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of the**

**SRI LANKA ASSOCIATION FOR FISHERIES
AND AQUATIC RESOURCES**

THEME:

**Aquatic Resources in a Changing World: Present Trends and
Future Strategies**



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Seventeenth Annual Sessions

“Aquatic Resources in a Changing World: Present Trends and Future Strategies”

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Ecocentrism vs anthropocentrism: Can we exploit the cultural keystone species to combat changing aquatic habitats?

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Man through his actions has brought several aquatic systems, on which the civilization itself initiated, to tipping point. Conventional attempt in managing these aquatic ecosystems have evolved around the foundation of ecocentric and deontological virtues. However, in reality, both concepts function on the hypothesis that stakeholders of resources possess necessary attitudes, skills and knowledge to either “do the right thing” or “respect environment before self”. Yet when analysing the rate at which aquatic habitats are deteriorating it is evident that commons (especially the open access) are being utilised by a majority without above values, also resulting both deontologists and ecocentrists being classified as environmental advocates opposing any development that would improve the living standards of humans. Hence it is important that alternative approaches are explored bearing in mind that “game theory” rules the behaviour of most of us when it comes to resource utilisation. One such alternative approach is exploiting the different facets of anthropocentrism (human beings regarding themselves as the central and most significant entities), since when a resource or an environmental service reach a critical point, there is both social and environmental injustice felt by everyone. Recent environmental valuation and human behaviour studies have indicated that this injustice is felt strongly not when a critically endangered species becomes extinct, but when an environmental service or a product is no longer available. Therefore, can we rally stakeholders around species like wild shrimps which is a cultural key stone species in our lagoons and estuaries instead of mangroves? Can we create active participation among stakeholders to manage our reservoirs for quality bathing water instead for waders? Elsewhere, this concept has created ecological citizenship as a politics of obligation, duty and responsibility and also for simulations resource utilisation and protection.

“Imposter still reigns” – the truth behind the national flower of Sri Lanka

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The family Nymphaeaceae Salisb. is represented in Sri Lanka by the genus *Nymphaea* L., which harbors *N. nouchali* Burm. f. and *N. pubescens* Willd. In addition to these naturally occurring water-lilies, few ornamental species have been introduced in the past where one species, a violet flowered *Nymphaea* has being naturalized. This plant has being erroneously identified as the native *N. nouchali* in many literatures and occupies the prestigious position of the national flower of Sri Lanka.

A taxonomic study was carried out to solve the discrepancy regarding the identity of *N. nouchali* by collecting samples covering the three major climatic zones of the island, viz. wet, intermediate and dry zones. Based on the comparison of characters, specimens collected as *N. nouchali* secure its position as *N. nouchali* whereas the other *Nymphaea* species with violet flowers linked with the national flower unequivocally stands out. The study disclosed populations of *Nymphaea* species with intermediate characters, indicating hybridization of the native *N. nouchali* with the alien violet flowered *Nymphaea* species. The study highlights the importance of initiating measures to control the spread of this silent invader as populations of *N. nouchali* are smaller in size, they are at particular risk of genetic pollution. Therefore, conservation of pure populations of *N. nouchali* is strongly recommended.

Revealing the flawed identification of the *Nymphaea* with violet flower ‘The National Flower’, its hybrid origin and the hybridization with native *N. nouchali*, has opened up a new era in evolutionary biology and ecology in Sri Lanka.

Applying the ecosystem approach to fisheries in the Bay of Bengal

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Bangladesh, India, Indonesia, Malaysia, Maldives, Myanmar, Sri Lanka, and Thailand are collaborating through the Bay of Bengal Large Marine Ecosystem (BOBLME) Project to better the lives of their coastal populations by improving regional management of the Bay of Bengal environment and its fisheries.

BOBLME covers around 6.2 million km² of sea and supports the lives of over 400 million people. The Bay of Bengal is a place where competition for the use of marine resources is extreme and there is entrenched poverty in the burgeoning coastal communities. It is also a place where there is a scarcity of fish for food, overfishing exists, important marine habitats are being degraded and lost, and there is serious impact from land-based sources of pollution.

This presentation describes how the BOBLME Project through the application of the Ecosystem Approach to Fisheries (EAF), attempts to integrate ecological, economic, social, and governance elements into management platforms for three transboundary fisheries and, overall, into the Strategic Action Programme for the ongoing coordinated management and remediation of the Bay of Bengal marine ecosystem. It also describes how we intend to build on national EAF practices already in place, and introduce programs to strengthen management capability and harmonize management practices and policies so that effective regional management can be achieved.

An evaluation of the current status of ornamental freshwater fish export in Sri Lanka

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Many species of freshwater fishes in Sri Lanka are collected from wild habitats for export ornamental fish trade, posing a serious conservation issue. Present study was conducted to analyze and evaluate the trade of freshwater fish in Sri Lanka, with a particular focus on endemic species.

Data on ornamental fish exports were extracted from the Customs Goods Declaration Forms (Customs 53), submitted by the ornamental fish exporters to the Customs Department, Air Cargo (Exports) terminal, Bandaranaike International Air Port (BIA), Katunayake, Sri Lanka. A total of 5313, Customs goods declaration forms submitted during the two-year period from January 2005 to December 2006 were selected and data were extracted manually.

A total of 53 species of fish in 21 families, collected from freshwater habitats and reared in hatcheries have been exported from Sri Lanka during this period. Among the total species exported, 47 were indigenous species (under 18 families), which includes 18 endemic species (under 6 families).

The most common species exported was *Monodactylus argenteus* (138,380 individuals), followed by the endemic *Garra ceylonensis* (112, 856 individuals) and the exotic *Trichogaster trichopterus* (110,008 individuals). A number of endemic species exported in 2005 was higher compared to 2006.

Garra ceylonensis and *Rasbora vaterifloris* have been exported during every month in both years. *Puntius cumingi*, *Puntius nigrofasciatus* and *Puntius singhala* have also been exported regularly during the two year period.

There are 48 destination countries of freshwater fish exported from Sri Lanka. The leading importers of ornamental freshwater fish from Sri Lanka are United Kingdom, USA, France and Germany. In 2006, 19,138 numbers of *Garra ceylonensis* were exported to Germany and this quantity was 16,370 individuals in 2005. It is interesting to note that the five endemic freshwater species (*Puntius nigrofasciatus*, *Rasbora vaterifloris*, *Puntius titteya*, *Puntius cumingii* and *Belontia signata*) which were popular in 1994, a drastic reduction in export was evident in 2005 and 2006.

Among the endemics, *Garra ceylonensis* has earned the highest foreign exchange in 2005 (Sri Lanka Rs. 937,290.00), while *Esomus thermoicos* has brought in the least revenue in 2005 (SL Rs. 600.00). The total income generated from the ornamental fish trade in 2006 was SL Rs. 929,844,220.00 (US \$ 8,819,541.12), about 27% increase from 2005. Earnings from Endemic fresh water fish earned 2005 was SL Rs. 2,287,985.00 (US \$ 22,497.39) in 2005 and it was SL Rs. 1,721,015.00 (US \$ 16,323.77) in 2006. Lack of a minimum floor price for the exported fish species brings about low foreign revenue. For instance, *P. titteya* is sold at US \$ 0.12 to UK, but the selling price in UK is US \$ 40 per specimen.

There is a research need for introducing appropriate captive breeding techniques for the endemic freshwater fish species that are in high demand in the export trade.

Is feeding brood fish of *Puntius reval* with astaxanthin enriched diets effective for the enhancement of fry survival?

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Four treatment as Control, F1, F2 and F3 with three replicates were conducted to find out the survival success of fry obtained from *Puntius reval* brooders fed with astaxanthin enriched feed. Commercially available feed enriched with the emulsion of astaxanthin with different concentrations (2, 4, 6 mg Astaxanthin per 100 ml of emulsion for the enrichment of 100 gm feed respectively) were used as the experimental feed for *P. reval* brood fishes for two months while non-enriched feed was used for the controls. After one month feeding, the male and female brooders were introduced together into breeding tanks and the fry obtained were reared up to 45 days. There was a significant difference (One-way ANOVA; $P < 0.05$) in the fry survival in all treatment. Significantly highest fry survival (37.33 ± 6.1) was detected from F1 treatment (brood fish fed with artificial feed enriched with 2 mg concentration of astaxanthin) followed by control treatment (26.0 ± 6.1) (fish fed with non-enriched feed) whereas the lowest survival (5.33 ± 0.33) was indicated in F2 treatment (fish fed with feed enriched in 4 mg astaxanthin concentration). This results showed that the use of 4 or 6 mg of astaxanthin in the enrichment emulsion was not much effective for the fry survival of *Puntius reval* and the fecundity of the adult fishes, as some replicates resulted a very low or negligible fry production with those concentrations.

Effects of chicken blood meal incorporated fish feed, on growth performances and protein assimilation in red tilapia

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Crude protein level in fish feed has significant impact on physiological functions of fish. As the production of fish meal has both economical and ecological expenses, fish feed industry is at a turning point from fish meal to alternative protein sources. Present study was carried out to investigate whether chicken blood meal incorporated fish feed could contribute well for growth performances and protein assimilation in red tilapia while reducing the cost of production of feed. Crude protein level in experimental feed was adjusted to 40% to be equal to the control feed; dried chicken blood meal was used as the major protein source. Two groups of red tilapia fry (3.0 ± 0.07 cm) were fed with two feeds separately over a period of 112 days. Protein content of flesh of fish was analyzed at the beginning and at the end of feeding experiment. Mean final body weight and mean final standard length of red tilapia fed with experimental feed ($23.8 \text{g} \pm 0.4$; $9.5 \text{ cm} \pm 0.02$) were not significantly different ($P > 0.05$) from values recorded for the fish fed with the control feed ($24.3 \text{g} \pm 0.28$; $9.8 \text{ cm} \pm 0.05$). Arcsine values of specific growth rate (SGR), average daily growth (ADG), weight gain (WG) and condition factor (CF) for the fish fed with experimental feed were not significantly different from respective values recorded for the fish fed with control feed ($P > 0.05$). The respective feed conversion ratio (FCR) recorded for the experimental feed and control feed were 1.45 ± 0.08 and 1.34 ± 0.24 , which were not significantly different from each other ($P > 0.05$). protein efficiency ratio (PER) and net protein utilization (NPU) recorded for experimental feed (1.64 ± 0.07 ; 16.91 ± 0.16) also were not significantly different ($P > 0.05$) from those values recorded for the red tilapia fed with control feed (PER 1.72 ± 0.05 ; NPU 14.5 ± 0.14). Added cost of ingredient used to prepare 50 kg of the experimental feed was SL Rs. 3600 while market price of 50 kg of the control feed was SL Rs. 7000.

Determination of breeding performance of three guppy (*Poecilia reticulata*) varieties

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In Sri Lanka *Poecilia reticulata* is an ornamental fish species with high demand. There are many guppy varieties available in the industry, but their breeding performance hasn't been well studied. Culture of the best variety according to the breeding performance is advantageous and therefore, the current study was carried out to select the best variety depending on the breeding performance. Three popular guppy varieties namely Red cobra, Blue neon and Blonde tuxedo were selected and were cultured for a three-month period. Broodstocks of each variety were stocked in separate cement tanks (70 fish/tanks) in triplicates and were fed with commercial feed, at a rate of 5% body weight. Growth of the fish was measured in terms of length and weight. Water quality was maintained at an acceptable level for guppy and measured once in two weeks. Breeding performance of each variety was measured according to the number of fry delivered and the length of the gestation period. In addition, number of males and females in F1 generation were recorded.

According to the results, there was a significant difference ($p < .05$) between the growth of both Red cobra and Blue neon varieties with Blonde tuxedo variety in the first and the third week. Three varieties were significantly different from each other for second and sixth week. The results revealed that the Red cobra variety had the highest breeding performance when compared with other two varieties. Accordingly, of the three varieties studied, Red cobra variety can be recommended as the best guppy variety for Sri Lankan ornamental fish industry.

Marigold flower (*Calendula officinalis*) and China rose (*Hibiscus rosasinensis*) as carotenoid sources on pigmentation of *Poecilia reticulata*

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Current study was conducted to observe the effectiveness of two flower petals; Marigold flower (*Calendula officinalis*) and China rose (*Hibiscus rosasinensis*) on enhancing colouration in a guppy variety “red blond” (*Poecilia reticulata*). Basal feed was formulated using prima note 900 g, fish meal 100 g, vitamin C 10 g, vitamin E 6 g, minerals 10 g and CMC 10 g and this mixture was used as the control. Colour additives; Marigold flower petals (MF), China rose flower petals (CR) (Oven dried under 50 °C, grounded and sieved with 100 μ mesh) and mixture of two flower petals (1:1) were blended with the basal feed separately to formulate three different feed types. Twenty-one days old male guppy fry of same size and were stocked (25/ft²) in the cement tanks (60 cm*60 cm*45 cm). Three replicate tanks for each treatment and for control were arranged. Fish were fed with 5% of body weight for 7 weeks. Body weights of fish samples from each tank were measured initially and biweekly and accordingly total amount of feed was adjusted. The required amount of feed per single day was divided into three portions. Feed was mixed with water to prepare it as a dough before feeding. Water quality parameters were maintained at optimal levels throughout the study period. After 7 weeks, a sensory evaluation was conducted with 30 panelists to assess the effectiveness of three feeds and control feed on pigmentation of the guppy variety. Freedman ranking test of least significant difference method was carried out to check the performance of different feed treatments. Similarly growth parameters; absolute growth rate, relative growth rate and specific growth rate of different treatments were estimated.

According to the sensory evaluation treatments of two flower petal mixture (MF+CR) and China rose petal mixture (CR) have shown significantly higher preference than control ($p < 0.05$). No significant preference was observed between Marigold flower petal mixture (MF) and control. Colouration on the caudal peduncle area was highly influenced by the MF+CR mixture. However, growth rates were significantly higher in the fishes fed with CR ($p < 0.05$).

Adapting an indigenous water resource management system to new climatic realities

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Climate change is regarded as the overarching development challenge of the century. Although Sri Lanka's contribution to the global warming is negligible, it is vulnerable to the impacts of climate change in terms of increase in the severity and frequency of disasters, variability and unpredictability of rainfall patterns, increases in average temperatures and sea level rise. Coastal communities in the north and east of Sri Lanka emerged from a 30-year old civil war recently. Community infrastructure (irrigation tanks, channels, roads) and social institutions that supported their livelihoods have been deteriorated over the war time making them more vulnerable to challenges posed by climate change.

Kathiraveli situated about 80 km north of Batticaloa on the Batticaloa – Trincomalee main road is a coastal village situated at the right bank of the Verugal Aru (perennial branch river of Mahaweli river: the largest river system in Sri Lanka). This village suffered heavy damage from the war and Asian tsunami. Main livelihood of the communities of this village is paddy farming and they depend on the “Thamaravillu Kulum” irrigation scheme for the water for the paddy lands. “Thamaravillu Kulum” is a natural villu ecosystem situated at the lower floodplain of the “Verugal Aru”. Local farmers have constructed an earthen bund at the tail end of the “villu” creating a small reservoir to store water. Farmers in this village have been able to cultivate two seasons when other communities in the vicinity cultivate only one season. This has been possible due to collection of rainwater during the rainy season and getting water from the river through a small channel in the dry season. This irrigation scheme was damaged during the war due to lack of maintenance and from the tsunami wave that funneled along the river. As a result, water holding capacity of the irrigation system was drastically reduced. This resulted in loss of livelihoods for paddy farmers, fishermen and cattle farmers. This is a wetland ecosystem shared by multiple users such as fishermen, cattle farmers, women for domestic uses such as washing and bathing and wildlife. It helps to maintain the ground water table in the area and to keep water in the wells at stable level.

Practical Action started the rehabilitation of the irrigation system to secure the livelihoods and reduce the vulnerability of the local communities. Participatory discussions held with farmers and other user groups in the area revealed that there is a complex water management system, where farmer group manage the water inflow and outflow by adjusting control gates in three distinct management systems. Furthermore discussions, participatory analysis using modified Participatory Capacity Vulnerable Assessment (PCVA) and rainfall data analysis to capture trends of changing climate clearly indicated shifts in rainfall in terms of seasons, frequency and intensity. The participatory exercises and discussion clearly indicated changes in the intensity and shifts in the season. Statistical analysis of rainfall data over the last 30 years clearly showed the shifts in the onset of the monsoon, where communities start sowing their rain-fed fields and peak rainfall towards December–January from October–November. These results were shared with the community and adaptation strategies were identified. The farmers, agriculture extension officers and government officials were involved in devising new strategies. This resulted in modifying the water management system,

cultivation practices, crop selection and strengthening bunds and water control gates to suit new climate realities. Furthermore, training and capacity building of local communities and government officials, creating linkages among village institutions and government agencies and developing a simulation model to forecast flood level changes are taking place.

The ignored biomass: Can *Eichhornia crassipes* used for organic paper production?

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Water hyacinth (*Eichhornia crassipes*) is a free-floating perennial aquatic plant known to be a noxious invasive in most of its invaded territories. The high productivity and absorption capacity of the plant creates a big problem for freshwater reservoirs and rivers by obstructing navigation, impeding drainage and destroying wildlife. In Sri Lanka *E. crassipes* is considered as an established invasive and in most management practices, the plant is removed and discarded elsewhere. The current study explored the possibility of using the biomass to produce an organic paper along with another terrestrial invasive *Panicum maximum*. Four different types of papers were produced under different plant combinations; Type I: entire *E. crassipes* plant, Type II: *E. crassipes* plant without roots, Type III: entire *E. crassipes* plant and *P. maximum* leaves in 1:1 ratio (according to weight), and Type IV: *E. crassipes* plant without roots and *P. maximum* leaves in 1:1 ratio (according to weight). Papers were prepared without addition of any chemicals according to the current organic paper production procedures. Final products were tested for physical and chemical quality parameters to select the best paper. According to results, type I and II papers had a higher tensile strength compared to Type III and IV ($p < 0.05$). Although not significant, the lowest tearing strength was in type IV paper and the highest water absorption occurred in papers with *P. maximum* compared to type I and II. The lowest grammage was detected in Type I and II papers compared to other two types ($p < 0.05$). Significantly lower crude fiber content was present in type II papers compared to other three types. The cost benefit analysis indicated approximately SL Rs. 300 profit per m² of paper produced. It is concluded that type I paper has promising characteristics for future production and could be used as a method to manage the biomass generated from *E. crassipes*.

Spatial variation of macrobenthic fauna in some selected sites in Negombo estuary in relation to prevailing physico - chemical parameters in the environment

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Analysis of the spatial distribution of benthic communities gives an insight to the status of environment where they inhabit. With this view the present study was carried out to see whether the spatial distribution of macrobenthic fauna in some selected sites in Negombo estuary is governed by the physicochemical parameters in the water and sediment there. This study also attempted to determine the key physicochemical parameter/parameters that govern this spatial distribution.

During the study, the macrobenthic fauna at five selected sites i.e., Moya, Virisiyanu Duwa, Kadol Kele, Dungalpitya, and Pamunugama within the Negombo estuary were collected and their species diversity and species richness were determined. Physico-chemical parameters in water i.e., salinity, pH, temperature, conductivity, DO, BOD₅, NO₃⁻-N concentration as well as in sediment i.e., salinity, temperature, pH, percentage sand, percentage silt, percentage clay and percentage organic matter were also measured and analysed using appropriate standard techniques.

Results revealed that the species richness, species diversity and the prevailing physico-chemical parameters varied significantly between the five study sites. The species diversity and the species richness appeared to be positively correlated with the salinity and negatively correlated with the BOD₅ and temperature in water positively correlated with the salinity and sand % and negatively correlated with the percentage silt and percentage organic matter of the sediment in the five study sites. It is therefore evident that the spatial distribution of macrobenthic fauna in Negombo estuary is governed by a combination of some salient physicochemical parameters such as salinity, sand % and BOD₅ in water and in sediment.

Current status of the water quality of Diyawanna Oya: an assessment conducted during the heavy rainy periods of the south-west monsoon

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Diyawanna Oya and its environs are important flood detention areas in the Greater Colombo area. However, pollution of this waterway is a serious concern due to various anthropogenic activities, though literature pertaining to the pollution status of this waterway is scarce. Therefore, this paper presents an insight into the current water quality status of this waterway assessed during the south-west monsoonal period (May-September, 2009). pH was within the Central Environmental Authority (CEA) proposed inland water quality standards (6-8.5). Total suspended solid (TSS) content was relatively high in the highly urbanized areas. Biological oxygen demand (BOD) levels exceeded the CEA proposed limits of 3-5 mg/L and chemical oxygen demand (COD) levels also exceeded the CEA proposed limits of 15 mg/L (Class I Waters under Category 2; drinking water with simple treatment and Class II Waters under Category 4; fish and aquatic life survival), 20 mg/L (Class II Waters under Category 3; Bathing) and 30 mg/L (Class II Waters under Category 5; drinking water with conventional treatment). COD/BOD₅ ratio was > 1:2-1:4 indicating industrial wastewaters significantly contributes to organic pollution.

Oil and grease contamination was also significant (especially at the highly urbanized areas). During most of the study period, ammoniacal nitrogen levels were above the CEA-proposed limits of 0.94 mg/L and 0.91 mg/L under pH < 7.5 for Class II Waters (fish and aquatic life survival) and Class III Waters (minimum quality), respectively. However, there was no evidence of Pb, Cd and As contaminations. Nevertheless, further studies are needed to evaluate the heavy metal levels in sediments and biota and also to conduct water quality analysis during the drier periods.

Diversity and abundance of external parasites found in two commercially important fish species *Mugil cephalus* and *Etroplus suratensis* in Negombo Estuary

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The present study is an investigation from February to June 2010 on ectoparasites of two commercially important fish species *Mugil cephalus* and *Etroplus suratensis* caught from Negombo estuary located at the west coast of Sri Lanka. Sixty seven *E. suratensis* and seventy two *M. cephalus* specimens were examined. Standard length and weight of fish were recorded and the external parasites present on skin, fins, gills, operculum and eyes of the fish were counted and identified using standard procedures.

The mean condition factor of infected *E. suratensis* ($0.049 \pm 0.00 \text{ g cm}^{-3}$) was lower than that of uninfected *E. suratensis* ($0.053 \pm 0.00 \text{ g cm}^{-3}$). Nevertheless, there was no a significant difference between mean condition factor of infected ($0.018 \pm 0.00 \text{ g cm}^{-3}$) and uninfected *M. cephalus* ($0.018 \pm 0.00 \text{ g cm}^{-3}$). The level of infection was higher in *M. cephalus* (87%) than in *E. suratensis* (72%). Number of parasites per fish was not significantly correlated to either length class or condition factor of the fish in each species. Percentage occurrence of ectoparasites was higher in gills of both *M. cephalus* (84.62%) and *E. suratensis* (88.46%) other than skin, fins and operculum. No parasite was isolated from eyes.

Protozoan parasites, monogeneans, copepods, isopods and nematodes were detected in both fish species. *Caligus curtus*, *C. robustus* and two species of *Dactylogyrus* sp. and *Ergasilus* sp. showed the highest prevalence and intensity of infection in both fish species, while diversity of parasitic species was higher in *E. suratensis* (1.36) than in *M. cephalus* (1.25). Evenness of parasites was higher in *M. cephalus*. Parasitic species richness was higher in *M. cephalus* (0.06) than in *E. suratensis* (0.05). As diseases of wild fish cannot be observed until an outbreak is occurred, this study could be used in management of disease outbreaks and aquaculture development activities in estuarine environment in future.

Key words: ectoparasites, diversity, condition factor

Induction of erythrocytic micronuclei and nuclear abnormalities in Nile tilapia (*Oreochromis niloticus*) following exposure to selected industrial effluents

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The pollution of water resources may not only cause direct health effects to biota but also they pose subtle dangers in that they may be genotoxic substances which could lead to serious afflictions. In the present study, potential genotoxic effects of treated industrial effluents reaching Kelani River at two locations viz. Common Treatment plant of the free trade zone at Biyagama and South Asia Textile at Pugoda were evaluated using erythrocytic micronuclei and nuclear abnormalities of Nile tilapia, a test fish used for assessing pollutant impacts under tropical conditions. The effluent samples were collected from the effluent discharge outlets during three visits in 2010 and physico-chemical parameters of water/effluents were measured in situ. Seethawaka site of the Kelani river was used as the reference site. Nile tilapias were exposed in the laboratory to these effluent samples and genotoxic effects were investigated using erythrocytes of the fish. Fish which were exposed to aged tap water or the water collected from Seethawaka site were tested concurrently for comparisons. Most of the pollutant indicative physicochemical parameters in the effluents were significantly higher compared to the water collected from Seethawaka site and tap water. Frequency of micronuclei occurrence was greater in both peripheral erythrocytes and anterior kidney samples of the fish exposed to effluent samples compared to those exposed to water collected from reference site and tap water. Total erythrocytic nuclear abnormalities were 2- 6 folds greater in the fish exposed to the effluents compared those exposed to the tap water and water from the reference site. No significant differences were noted between the aged tap water and water collected from the reference site in relation to the parameters measured in most cases. The present study revealed that the tested effluent samples contain substances that are genotoxic to fish fauna and that genotoxic substances had not been eliminated by the effluent treatments.

Assessment of benthic floral communities in Kapparahota seagrass meadow, with respect to its proximity to the adjacent boat anchorage

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A marine biodiversity survey was carried out in Kapparahota, located on the west bank of Weligama bay of southern Sri Lanka. The survey was designed to highlight the benthic floral communities of the study area. Two 300-m² sub-sampling sites were selected depending on their proximity to the adjacent boat anchorage; one site close to a boat anchorage and the other far away. Ten line transects were deployed in each site and the percentage ground cover and abundance of each macrofloral type was estimated. Further, water depth (at low tide) and particle size of the surface substrata were also assessed. Data of the two sites were comparatively analyzed using Mann-Whitney independent-sample rank test, at 0.05 significance level. As a whole, three species of seagrasses and four species of green algae along with two species of Brown algae were identified within the study sites. Water depth and average particle size of the substrate of two sub-sites were not significantly different ($P = 0.256$ and 0.277 respectively). Among seagrasses, *Halodule uninervis* exhibited a significantly different ground cover ($P=0.007$), while that of *Thalassia hemprichii* and *Syringodium isoetifolium* were not significantly different ($P = 0.076$ and 0.066 respectively) in the two sampling sites. Furthermore, ground cover of none of the seaweed species was statistically significant ($P = 0.075, 0.126, 0.368, 0.136, 0.521, \text{ and } 0.317$ respectively for *Caulerpa sertularoides*, *C. taxifolia*, *C. racemosa*, *Halimeda opuntia*, *Stoechospermum polypodioides* and *Padina sp.*). Potentially invasive species such as *C. taxifolia* and *C. sertularoides* were also observed with an average ground cover of $1.48\% \pm 1.24$ SD and $0.60\% \pm 1.08$ SD respectively, which is only second to that of *Thalassia hemprichii* ($3.71\% \pm 3.90$ SD). The present study does not indicate the distance to the boat anchorage has an effect on the community structure.

Spatio-temporal variations in regular Echinoids populations (Phylum: Echinodermata, Class: Echinoidea) in disturbed and less disturbed rocky shores

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Sea urchins (or regular echinoids) are one of the most common macro-grazers and keystone species in rocky shore systems. However, their ecology is little investigated in Sri Lankan waters. Therefore, a study was conducted to investigate the spatio temporal variations in the diversity and density of regular echinoids off Nilwella in southern coast of Sri Lanka. Duwagahawella harbor area and Hirikatiya bay area were selected as disturbed and less disturbed areas respectively, considering the presence and absence of a harbor respectively. Random permanent strip transects of varying lengths (11-20 m × 0.5 m) were used to estimate the number of sea urchins for 5 months with 20 repeated samplings. Random quadrat sampling (0.5*0.5m) was used for calculating the percentages of macro flora in each transect at every sampling session. Regular echinoid density and diversity were calculated for two sites and means were compared. According to the results, a total of 8 species were detected from the two areas. The mean density of *Stomopneustes variolaris* was significantly higher in disturbed area compared to the less disturbed area ($P < 0.05$). *S. variolaris* was the dominant species in both areas. However, compared to disturbed area, in less disturbed area *Tripneustes gratilla*, *Diadema setosum*, *Diadema savignyi*, *Echinotrephus molaris* and *Echinometra mathaei* densities were higher ($P < 0.05$). Throughout the sampling, Shannon Weiner index of diversity was higher in less disturbed area ($P < 0.05$). In the disturbed area, more than 50% of the surface is covered by coralline algae. It is concluded that further studies are necessary to establish if *S. variolaris* out competes the other regular echinoids in disturbed areas.

Dissemination of Biodiversity, Archaeological and Socio-economic Information on the Gulf of Mannar

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The 30-year separatist war in the north, north-east and the east of Sri Lanka precluded any systematic field-based scientific studies in the area, and the Gulf of Mannar (GoM) is no exception. The situation in the GoM is even more serious in that the scientific efforts in that area even before the separatist war were scanty. The GoM is a rich resource exploited by the coastal communities in the Mannar, Kilinochchi and Jaffna Districts as well as those from south India. Due to the unsettled conditions, restrictions and regular patrolling by the navies of Sri Lanka and India, exploitation of coastal and marine resources during the war times was limited. However, with the normalcy returning very fast after the cessation of war in mid-2009, full exploitation of the coastal and marine resources is to be expected.

With the financial support from the Bay of Bengal Large Marine Ecosystem (BOBLME) Project of the Food & Agriculture Organization (FAO), IUCN undertook studies in the Gulf of Mannar, and disseminated study findings among local stakeholders. This presents part of the study findings.

The rapid floral and faunal surveys on entire coastal belt of GoM supplemented with informations from available literature were used to compile the biodiversity within the GoM. Baseline archaeological information also collected through a literature and field surveys to assess its historical aspect.

There are four major habitats types were identified along the GoM representing Forests and related habitats, Inland wetland habitats, Coastal and marine habitats and man modified agricultural lands. Over 50% of the Mannar district is under forest cover, which is largely tropical dry mixed ever-green forest followed by dry thorny scrublands. Others include coastal habitat types such as mangroves, salt marsh, sand dunes and beaches as well as inter tidal habitats including coral reef, algal communities and sea grass meadows. The mangroves and salt marshes are distributed predominantly in the coastal lagoons, and estuaries along the coastal stretch of Puttalam lagoon to Vidattaltivu via Silavatura, Arippu and Vankalai. During the survey, a total of 583 plant species were recorded from Mannar bay and coastal belt of Kalpitiya and Puttalam. It was included eight endemic species and 11 nationally threatened species.

Due to the close proximity to the Indian mainland, Gulf of Mannar coastal ecosystems harbour a large number of migratory bird species which directly land from the Indian mainland during the winter migratory period. A total of 398 vertebrates (freshwater fishes, amphibians, reptiles, birds, and mammals) and 98 invertebrates (dragonflies and butterflies) were recorded within the coastal habitats in the GoM. Among them 31 are endemic, 66 are migrant species and 15 species are known to be nationally threatened.

GoM coastal belt is rich with archaeological monuments such as millions or years old Miocene fossil sites to Prehistoric, Proto-historic and historic sites. Miocene invertebrate and vertebrate fossils are exposed along the coast of Uchchamunai, Karative Island, Aruvakkalu, Kudiramalai, Kal aru, and Arippu areas. The Vembu type habitat rich with Pleistocene gravel beds, have been observed along the coastal Aruvakkalu, Pomparippu, Wilpattu, Kudiramalai, Mullikulam, and Arippu areas. These gravel beds

contain Quartz and Chert stone implements which belong to Paleolithic and Mesolithic prehistoric humans. Evidence of Megalithic (Iron Age) culture (proto historic human activities) is also found near the Gangevadiya, bank of Pomparippu Ara, Pomparippuva, Palugahaturai, Mantai and Pukkulam areas. Due to the pearl fisheries activity the area was attract by foreign traders as well as invaders. There are nearly over 50 archaeological sites such as Buddhist monasteries, ports, forts, Hindu kovils, and churches can be seen in the GoM.

Compared to other coastal areas of Sri Lanka, threats to biodiversity and archaeological monuments in the study area had been few, largely due to the war situation during the last few decades. However, future rapid development activities proposed need to give adequate consideration to the biodiversity and historical monuments conservation aspects. Otherwise these resources will be badly affected by activities such as deforestation, mining, land clearings and treasure hunting.

Anthropogenic disturbances alter the intertidal community structure: an assessment by log-series model

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Human activities threat seashore communities in many areas of the world and their impact on coastal ecosystem is a matter of increasing concern. Present study describes the anthropogenic disturbances on the rocky shore community structure by comparing the benthic communities of disturbed and non-disturbed areas in Sri Lanka. Impacts of human disturbances; trampling, handling and exploitation on the community structure of rocky macro benthic assemblages were tested in high-, mid- and low-intertidal areas by stratified sampling method at Rumassala marine sanctuary and adjacent two localities at either side of the marine sanctuary, Galle and Unawatuna. A log series model was used to discriminate the communities with respect to the disturbances In the three study localities, physico-chemical parameters of sea surface water are more or less uniform. Changes in community structure were therefore due to human disturbances. Human disturbance was recorded as visitor census by transect walk method. This indicated that Rumassala can be categorized as non-disturbed, Unawatuna as disturbed with Galle being of moderate disturbance. The community compositions from dominant conservative species to fast growing opportunistic species were well described by the log series model, showing left skewed distribution. Log series model for Rumassala, representing reference model lies most rightward with higher slope indicating greatest evenness. The moderately and highly disturbed communities show the skewed distribution towards the left. This distribution pattern can be explained in terms of variation in recruitment and mortality rate resulting differences in species abundance.. The least disturbed community, Rumassala, contains a few very abundant species and many rare species. With increased disturbance from Galle to Unawatuna, dominant conservative species have been affected first and their abundance was low. Present study indicated that allowing less time for recovery, human activities created press-type disturbance on macro-benthic assemblages. Subsequent changes in community structure could be attributed to less suitable substrata. Present study strongly supports the growing concern that human impact on intertidal assemblages is significantly severe.

A comparison of reproductive biology of the sea urchin *Stomopneustes variolaris* (Lamarck, 1816) in two rocky shores of Sri Lanka

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The reproductive biology of *Stomopneustes variolaris* (Lamarck, 1816) (Phylum: Echinodermata, Class: Echiniodea), the most abundant sea urchin species in intertidal zones of Sri Lanka was investigated from May 2007 to April 2008. Samples were collected every month (full moon +5 days) from two study sites; Meegamuwa in western province and Hikkaduwa in southern province. The specimens ranged from 0.8 cm – 9.03 cm in test diameter. Gonado-Somatic Index (GSI), sex ratio and size at 50% maturity along with other standard body measurements were recorded. A histological analysis of the gonads was used in determination of sex and maturity stages. Results indicated that mature individuals existed throughout the year in both sites. However, variations in %GSI values showed two major spawning peaks of *S. variolaris* population in Meegamuwa within a year in August and between January-March. Samples from Hikkaduwa indicated only one major spawning peak during January. The peak reproductive phases of Meegomuwa and Hikkaduwa fell during monsoonal and non-monsoonal periods respectively. Male and female reproductive cycles synchronized at both sites. There were no differences in mean test size between males and females in Hikkawuwa and Meegamuwa ($P>0.05$). Similarly there was no difference between size at 50% maturity between females from Hikkaduwa and Meegamuwa ($P>0.05$). However, mean test size of males from Meegamuwa (3.9cm) was higher than that of the males from Hikkaduwa (3.75cm) at 50% maturity ($P<0.05$). The Repletion Index had a significantly negative relationship with the %GSI for males in both sites and for females at Meegamuwa. It is concluded that *S. variolaris* has regional differences in reproductive activity and as typical to most sea urchins, have reduced feeding during peak reproductive phase.

Shrimp farming in Sri Lanka: Present status and recent trends

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Narrow coastal belt of 120 km of Puttalam district facilitates for more than 90% of the shrimp farming in Sri Lanka. The shrimp industry in Puttalam district is increasingly constrained by diseases and environment related problems. As a result, a considerable amount of farms are now abandoned. The present study was aimed to assess the current status of shrimp industry in Puttalam district and to identify the sensitive areas for restoration. The study was confined to shrimp farming zone between Daduru Oya to Mi Oya. The information about shrimp farms such as extent, their present status and distance to ecologically sensitive areas were collected by visiting farms and interviewing service providers for shrimp farms, office bearers of farm associations, community leaders and relevant government officials. Maps were prepared using Google earth and all farms were identified as functional or abandoned. Calculation of abandoned farms was done using the criteria if a farm had been in operation during the three year period 2008- 2010 or not. The results indicated that total allocated area for shrimp farming in the project area as 2535 ha. Out of the 814 farms 524 are functional, accounting to about 1000 ha of operational area. Highest percentage (78.1%) of abandoned farms were in Mundalama and Kalpitiya areas. Results also revealed that most of the large scale farms as abandoned and majority of the operational farms as small scale. Anawillundawa, Muthupanthiya, Seguwthivu, Anaikutti and Kalpitiya subzones were identified as the areas in need of ecological restoration considering the significance of mangrove, salt marsh and mud flat ecosystems in the area. It is concluded that viable shrimp farming in the study area is presently by small scale farmers, hence targeting that community to promote sustainable shrimp culture is vital for both the industry as well as the environment.

Conditions in shrimp broodstock holding facilities maintained by shrimp broodstock collectors

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The quality of seed depends on the health of brooders. In the shrimp industry, brooders are collected by fishermen from the wild and they are stored in holding facilities by broodstock collectors from whom hatchery operators purchase brooders. The storage conditions and handling during this period may cause stress to brooders and this would affect the quality of brooders at this level. The study investigated the methods of transporting, handling and storage of brooders along the western coast. The brooders were examined for gonad development and any damages before purchase.

Samples and data were collected from broodstock collectors in the area between Beruwala and Kalpitiya. Only 2 collectors used their own boats for collecting brooders, while others purchased live brooders from fishermen in the area. Brooders were transported in seawater-filled polythene bags and plastic vessels.

Storage of brooders was in plastic basins, buckets, tubs, regifoam boxes or fiberglass or glass tanks. Number of brooders in a vessel varied according to the vessel size, and ranged between 12 brooders per m² and 36 brooders per m². The maximum area of a storage tank was 0.5 m² with a maximum water depth of 25.0 cm. The water quality parameters in the storage vessels were, ammonia, 0.5 - > 3.0 mg/l, nitrite 0.48 – 0.98 mg/l, pH 8.0 - 8.5, temperature 27.0° - 32.0°C, dissolved oxygen 3.0 – 4.0 mg/l. One to two aerators were used in the vessels according to the size and shape of the vessel. Brooders were packed into vessels and had no room for movement. Water in the vessels was changed once a day time of stocking varied from few hours to 1 week until they were purchased by hatchery operators. This study indicates that the overall conditions in the holding facilities were not acceptable for storage.

Monitoring of the management practices adopted by collectors is therefore needed to improve the condition. Also the hatchery owners should be educated to purchase brooders from collectors who have better storage facilities, to reduce contamination, and to produce better quality seed.

Determination of morphological characters that can be used in identification of closely related two freshwater prawn species: *Macrobrachium rosenbergii* (De Man) and *M. malcolmsonii* (Milne Edwards)

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Freshwater prawn *Macrobrachium* species are an economically and ecologically important macro invertebrate group. Freshwater prawn farming is an economically important industry in many countries. Eighty six *Macrobrachium* species are recognized as economically important and among them at least 11 species have gained great commercial value in different countries. In many Asian-Pacific countries, freshwater prawn culture industry is mainly based on *Macrobrachium rosenbergii* (De Man 1879). However, presently there is a growing interest in many Asian countries to use *Macrobrachium malcolmsonii* (Milne Edwards 1844) as a potential candidate in aquaculture due to its high growth rate. In Sri Lanka, culture based fishery of freshwater prawns is still at the level of infancy and *M. rosenbergii* is the only cultured freshwater prawn. However, *M. malcolmsonii* is reported from the eastern part of Sri Lanka and therefore there is a possibility to use this species in future aquaculture programs. Morphology of both *M. rosenbergii* and *M. malcolmsonii* is very similar. Characters of the rostrum and the 2nd pereopod are usually used in delineating two species. Nevertheless, pereopods and rostrum are sometimes subjected to damage during their activities such as reproduction and agnostic behaviour and more often they shed their pereopods during trapping and collecting. These reasons lead to misidentification of the two species in many occasions. The current study was designed to determine morphometric characters other than rostrum and 2nd pereopod that can be used to separate two related freshwater prawn species *M. rosenbergii* and *M. malcolmsonii* using Discriminant Function Analysis (DFA) method. Initially fifteen morphometric characters were measured and finally only nine characters were subjected to DFA. Among them, seven characters (total length, carapace width, diagonal carapace length, abdominal length, 1st abdominal segment length, 1st abdominal segment height and length of 2nd pleuron) were derived as contributors that help in delineating two species. The results are important in planning aquaculture of these species.

Shrimps species of coastal fishery in Kakkaitivu Coastal Area in Jaffna, Sri Lanka

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Shrimps form one of the most economically important constituents in the world's marine fish landings. It is rich in protein and is preferred by majority due to its specific taste. Shrimp of Sri Lanka collected from estuaries and sea are an important commercial fishery resource. . The coastal fishing grounds around Jaffna district and the estuary in the district are resourceful when compared to other parts of the country.. Kakkaitivu coastal area is a part of the Jaffna estuary.

Due to the security situation in the area during the recent past, information about the fisheries at least on the basic aspects such as species occurrence is scanty in this area. A field study was therefore conducted to identify the shrimp species in Kakkaitivu coastal area in Jaffna district in Northern Province, Sri Lanka. Samples were collected from Kakkaitivu landing centre from November, 2010 through April, 2011 at two-week intervals.

Collected shrimps were initially identified using standard keys according to the morphological features. Six species of shrimp *Penaeus indicus*, *P. monodon*, *P. latisulcatus*, *P. semisulcatus*, *P. japonicus* and *Metapenaeus sp* were found to be present in this region.

In Jaffna peninsula, this resource has been over-exploited both in the sea and brackish waters. Shrimp catch is in decline due to the over-exploitation and also due to effects of pollution. Scientific knowledge of the biology of shrimp and their fisheries in this region is therefore important for future management of these fisheries.

A Comparative analysis of Monodon Baculaovirus (MBV) diagnostic methods adopted in Sri Lanka to investigate their accuracy and specificity

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Monodon baculaovirus (MBV) is a common viral pathogen infecting cultured *Penaeus monodon* worldwide resulting growth retardation. Since its first appearance in Sri Lanka in 1989, several detection methods recommended by the Office des Epizootics (OIE) have been used locally. However, confusing test results have frequently been encountered when detections were performed with different methods on the same sample and between diagnostic laboratories. Therefore the study aimed to evaluate the present MBV detection protocols recommended by the OIE and to recommend an appropriate cost effective and accurate method for screening of MBV infection in *P. monodon* in Sri Lanka. Using these methods, 50 number of *P. monodon* PL samples obtained from different shrimp hatcheries located in the North-western province were subjected to screening for the presence of MBV and the results were comparatively evaluated.

Highest prevalence was recorded with wet mount observations (84%) and the lowest was recorded using histology (23%). Comparisons of PCR tests generated inconsistent results in 17 and 10 samples respectively. This demonstrated the unreliable nature of these PCR protocols as screening tools for MBV in Sri Lanka. The results obtained with the IQ2000 commercial kit were the most reliable; producing a high degree of consistency amplifying 35 samples indicated 70% prevalence. Using IQ2000 kit is not economically viable for screening MBV due to the low degree of impact caused with MBV on the shrimp farming industry compared to the white spot syndrome virus (WSSV). Therefore, wet mount observation could continue to be used for screening provided that cautious interpretation of results is applied with the service of experienced diagnosticians. Research should focus on designing reliable primers by understanding the genetic diversity of the MBV in Sri Lanka which could help to develop an improved PCR method to be used as a supportive test to endorse the wet mount results when required.

Identification of taxonomic status of freshwater prawn known as “Karadandu issa” or “Andu issa” in Nilwala River, Matara

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Freshwater prawn *Macrobrachium* species inhabit in a wide variety of environments such as inland freshwater areas including rivers, swamps, irrigation ditches, canals and ponds, as well as estuarine areas. Freshwater prawn ‘*M. idae* group’ is commercially important in some countries in South Asian region including Sri Lanka. Three species have been recognized within this group: *M. idae*, *M. idella idella*, *M. idella georgi* which have been recorded from both fresh water and brackishwater habitats. From morphological point of view, a close relationship and taxonomic ambiguities among the above three species have been reported. In Sri Lanka, wild populations of these varieties are heavily exploited for human consumption. Different local names such as “Karadandu issa”, “Andu issa” and many other synonyms are being used to recognize them. However, the exact taxonomic status of “Karadandu issa” or “Andu issa” has not been identified. The objective of this study was to determine the taxonomic status of “Karadandu issa” or “Andu issa” that is available in Nilwala River, Matara using partially amplified nucleotide sequences of mitochondrial 16S rRNA gene region. Additional sequences for *M. idae*, *M. idella*, *M. rude* and out-group taxa were downloaded from the gene bank. To root the phylogenetic trees sequences of two out group taxa (*Palaemonetes atrinubes*, *Palaemon debilis*) were included. Total of 471 base pairs were amplified and it was a A+T rich region which is common to other *Macrobrachium* species. According to the derived phylogenetic tree, prawns in Nilwala River grouped with *M. idae* clade with a higher support (bootstrap value 98%). There were no phylogenetic differences found among Sri Lankan and Chinese *M. idae* samples. However, there was 0.9% divergence level between Sri Lankan and Australian *M. idae* samples and it was 1.6% with European species. The divergence levels between *M. idae* and *M. idella* ranged from 4.9%- 5.4%. These types of studies are important to explore our wealth of the hidden biodiversity.

Simultaneous detection of Infectious Hypodermal and Hematopoietic Necrosis Virus (IHHNV) strains in the genome of wild and cultured *Penaeus monodon* shrimps from Sri Lanka using Duplex Polymerase Chain Reaction (PCR)

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We reported IHHNV and IHHNV-related sequences within the shrimp genome in populations of *Penaeus monodon* from Sri Lanka for the first time in 2009 through consensus PCR and phylogenetic analysis of the identified isolates. IHHNV is a single stranded DNA virus that has been reported to cause severe mortalities, growth related problems and deformities in several penaeid shrimp including *P.monodon*. The virus-related sequences have a high degree of similarity to the viral genome, hence has often generated false-positive results with most of the PCR assays previously described for detection of IHHNV as they amplify both the infectious and the non-infectious with no discrimination.

The consensus nested PCR which we developed to identify the presence of IHHNV in Sri Lanka cumulatively amplified both types (IHHNVC F1/R1 IHHNVC F2/R2) and generated 490/639 positive samples during the period 2008-2010. Only 245 were positive with a pair of IHHNV primers (IHHNV309F/R) which were previously designed to only amplify the infectious IHHNV strain. The infectious strain was detected 44%, 25% and 31% in post larvae (PL), sub adults and in wild brooder samples during sampling period respectively. A PCR test was also described earlier to simultaneously detect and discriminate IHHNV type A (MG831F/R) from all other IHHNV strains (389 F/R).

We report here an improved version of a detection protocol for IHHNV including primer pairs 309 F/R and 389 F/R to simultaneously detect the infectious strain (309 F/R) and all IHHNV strains (389 F/R) identified in Sri Lanka. The new combination of primer pairs used in this detection protocol can detect and differentiate the infectious strain from the others and also there is a built-in mechanism for reconfirming of the presence of infection in the PCR test itself. The developed duplex PCR could be used as a screening test for post larvae prior to stocking which could avoid unnecessary sacrifice of stocks by using a consensus detection protocol.

Genetic analysis of cultured and wild barramundi (*Lates calcarifer*) species based on mitochondrial DNA

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Lates calcarifer commonly known as Barramundi or Asian sea bass is a large, highly fecund and euryhaline fish with a tropical Indo-West Pacific distribution. It is an important marine food fish belonging to the family Centropomidae. There are no previous genetic records of this species from Sri Lanka and no attempts have been made to assess the genetic status of both wild and cultured *L. calcarifer*.

In the study, an attempt was made to assess the applicability of mitochondrial COI for identity/separation of two entities; the wild type and the imported varieties of Barramundi. We obtained partial 650 bp mitochondrial DNA (mtDNA) COI sequences of wild type *L. calcarifer* samples from Sri Lanka and genetically improved variety of *L. calcarifer* samples from Thailand. Phylogenetic inferences were made based on the mitochondrial COI gene sequences and the genetic distance between the two groups (i.e., the wild type, an imported variety) was calculated. Two distinct clades of imported and the wild type were revealed. Our data also revealed a relatively high mean genetic distance between the wild type and the imported variety (0.202). This study shows that the rate of evolution of the COI is sufficiently rapid to allow the discrimination and establishing the genetic differentiation between the two entities; the wild and the imported *L. calcarifer*.

Identification of jellyfish species found in Sri Lanka by molecular methods

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There are no records available on the species or the biology of jellyfish found in and around Sri Lankan waters. In spite of several edible jellyfish species being exported in bulk from Sri Lankan waters, the species to which these edible jellyfish belong to are unknown and in most occasions referred with vernacular names.

Jellyfish samples were collected from Modara, Negombo, Chilaw, Kalpitiya, Beruwela, Galle, Kalmunai and Batticaloa. The mitochondrial COI region of the extracted DNA was PCR amplified and sequenced. The Blast database of The National Centre for Biotechnology Information (NCBI) and the BOLD identification system were used to identify the species by comparing the sequences obtained.

The commercially exported species of jellyfish caught from Kalmunai (E: Mushroom jelly) was identified as belonging to the genus *Crambionella*. The large mushy purplish coloured jellyfish (S: Eth hori) collected from Negombo, was identified as *Cyanea capillata*. A similar specimen with spots collected from Modara. A species of jellyfish collected from Pambala (Chilaw) which possessed a rigid bell, 8 arms with spots on its bell was identified by sequence comparison as belonging to the genus *Acromitus*. Similar specimens collected from Kepungoda in western province were also identified as belonging to the same genus by sequencing. The size and the pattern of the spots of individual specimens varied but the remaining features were identical.

Detection of histamine forming Enterobacteriaceae bacteria in fish using Polymerase Chain Reaction

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Fish is a nutritious article rich in protein, fat, vitamins and minerals. As it is a perishable food item, it spoils easily when decarboxylase enzymes form by bacterial growth causing generation of bioactive amine including histamine. In most amine containing foods, the majority of amines are generated by decarboxylation of corresponding amino acids through substrate specific enzymes designed from micro organisms present in the foods. The formation of biogenic amines is important for not only from the stand point of their toxicity, but also because they can be used as the freshness or spoilage indicators for food. Histamine is formed by free histidine, an amino acid, which is present in large amounts in the muscle tissues of fish belonging to Scombridae family such as tuna and mackerel, decarboxylating with decarboxylase enzyme of bacterial histidine. There are various bacteria species facilitating decarboxylation of histidine, mostly the group of gram negative enteric bacteria including *Morganella morganii*, *Klebsiella* spp, *Enterobacter* spp.

Presence of histamine decarboxylating gene (*hdc*) in bacteria can give a clear idea about those which can form histamine. In this study, mackerel (*Rastrelliger kanagurta*) were collected in local markets and samples were prepared in Maximum Recovery Diluent (MRD) and the colonies were grown on Violet Red Bile Glucose Agar (VRBG). Further, the colonies were streaked on Nutrient Agar and used for the PCR. Positive result for the *hdc* gene gave a band size of 709 bp, gene which is responsible for the formation of histamine. Out of 216 isolates, 46 gave positive results for *hdc* gene. Pink colour cells were obtained in Gram staining. Colonies were biochemically identified with the test of urease test, oxidase test, indole test, citrate test, TSI reaction and VP test and they were identified as *Enterobacter* spp, *Klebsiella* spp, *Proteus* spp. and *Morganella morganii*. The use of this method can detect histamine forming gram negative bacteria early and rapidly and also this helps evaluating the potential of histamine formation in fish.

Development of HACCP plan for steam-boiled crab meat of Asian blue swimming crab (*Portunus pelagicus*)

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Food-borne diseases out breaks have been a major impetus in the application of new quality management systems such as Hazard Analysis and Critical Control Point (HACCP). The present study aimed at identifying the HACCP in steam-boiled crab meat production line. Good Manufacturing Practices (GMPs), Standard Sanitary Operating Procedures (SSOPs) and Standard Operating Procedures (SOPs) were developed and documented as pre-requisite programs for HACCP plan development. The product description, intended use and flow diagrams were constructed and potential hazards associated with entire process from raw material reception to dispatch of the end product were identified by critically evaluating each processing step by using CCP decision tree. The microbiological, chemical and physical hazards and their significance and likely occurrence at each step of the process were observed. The CCPs of steam boiled crab meat production line were identified as the receiving of raw materials, steam cooking, picking of crabs, and chill/cold storage. Critical Limits of identified CCP's were then established by using government regulations, company policies, effective monitoring activities, corrective actions and verification procedures and the number or percentage of live crabs, steaming temperature of 15 minutes at 100 °C, cooling crab meat temperature of 4.5 °C or less within 2 hours during or after picking are identified as the critical limits. Corrective actions were established such as: supplying of wet sacs, removing the improperly cooked crab meat and immediate icing of the product. Finally, a HACCP plan was developed and verified for its validity.

A comparative economic viability of two community-based small scale aquaculture practices in Sri Lanka

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Information on the economic viability of aquaculture is crucial for investors when assessing the feasibility of an aquaculture investment. Cost and profitability analysis is essential for development and management of a farm to understand the production cost and its evolution to determine where cost reduction can be achieved. As information on such aspects is scarce in Sri Lanka, present study evaluated the cost and profitability of two community-based small scale aquaculture practices in Sri Lanka namely net cage culture of Asian sea bass (*Lates calcarifer*) and monoculture of hybrid Tilapia mainly in net cages. The economic analysis, data on yield, cost and return of farming were estimated to quantify production costs and to assess the profitability. Economic analysis of the production systems revealed that the cost of tilapia and sea bass production per kg were Rs. 142.19 and 268.62 respectively. The yield of tilapia/m³ was estimated to be 22.5 kg and the yield of sea bass/m³ was 22.11 kg. Tilapia cage culture had the highest return on investment (40.65%) and required 353.06 kg of total production to reach the break- even point compared to sea bass.

Feed was the main cost factor and was 66.21% for sea bass production while that of tilapia production was 60%. The ratio of the variable cost in total costs of tilapia production was 74% while that sea bass production was 82%. The benefit-cost ratio in tilapia production (1.40) was higher compared to sea bass production (1.12). Culture of tilapia showed the highest viability and profitability of the two culture practices evaluated.

Household food security of muslim fishing community in the Beruwala divisional secretariat division of Sri Lanka

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The purpose of this study was to examine empirically, the status of household food security (HHFS) of muslim fishing communities in Sri Lanka, given that the socio-economics, religious and cultural peculiarities as well as the norms, customs, traditions and beliefs of these communities are remarkably different from their counterparts (i.e. Sinhala and Tamil-based fishing communities). The data were collected from 494 individuals belonging to 80 households located in the Beruwala Divisional Secretariat Division (BDS) to fit into the “*Aggregate Household Food Security Index*” (AHFSI) developed by FAO, which takes into account both the extent and depth of undernourishment and variance of household food supplies within a specific period of times. The proportionate random sampling techniques were adopted to select respondents from 5 Fishing Inspection Divisions in the BDS (i.e. Aluthgama, Beruwala North, Beruwala South, Maggona, and Payagala). Multiple criteria were employed to gather data required to develop the AHFSI, including: (a) an in-depth personal interview carried out with the members of a household with the aid of a structured questionnaire; (b) anthropometric measurements, and (c) direct observation of individual housing conditions. Further, the secondary data pertaining to socio-economics, geographical and demographical status were extracted from the published reports, records and bills etc., which were maintained by various public institutions, including the BDS. The results highlighted that AHFSI of sample population was 84.6 [AHFSI value range from “0” (total famine) to “100” (total food security)], i.e. a “sufficient level” of HHFS based on the FAO classification. The outcome of analysis implies that their accessibility to loans, fishing effort, age and gender had positive impacts to achieve sufficient level of HHFS, while literacy rate and household size had a negative impact and household expenditure had no significant effect in this respect.

Social perceptions on aquatic plant invasions: Exploring the case of Lunuwewa tank habitat

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The spread of invasive species is a significant and growing threat to Sri Lanka's biodiversity, because it not only generates ecological impacts, but also possesses economic and human welfare consequences. In line with this, the issue of managing invasive alien species (IAS) is increasingly recognized. This study was carried out as an initial assessment/pilot study of a multi-phased research programme on the economic prospects of alien aquatic plants infested dry zone tank habitats and aimed to investigate the social processes and perceptions of the aquatic invasive plant problem in dry zone tanks. An initial field survey and consultation with the Mahaweli Authority led to the selection of Lunuwewa Tank Habitat in the Anuradhapura district (80°17.5'E, 8°10.3'N). An extensive review of literature was carried out, concurrently and thereafter, a number of field visits were made to the selected area between 2008 and 2010 for this qualitative review. Stakeholder methodologies and rapid community appraisal techniques were employed and key informant surveys were conducted by means of depth interviews supported through semi-structured interview schedules. Qualitative content and thematic assessments revealed four broad, distinct stakeholder groups: 'direct farmers', 'farmers of the tank catchment/reservation ("*wew thavulla/rakshitha*")', 'fishermen' and 'administrators', in terms of their livelihood linkages with the tank. Although they all identified aquatic invasive plants as a 'problem' or 'threat', their level of concern and definition were diverse. The surrounding community, in general, did not define aquatic plants as a critical threat to their livelihood, in contrast to the perceptions of the Mahaweli Authority. The farming community has adapted to manage the problem through mechanical removal, to keep it below their threshold level, while the fishermen dislike the removal of invasive species citing that as they act as impediments for fishing, prevent over-fishing. These outcomes call for policy makers to take into account the differing perceptions and attitudes of the different stakeholders in invasive plant management programme.

Histological alterations in fishes inhabiting Koggala lagoon, Sri Lanka

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Koggala lagoon has been categorized as a highly threatened coastal wetland in Sri Lanka. In the present study, histological structure of the gill and liver tissues of selected fish species inhabiting the Koggala lagoon (*Mugil cephalus*, *Lutjanus russeli*, *Terapon jarbua*, *Oreochromis mossambicus* and *Etroplus suratensis*) were examined to assess their overall health condition. Fish were collected from three sites of the lagoon viz. southern part near the lagoon mouth, southern part behind the island Madol Duwa and northern end of the lagoon during the period February–July 2010 and gills and liver tissues were processed for histology using standard procedures. Histological alterations mostly seen in the gills of fishes were primary and secondary lamella hyperplasia, lamellae fusion, aneurism and mucous cell proliferation. Severe lamellar hyperplasia was found mostly in association with copepod or monogenean parasitic infections. Liver tissues of the fishes revealed degeneration of hepatocytes, vacuolation and sinusoid congestion. In addition pre-neoplastic type conspicuous basophilic or vacuolated cell foci were found in the livers of some *M. cephalus* and *L. russeli* collected from the southern part of the lagoon. Histopathological lesions indicate that the health of the fish populations inhabiting Koggala lagoon are under threat due to prevailing stress factors.

Contribution of mangrove above-ground roots for carbon sequestration function in mangrove ecosystems at Kadolkele in Meegamuwa estuary

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Contribution of mangrove aboveground roots for carbon sequestration function was studied at Kadolkele mangrove stand in Meegamuwa estuary (7°11' N and 79°50' E). The structure of mangrove vegetation was analyzed to determine the effect of structure of mangrove vegetation on carbon sequestration capacity of mangrove aerial roots. Structural parameters were obtained along the three belt transects (10 m x 50 m, 10 m x 70 m, 10 m x 80 m) laid perpendicular to the shoreline. Plant density, stem density, basal area, tree height, species diversity and species richness were analyzed to determine the structure of mangrove vegetation. Prop root, pneumatophores and knee roots are the aerial roots that observed to occur in Kadolkele mangrove stand. Prop roots can be divided into four types, i.e. primary, secondary, tertiary and quaternary roots, depending on their branching pattern and maturity. Organic carbon content in these aerial roots was analyzed using the Walkley-Black method.

When comparing the carbon content per unit dry weight in different types of prop roots, it was higher in primary roots (0.431 C g⁻¹) than that of secondary (0.411 C g⁻¹), tertiary (0.405 C g⁻¹) and quaternary roots (0.363 C g⁻¹). Carbon content per unit dry weight in these prop roots was higher to that of pneumatophores (0.318 C g⁻¹) and knee roots (0.227 C g⁻¹) and there was a significant difference (p<0.05) in carbon content among these roots. Results clearly indicate that prop roots highly contribute to carbon sequestration function than pneumatophores and knee roots. In Kadolkele mangrove area, contribution of knee roots for carbon sequestration (517.0 g m⁻²) was higher than that of prop roots (226.3 g m⁻²) and pneumatophores (456.2 g m⁻²), as biomass of knee roots (1686.42 g m⁻²) was higher than that of prop roots (585.14 g m⁻²) and pneumatophores (1371.74 g m⁻²) and showed no significant difference at 0.05 level.

Present study reveals the structural changes of mangrove vegetation in three transects and along the gradient from shoreline to land affects the carbon sequestration capacity of aerial roots of mangroves in Kadolkele. Carbon storage capacity of aerial roots per unit area in transect 1 (1322.3 g m⁻²) and transect 2 (1494.3 g m⁻²) was higher than that of transect 3 (902.6 g m⁻²) owing to higher importance value of knee root bearing *Lumnitzera racemosa* in transect 1 and 2. When comparing the carbon storage capacity of mangrove aerial roots per unit area along the gradient from shoreline to land, it was higher in stratum 3 (1398.1 g m⁻²), the most landward zone than that of stratum 1 (1332.6 g m⁻²) and stratum 2 (978.5 g m⁻²).

Effects of the weedicide ‘Roundup’ (glyphosate) on the fingerlings of guppy, *Poecilia reticulata* (Peters, 1859)

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Weedicides bring about adverse effects to non-targeted animal species both in the agricultural fields as well as in the associated habitats. Among these weedicides ‘Roundup’ is one of the commonest one. The present laboratory investigation examined the effects of ‘Roundup’ on the fingerlings of guppies (*Poecilia reticulata*) that are commonly found in aquatic habitats associated with agricultural fields.

In this investigation the 24 hour and 96 hour LC₅₀ of ‘Roundup’ for the guppy fingerlings were determined by exposing them to a series of ‘Roundup’ preparations ranging from 3.6 mg/l to 36 mg/l. Further, the behavioural changes of the fingerlings at these test preparations were studied and the histopathological changes of their gills were examined.

The results indicated that the 24 hour and 96 hour LC₅₀ for ‘Roundup’ were 15.1 mg/l and 9.76 mg/l respectively. These values are well below the recommended concentration of ‘Roundup’ to be used in the field, which is 2592 mg/l. Fingerlings were observed resting more at or near the surface of test preparation than resting elsewhere in the control and in the test preparation containing the lowest concentration of 3.6 mg/l. This change in behavioural pattern was probably due to the stress caused by ‘Roundup’. The histopathological study showed that the fingerlings exposed to high concentrations, i.e. 7.2 mg/l, 10.8 mg/l and 14.4 mg/l of ‘Roundup’, showed severe gill hyperplasia. It can be concluded that gill damage caused by ‘Roundup’ could contribute to the mortality of guppy fingerlings.

Influence of humic acids and quinone moieties on the reductive dechlorination of chlorinated hydrocarbons in natural Fe(II)-Fe(III) systems

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The objective of the present study was to investigate the effect of humic acids (HA) and quinone moieties (QM), which are thought to be representative active chemical components of natural humic substances on the dechlorination mediated by surface-bound Fe(II) associated with natural iron minerals. Goethite (α -FeOOH) was used as the natural iron mineral and humic acid (Aldrich) was used to represent natural humic acids while anthroquinone disulfonate (AQDS), and Lawson (Aldrich) were used as quinone moieties (to study the influence of humic acids and quinone moieties on the reductive dechlorination of chlorinated hydrocarbons in natural Fe(II)-Fe(III) systems. Amber bottles of 55-ml total volume were used as reactors for dechlorination process, maintaining total liquid phase volume of 50 ml. Bottles were sealed with viton caps and kept in horizontal orbital shaker (150 rpm) at 20°C in dark condition. Before sealing the bottles, all the preparations were carried out in an anaerobic glovebox at N₂ condition (O₂ < 0.01 ppm) with automatic system for trace levels of O₂ detection. Parallel experiments were carried out using Goethite (α FeOOH) alone, and goethite with Fe(II) in the absence and presence of chemically reduced HA or QM separately for dechlorination of CCl₄ (0.65 μ M) at neutral pH in the dark. CCl₄ and its degradation byproducts in GT-Fe(II) suspension were analyzed qualitatively and quantitative by GC-MS head space method. In order to investigate the effect of the concentrations of organic matter (HA or QM) in Goethite-Fe(II) system, ten times high concentration of HA and QM were also used. Results showed that the dechlorination of CCl₄ in goethite-Fe(II) system followed first-order reaction kinetics and the rate constant during observed period (k_{obs}) values were 0.087d⁻¹, 0.3d⁻¹, 0.46d⁻¹, 0.38d⁻¹ and 0.37d⁻¹ in the systems of Goethite-Fe(II) alone, and 0.1mM AQDS, 0.1mM Lawson, reduced and non-reduced HA (11.3 mgL⁻¹ C) respectively. This indicates that both humic acid and quinone moieties have the capacity for increasing the reductive dechlorination of CCl₄. But increasing the HA or QM concentrations with 10 times, the dechlorination rate constants were 0.12d⁻¹, 0.082d⁻¹, 0.084d⁻¹ and 0.053d⁻¹ in AQDS, Lawson, HA(reduced) and HA (native) amended goethite-Fe(II) suspensions respectively. This results provide evidence that quinone moieties or humic acid at low concentrations can accelerate the dechlorination rates through electron shuttling between reactive surface bound Fe(II) on goethite. Dechlorination of CCl₄ occurred with k_{obs} of 0.108d⁻¹, 0.342d⁻¹, 0.045d⁻¹, 0.034d⁻¹ in the systems of Goethite-Fe(II) with AQDS, Lawson, HA(reduced) and HA (native) respectively when organic matter was first exposed to goethite surface prior to be exposed to Fe(II). This result indicates that both concentration and HA & QM and sequence of their addition respected with Fe(II) into goethite system are important factors for CCl₄ dechlorination by Fe(II) ions associated with iron mineral.

Quality characteristics of soil and water at farmer's field of Madukkarai resettlement village with reference to electrical conductivity

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Groundwater is an important resource for drinking water supplies and for irrigation. The significance of groundwater for supplementary irrigation is being realized increasingly.. This study focuses on the groundwater salinity problem in the Madukkari resettlement village in Mannar district. The village is located about 30 km South-East from Mannar town. At present more than 250 families (mostly resettled internally displaced people) are living in the village. Groundwater-irrigated agriculture is the major economic activity but groundwater salinity is seen as a threat to their livelihood.

Accordingly, electrical conductivity (EC) and pH were measured to evaluate the quality and condition of ground water in Madukkarai resettlement village. Initial monitoring of EC and pH of all the wells was done within three weeks in April 2007. EC of selected wells and temperature of each selected agro-well were monitored at monthly interval from July 2007 to March 2008. Further EC, pH and river water levels at three selected locations in the nearest river known as Aruvi Aru/ Malwattu Oya - at head, middle and tail end of the settlement were also measured. Monthly average rainfall data for the period from 1994-2007 was also obtained from Meteorological department, Mannar. GIS based database and map of EC were also developed for the project boundaries, locations of wells and sampling locations. Past experiences of selected farmers in relation to water quality, crop management, and information on soil layers (soil profile) were also gathered through a questionnaire survey. Further, soil samples were collected from critical locations of the study area and analysed for soil texture, soil pH, cation exchange capacity, base saturation, acid saturation, electrical conductivity, organic matter, active acidity, calcium, magnesium, sodium, potassium, Ca:Mg, Mg:K, nitrogen, phosphorus, boron, copper, iron, manganese and zinc.

The results showed that the best quality water of the study area was present in agro-wells far away from the river. The intermediate quality water was present in the areas of intermediate distance from river. As expected, the poor quality water was found in wells which were situated very proximity to the river. This could be due to the back flow of sea water into the river and backflow of river water into the groundwater aquifer during the dry period. Soil analysis results also prove that there is no evidence of development of salinity in soil in Madukkarai resettlement village.

It was concluded that there was no evidence of building-up of higher concentrations of solutes in the agro-well waters and that it could be due to the "Maha" seasonal rains. Also, the total annual rains received in this region are sufficiently adequate to leach out and dilute solutes that have built up in the soil during the dry season.

A comparative study on avifaunal diversity of two selected seasonal reservoirs at Kurunegala district

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The abundance of birdlife makes Sri Lanka an ornithologist's paradise with around 492 recorded species, of which 233 are resident including 33 endemics to the country. The ancient multitude of reservoirs have over the years, evolved into important avifaunal habitats. However, the contribution of reservoirs to dry and intermediate zone bird diversity has not been fully appreciated. Current study therefore, looked into diversity of avifauna and surface flora in Kithala wewa and Imbulgoda wewa seasonal reservoirs of Kurunegala district in 2009. Birds seen in the vicinity of two reservoirs were counted from three randomly selected sites for each reservoir between 06.00 am and 09.00 am. Reservoirs underwent wet (W), early dry (ED) and dry (D) spells during the sampling period. Surface flora of reservoirs were recorded with random quadrat sampling (n=30) during wet period. The bird diversity of two reservoirs was compared by calculating the diversity indices. Forty eight species of birds belonging to 24 families and fifty species of birds belonging to 27 families were detected from Kithala wewa and Imbulgoda wewa respectively. There were no significant differences between species richness, Shannon Weiner diversity and evenness of the two reservoirs for the entire study period and between seasons in Imbulgoda reservoir ($P>0.05$). However in Kithala wewa, there was a significantly low species richness during wet period ($P < 0.02$) compared to other periods. Sorenson index of similarity between two reservoirs for wet and early dry periods indicated nearly 60% similarity in species between two reservoirs (ED=0.609, W=0.667) but during dry period, there was only 2% similarity in species patronizing the two reservoirs (D = 0.025). *Eichhornia crassipes* and *Nelumbo nucifera* were the dominant surface flora at Imbulgoda reservoir while *Salvinia molesta*, and *Panicum repens* were dominant at Kithala wewa. In both reservoirs, surface open water is taken up by mat forming invasive plant species. Results indicate that despite both being seasonal reservoirs and located in the same biogeographic zone, they possess unique characteristics which need maintained to provide continued support for avifauna in this area.