* were volumetrically analyzed and ontogenetic variations of relative abundance of different food categories were evaluated. Its gape size was positively correlated to body length and the relative gut length remained consistent with body size. It showed strong ontogenetic diet shifts from omnivory in 30-35 cm fish to carnivory in fish > 35 cm. *C. ornata* of 30 – 35 cm mainly fed on plant matter and it was exclusively piscivorous when it was > 50 cm. Indigenous cyprinids were the major prey species. *C. ornata* might possibly have adverse impacts on native fish populations as well as on other aquatic fauna. Investigation of the impact of this exotic fish species on indigenous aquatic fauna in relation to prey abundance and predator-prey relationships should therefore be an important area of investigation in order to minimize its possible impacts on the aquatic biodiversity.

Is Tilapia becoming and invasive fish in Sri Lanka?

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Invasive species are organism which successfully establish themselves in, and then overcome, otherwise intact, pre-existing native ecosystem. Many species of tilapia native to Africa and has been introduced by man to other part of the world. In most cases the introductions either have been accidental or deliberate. Tilapia had also been introduced to Sri Lanka as food fish to lakes and other bodies of water in early1950s and thrive well all over the country compete with other species having opportunistic feeding style.

It was introduced only with the hope of augmenting fish production in the country in 1950s. However, the performance of tilapia in the water resources as commercial table fish has been discouraging since recent past mainly due to early maturity, continuous breeding, overpopulation and dwarfing of the species. The presence of native fishes in the water resources had dwindled wherever the presence of tilapia was found in large numbers. This might be due to its early maturity, continuous breeding, high survival rate and its carnivorous behavior on eggs and juvenile of other fish and aquatic fauna. However the damage caused by tilapia on the eco system and biodiversity in Sri Lanka has not been assessed properly so far.

Tilapia is a highly popular among low income population as cheaper animal protein source in some countries including Sri Lanka, because of its growth rate and the ability to grow in extremely diverse conditions. However, tilapia culture was reportedly banned in some countries. Many countries have also initiated regulatory programmes for controlling the present population of tilapia in their countries and introduction of this exotic fish.

In Singapore, the problem with tilapia as an invasive species may be on its way of solving itself by the introduction of other tilapia species, strains or hybrid which able to produce resulting batches tend to have a much skewed male sex population. Realizing that male tilapia grow faster, further approaches to solving the problem of stunted overpopulation of tilapia in Sri Lankan water bodies, all male mono-sex tilapia culture system can be adopted to lakes and other water bodies without affecting any economic losses to country as well any food shortage for low income group which mainly depend on tilapia fish as animal protein source.

When certain species or strains of tilapia breed with each other the resulting batch of hybrids consist of a very low number of females or no females at all. It is also common for hybrids to produce a lower number of fry per spawning. Hormone treatment is also an effective method of making female offspring turn into male offspring. If newly hatched tilapia fry are subjected to sufficient amounts of male hormones, they will turn into reproductively function males. This method is also known as the sex reversal. Breeding mono-sex male tilapia by using YY super male technology has also developed, but is not yet a commercially available alternative.

In view of the above considerations, as remedy to avoid tilapia becoming an invasive fish to Sri Lanka: it needs to take measures to increase male tilapia in present population followed by introduction of strains, hybrids that could be able to produce all male tilapia off springs with lower spawning ability that leads to reduction of its present population to non invasive level.

Policy interventions for managing IAS within Protected Area Systems of Sri Lanka - A case study from Bundala National Park

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In protected areas, invasive alien species can become a major concern, particularly when it impacts the ecosystem function, structure and the high biodiversity it contains. The threats to PA can be associated with IAS in the wider landscape, rather than just in the site itself. Mesquite *(Prosipis juliflora*) introduced to Hambantota in early 1950s to improve the ground cover and saline conditions of the soil now have become a major challenge to the ecological integrity of Bundala National Park (BNP) and therefore its removal and management has been identified as high priority.

The success of Prosopis as an invader at BNP is largely attributable to their dispersal through livestock and by floods. Uprooting the IAS through mechanical means and disposal them outside the park as well as restoring the areas where uprooting is done is recommended in the Operational Plan for BNP.

At BNP removal of Prosopis have been undertaken at experimental level and it was found that this activity is costly and requires around Rs 100,000/ha. As lack of funding and resources is a general challenge for PAs and not specific to IAS management, DWLC found it hard to continue this process after each project end. Although the plant is economically valuable and can be sold as a fuel wood and for timber to offset some of the cost, the FFPO, the law which is responsible for the establishment of the BNP if strictly interpreted does not allow for it to be sold or taken out from the park. At Udawalwe National Park, the sustainability in removal of Lantana sp has created the same issues.

Successful and sustainable control of IAS with economic value will be possible through policy level interventions. Among them will be a change in the FFPO, or an intervention through Section 55 of the existing FFPO by the Director General. Further to ensure financial sustainability, the establishment of a "Trust" is recommended. The park managers should be empowered to manage the trust funds with money earned by selling economically viable IAS species, which then can be solely utilized to monitor, re-planting and continuous removal of IAS. If this is not feasible a third party such as an NGO or local authority should be given the responsibility of handling the trust fund in collaboration with DWLC.

Invasive Alien Species of agricultural importance in Sri Lanka: Have we managed them properly?

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Rapid spread of Papaya mealybug (*Paracoccus marginatus*) in Sri Lanka has placed the issue of invasive alien species (IAS) in top of the country's agriculture agenda. There is an established methodology to follow in combating IAS. This article reviews the attempted management practices for selected IAS recorded during the past decade in the agriculture ecosystems in Sri Lanka, and examines the comprehensiveness of the actions taken. Methodical approach of prevention, early detection and eradication, containment and control has failed at different levels is highlighted. It is shown that no planed program of activity has been adopted in combating any of these IAS resulting in scarcity of information to evaluate the economic or biological impact of these species on agriculture ecosystems. Lack of direct communications between the provincial and the central agriculture system, and lack of taxonomic expertise in the country are implicated as reasons for failure of early detection. Cooperation between Environmental and Phytosanitory authorities and adoption of International Standard for Phytosanitory Measures (ISPM) guidelines to manage alien invasive species is recommended.

Importance of identifying biodiversity signatures in implementation of article 8(h) in the Convention on Biological Diversity

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The global concern over Alien (or exotic) Invasive Species (AIS) has reached a high degree of importance in policy making, due greatly to the adoption and passing into force the Convention on Biological Diversity (CBD). However the inability to identify the differences in the biodiversity signatures between natural and anthropogenic ecosystems, severely undermine and can restrict the application of article 8(h) of the CBD and create great confusion over its application.

Invasion of alien plankton to Sri Lanka through ballast water of cargo ships

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Invasion of alien species through ballast water has resulted severe ecological changes and financial damages in many countries in the world. Since Sri Lanka is located in the middle of the east-west trans-oceanic route, and her harbours being world famous stopover sea ports, there is a high potential of alien marine plankton species to be introduced into the Sri Lankan maritime zone by the ballast water and cause severe ecological problems. Nevertheless, studies addressing whether alien planktons are actually introduced into our maritime zone and, if so, their effects on the local biota have never been investigated. Therefore, the present study was carried out to observe whether the alien plankton species are introduced into Sri Lankan waters through the ballast water.

Marine plankton occurring within the Colombo inner harbour and in two neighboring sites in the open sea bordering the coasts of Panadura and Pamunugama near the Colombo harbour was collected and identified. In addition, plankton occurring in the ballast tanks of five cargo ships called at the Colombo harbour was also sampled. The physico-chemical parameters of the water samples collected from all the above sites and ballast tanks were also measured. Species abundance data and the data on physico-chemical parameters were analysed using multivariate and univariate statistical tests as appropriate.

Altogether 151 taxa of plankton were found in all the water samples. In the ballast tanks alone, there were 57 different taxa of which 30 taxa were not recorded elsewhere within the three local study sites. Multivariate statistical tests confirmed that the composition of the plankton community structure of the ballast water samples was significantly different from those of three sampling sites. However, the physico-chemical parameters of the water samples between the sampling sites and the ships did not differ significantly.

Considering the large number of ships calling at the Colombo harbour and all the other harbours in Sri Lanka, it could be assumed that a large number of alien plankton species are continuously introduced into the Sri Lankan maritime zone. Although, this study did not address the impact of these alien plankton on the native biota, the ecological implications of these alien species could not be easily undermined. Therefore, it is deemed necessary to monitor such species invasions, and investigate their effects on the local biota. It is therefore imperative to carry out similar investigations on this issue and open a national discussion to formulate policies and legislations to prevent these species invasions. As the present study is the first of its kind carried out so far, it would certainly provide a platform to address these issues.

Integrated actions for awareness and control of the Parthenium weed

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The noxious and invasive Parthenium weed [*Parthenium hysterophorus* L. (Asteraceae)] is a recent plant record in Sri Lanka having a history of multiple entry into the island from India, apparently from early 1980s. Since its presence in Sri Lanka was first discovered in 1999 in Vavuniya, a wide alarm was immediately sent across the nation using the media and all such activities were initiated by the Plant Genetic Resources (PGRC) of the Department of Agriculture (DA).

The PGRC immediately went into action and informed and stimulated the DA which carried out several actions that involved meetings of the stakeholders, awareness, control, research and legal measures which culminated in the publication of a gazette notification. Furthermore, the Ministry of Environment & Natural Resources was also informed of this new environmental problem and it coordinated and supported several activities in disseminating awareness.

At a different level, the PGRC continued the dissemination of knowledge and awareness through seminars delivered at various stakeholder institutions. Information on the parthenium weed and its current status in Sri Lanka were continuously published during 1999 – 2000. Meanwhile, contacts were established with countries (Australia and India) that have been affected by parthenium invasion and information received, especially on its control measures, was transmitted to the Plant Protection Unit (PPU) / DA. Concurrently, the PGRC and PPU were playing main roles in conducting joint programs in awareness, through lectures and field demonstrations in seriously infected areas.

The results of the concerted actions created an excellent and rapid public awareness and multi-prong cooperation to control the weed and to enhance the capacity to adopt legal measures to minimize the spread of the weed in the island. Despite the short period of rapid activities (1999-2001), an estimated 60 – 70 percent of the parthenium infestation was brought under control in seriously affected areas and totally eradicated from most of the isolated patches by the end of 2002. However, continuous activities are needed to keep the weed population at low levels until an effective self-sustained biological control program becomes a reality.

Research on Invasive Alien Plants in Sri Lanka: An analysis of past work

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Sri Lanka has short history on Invasive Alien Plants (IAP) as much of the work on Invasive Alien Species was initiated after organization of the first national symposium in 1999. During the past ten years IAP in Sri Lanka have received considerable attention by scientists and several publications have been resulted. An analysis was done using 124 published information on IAP over the past ten years, in order to identify the aspects/subject areas that have been given priority in past research, IAP species that have been studied in detail, specific locations in which studies on IAP have been conducted and the degree of involvement of the government and non government sectors in IAP research. The consistency of publications over the years was also observed.

Majority, (73%) of the publications on IAP published during the last decade was based on field and laboratory studies and 27% were reviews. Aspects such as impacts, control and management of IAP have been well addressed, but not many publications were focused on economical impacts. Genetics/germplasm studies, reproductive biology, germination, establishment and propagation methods, distribution and spread, potential uses, allelopathic compounds, legal issues and studies on public awareness have been paid little attention. Occurrences of IAP, physiology and competitive ability of plants were fairly investigated. Only 22 invasive alien plants have been subjected to autecological studies. Plant species such as *Lantana camara*, *Mimosa pigra*, *Parthenium hysterophorus*, *Prosopis juliflora*, *Cuscuta chinensis* were popular examples. Eighty three percent of the publications were focused on terrestrial species although aquatic species were the most problematic group. Locations such as Udawattekele forest reserve and Hantana range have been popular study sites among 18 areas in which IAP work have been based on. Authors of many of the publications were affiliated to government institutions and the involvement of the university community on IAP research was 62%. Frequency of publications on IAP were high in years 1999, 2000 and 2008 indicating that organization of national symposia has provided a better opportunity in disseminating findings of IAP work.

It is evident that very limited aspects of IAP have been explored during the past few years and many windows of opportunities exist for IAP work in the future.