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PROTECT NATURE
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ZOOLOGISTS' ASSOCIATION OF UNIVERSITY OF PERADENIYA

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Cover page: Golden-eyed shrub frog (Pseudophilatus ocularis)
male calling for a female - captured in Gongala mountain.

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EDITOR'S NOTE

"Mother nature has the power to please, to comfort, to calm, and to nurture one's soul."

~ Anthony Douglas Williams ~

It is with great enthusiasm that the Zoologists' Association of the University of Peradeniya (ZAUP) publishes the second volume of the Student Journal, "Protect Nature". The major objectives of this journal are to provide students the opportunity to publish their research findings and wonderful experiences with Mother Nature and also to make the community aware of the importance of protecting nature, which is a crucial task to be done.

Our world is our home and the source of our sustenance; however, it appears that people have chosen a road of self-destruction, killing the very place that provides us with sanctuary. Anthropogenic activities are harming our ecosystem biodiversity, from rising carbon emissions to deforestation and natural land degradation. Despite numerous strategic efforts and strategies to engage people at all levels, we are well behind schedule in attaining the set objectives. The declining trends in biodiversity and ecosystem conservation show that we still have a lot of work to do.

Significant changes are only feasible if nations and organizations change their policies and practices, however, we, as the youth, also have the power and potential to change things, whether by modest gestures or effective initiatives. We can lessen the amount of single-use plastic garbage we produce, reduce our carbon footprint, spend more time with nature, and help to protect, maintain, and restore biodiversity. This journal intends to bring you closer to nature and enhance your attention and care toward our beautiful environment. It will also work as an eye-opener while addressing some of the major problems the environment is faced with.

On behalf of ZAUP, I extend my humble gratitude to Dr. Shalika Kumburegama, Senior Treasurer, ZAUP, for mentoring, and supervision provided throughout and for being the guiding pillar to make this volume of this journal a reality. I sincerely acknowledge the lecturers of the Department of Zoology, University of Peradeniya who contributed their time and effort to review, edit and proofread the articles. Additionally, I wish to thank Prof. Inoka Karunaratne, Head of the Department of Zoology, University of Peradeniya, and all the other academic staff members for their generous support to make this task a reality. Furthermore, I wish to thank all the members of ZAUP for their kind contributions and all the authors, photographers, undergraduates, and researchers whose work has been published in this journal.

We genuinely hope you will enjoy reading the journal and invite you to join hands with us for the next volume of our journal. Contact us via our E-mail address zauperadeniya@gmail.com.

B.K.R.O. Rodrigo
Editor
ZAUP

The beauty of a wetland

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All around the world, there are places with shallow water or saturated soils whose vegetation is dominated by species of plants that are found nowhere else in the surrounding uplands. The plants in these areas include those that emerge from the water surface, floating plants, and plants that that are completely submerged. These highly diverse ecosystems also include groups of animals, especially birds, more or less restricted to these areas. These highly diverse and productive ecosystems are called wetlands.

According to Ramsar Convention 1987, a wetland is defined as an area of marsh, fen, peatland, or water, either natural or artificial, permanent or temporary, with either water that is static or flowing, fresh, brackish or salt including areas of marine water where the depth at low tide does not exceed six meters.

Introduction to Beddagana Wetland Park, Sri Lanka

Beddagana Wetland Park (139, Rampart road, Ethul Kotte) is an urban wetland and part of the floodplains of the Diyawanna Lake, which is part of a larger Wildlife Sanctuary declared by the Department of Wildlife Conservation in 1985. This park has been open to the public since 2016 after renovation. It comprises a very small area in the midst of the busy city of Kotte, approximately 18 hectares. This park has added a lot of beauty to the city while helping with flood control, providing a refuge for flora and fauna, and moderating the temperature of the surrounding environment. This is a splendid sight to behold and a haven for nature lovers. It is also popular among bird and butterfly watchers.

The ancient city of Kotte located adjacent to this marsh is well documented in chronicles of Sri Lanka. So this marsh is historic since the Kotte era (1410-1547 A.D.) and at that

time the marsh had been spread over 240 hectares. However, it is unfortunate to see that today more than 50% of the marshland has been reduced due to landfills and only a very small area has been retained in its natural condition.

Special Characteristics of a Wetland

A walk around the park gives a clear image of a typical tropical wetland. The shallowness of the water body, high tropical temperature, high nutrient content and a profusion of light guarantee a large biomass and rich, diverse flora and fauna communities. Wetland vegetation is very dynamic and temporal changes in vegetation are common. They include maturation, fluctuation, and succession. Micro-succession occurs annually and macro-succession can occur owing to changes in environmental conditions.

The major primary producers of a typical wetland are algae and macrophytes. Macrophytes create a mosaic of microhabitats that can be exploited by animals. Macrophytes and their litter create much of the physical structure of a wetland. These modify the water and soil, temperature, water velocity, water chemistry, and wind velocity of the wetland. Soil that develops under anaerobic conditions (hydric soil) is unique for a wetland. In addition, the presence of unique flora and fauna adapted to water level fluctuations and the periodic absence of water is another key feature.

Wetland Flora

Wetland flora includes macrophytes and microflora. They are the primary producers and provide much of the physical structure. Due to fluctuations in water levels, wetland plants encounter a variety of water depths seasonally and annually. Even submerged plants may have to endure periods without standing water. So flora shows a great deal of phenotypic plasticity (eg: heterophylly, a change in shape of the leaves). Clonal growth of certain plants also increases the probability of survival with rapidly changing water levels.

Varieties of plants present include rooted submerged plants like Water Celery, unrooted submerged plants like bladderworts, floating-leaved plants like Water Lilies, floating plants, emergent (shrubs and trees), and moist soil species (ferns and moss). Microflora includes cyanobacteria, diatoms, and green algae, which are a good source of food for many animals.

One of the abundant plant species found in the Beddagana Wetland Park is *Annona glabra*, a rapidly spreading introduced species. In addition, salt-tolerant trees like *Cerbera manghas*, noxious shrub-like weeds such as *Lantana camara*, noxious water weeds that form dense floating mats like *Salvinia molesta*, floating-leaved plants like *Nymphaea* sp., submerged weeds like *Hydrilla* and grasses like *Panicum* sp. are found.

Wetland Fauna

A wetland is a safe home for many birds and certain aquatic and terrestrial animals. Zooplankton act as a major primary consumer. In addition, aquatic insects like dragonflies, damselflies (Odonata), true flies (Diptera), and aquatic beetles (Coleoptera) are commonly found. These have eggs, larvae, or pupae that can survive periods without standing water. During dry seasons, many survive in the form of desiccation-resistant eggs. Moreover, most invertebrates have complex life cycles with multiple life stages that may be found in different parts of the wetland.

Wetland fishes face several problems that affect their survival like low oxygen levels, very shallow standing water, and fluctuating water levels. They have adapted to avoid anoxic conditions by moving to areas with more oxygen and aquatic surface respiration. This park houses a variety of endemic fish like *Clarias brachysoma* and other fish like *Channa striata.* There are only a few species of other vertebrates as resources are deficient. They include frogs, crocodiles, and turtles. As amphibians and reptiles are poikilotherms, they do best in wetlands to sun themselves. Most wetland animals are small. They forage for food and have burrows or nests here.

Wetland birds have many anatomical and physiological adaptations for survival (eg: ducks have large webbed feet that are far back on their bodies and small wings to aid in swimming underwater). Their feet may be adapted to swim, dive, walk on mud or floating leaves, wade in the water, and grab prey. Their bills have adapted for a variety of feeding methods like peck, strain, spear, store, and grab. Wetlands birds are usually opportunistic feeders with special foraging strategies that result in the efficient partitioning of available food sources. Surface swimmers strain food with their beaks from mud or grab food in the water column (ducks). Furthermore, there are filter feeders, flight feeders, divers that spearfish, and perch divers (kingfishers). Birds include

raptors, gulls, divers(loons), grebes, waterfowls, geese, swans, waders (egrets, storks, ibises), shorebirds (sandpipers, stilts), cranes and passerines (sparrows, wrens, warblers).

The Beddagana Wetland Park is an ideal habitat for a diversity of fauna. Among them, birds like Purple swamphen, Black-winged stilt, Indian Pond-heron, Lesser Whistling-duck, and White-breasted swamphen are dominant. The top predators of this park are fishing cats (*Felis viverrina*) and crocodiles that spend time in and around the wetland. During my field visit to the park, some droppings that can be suspected to be of a Fishing cat were observed. It is also a paradise for butterflies including Common Jezebel, Lemon Emigrant, and Crimson Rose.

Functions of a Wetland

The major function is the primary production of algae and plants. In addition, litter decomposition that involves leaching and microbial mineralization processes by fungi and bacteria aids in efficient nutrient cycling. Water quality and quantity regulation, groundwater recharge, absorption and retention of pollutants and sediments, water storage, wildlife production, recreation, and flood reduction are some other key functions of a wetland.

Urban wetlands like the Beddagana Wetland Park play a major role in flood reduction by acting as a basin for excess water. Urban cities like Colombo are prone to severe seasonal flooding due to reduced water infiltration into the soil. This can be minimized by creating flood retention areas simply by restoring the filled marshlands within the city suburbs with good planning and maintaining them well along with frequent monitoring.

Protection and Conservation

Wetlands are important in global carbon cycling as they sequester large amounts of carbon. Although wetlands are recognized to be important, they are still highly unprotected and continue to disappear around the world. Reasons can be uncontrolled landfilling, eutrophication due to high nutrient input, pollution, invasive species, and developing wetlands to crop fields. Many wetland ecosystems are indiscriminately exploited for commercial, agricultural, residential, and industrial development. Some are used as dumping grounds for waste. Wetlands in Sri Lanka are also affected by the same factors

The application of science to maintain the structure, processes, functions, and interactions among organisms and their environment is very important. The future of wetlands will depend on how we manage future economic growth and our emphasis on the conservation and protection of these unique ecosystems.

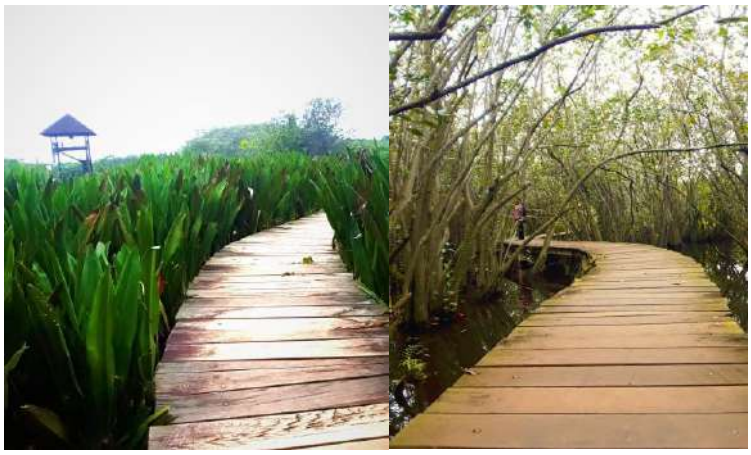

Figure 1: Wooden walkway at the park

Figure2: Purple Swamphen spotted at the park

Figure 3: Water lilies spotted at the park

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Species composition, diversity and abundance of mangroves in Kosgoda lake, Southwestern Sri Lanka

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Abstract

Small mangrove ecosystems in Sri Lanka have not been properly studied and neglected by the mangrove ecologists. Hence, their species composition and diversity are poorly known. The Kosgoda Lake has such a small mangrove that has been neglected. Main objective of this study is to find the present status and the diversity of mangrove in the Kosgoda Lake. The transect and quadrat methods were used in this study to enumerate the species. Transect were randomly placed perpendicular to the show line and sub-divided into 5m × 5m quadrates for convenient of sampling. All the true mangrove species and their abundance were recorded within the plots. Mangrove associates were also noted down. Eight true mangrove species and nine mangrove associates have been recorded from the area. True mangroves *viz*., *Rhizophora apiculata* (55.72%), *Excoecaria agallocha* (16.83%), *Aegiceras corniculatum* (11.27%), *Bruguiera gymnorhiza* (8.24%), *Bruguiera sexangula* (4.71%), *Lumnitzera racemosa* (2.18%), *Sonneratia caseoloris* (0.67%), and *Nypa fruticans* (0.33%). Shannon diversity (*H*') was computed as 1.35. Importantly a healthy population of *Aegiceras corniculatum* was recorded from this small mangrove ecosystem which is a rare species in wet zone mangrove ecosystem. The barriers to the tidal activities such as main road and the sand reef between the beach and the river make

some detrimental impacts to this ecosystem. Proper legal intervention is recommended to protect this mangrove ecosystem as several anthropogenic threats were detected.

Key worlds: composition, diversity, mangrove, Kosgoda Lake, Southwestern

Introduction

Sri Lanka consists of 15,668 ha of mangrove areas that cover approximately 0.1% of total land mass of the country (Prasanna and Ranawana, 2019). Given the low tidal amplitude, mangroves in Sri Lanka are restricted to narrow belts bordering coastal lagoons, estuaries, and sheltered bays (Bambaradeniya *et al*., 2002; Karunathilake, 2003; Ranawana, 2017). Twenty-one species of true mangroves have been documented from Sri Lanka (Jayatissa, 2002; Jayatissa, 2013; Ranwana, 2017). Mangroves have remarkable adaptations to grow in the extreme intertidal environment and play ecological functions and services where they occur (Reef and Lovelock, 2015; Wen *et al*., 2016; Das *et al*., 2019). Some mangrove vegetation has functioned as a bio-shelter during the 2004 tsunami event some areas in Sri Lanka (Dahdouh-Guebas *et al*., 2005). Although Sri Lanka has a small number of mangrove sites, most of their species' diversity has not been properly studied. Especially small mangrove stands in Sri Lanka have been neglected by the mangrove ecologists in the country. The mangrove in Kosgoda Lake is one such stand located in southwestern Sri Lanka. Jayatissa *et al*. (2002) has recorded one true mangrove species in their study namely *Aegiceras corniculatum* from the Kosgoda Lake. The present study focuses on enumerating the diversity and abundance of mangroves in the Kosgoda River.

Methods

The study area is located in the Galle District in the Southern Province (6°20'44"N and 80°1'20"E). Most of the mangrove stands in this lake have been cleared and converted to other land use types and only small, fragmented mangrove stands are left (Figure 1). Transects were laid perpendicular to the shoreline in randomly selected points (Perera

et al., 2013; Prasanna *et al*., 2019). The transect length was determined by the width of the mangrove stands. Transects were sub-divided into 5m × 5m quadrates to count all the mangroves occurring within the plots. Species and the number of individuals of trees of each species within each plot were recorded. The girth at breast height (GBH) of each tree was measured in centimeters using a standard measuring tape and approximate tree height was also measured in meters using standard methods (Cintron and Novelli, 1984; Ramachandra *et al*., 2012). Plants having < 2.5 cm GBH were excluded (Perera *et al*., 2013). When a tree had more than one trunk, the GBH of the larger trunk was measured as the GBH of the plant (Perera *et al*., 2019). When a tree was at an angle to the ground, 1.3 m GBH was measured along the trunk from the ground (Kathiresan and Khan, 2010). Geo-coordinates were obtained using the Garmin eTrex Venture HC handheld GPS Receiver in existing mangrove stands. The relative abundance of all the true mangrove species and the overall Shannon diversity (*H*') were calculated. Minitab version 19 and Microsoft Excel version 2016 were used to analyze and make graphical representations. The Arc GIS version 10.3 was used to make a map of the existing mangrove distribution in the Kosgoda Lake.

Results

A total of 594 individual trees were enumerated during the study. Eight true mangrove species belonging to six families in seven genera were recorded from the area. True mangroves recorded include *Rhizophora apiculata* (55.72%), *Excoecaria agallocha* (16.83%), *Aegiceras corniculatum* (11.27%), *Bruguiera gymnorhiza* (8.24%), *Bruguiera sexangula* (4.71%), *Lumnitzera racemosa* (2.18%), *Sonneratia caseoloris* (0.67%), and *Nypa fruticans* (0.33%) (Figure 1). Mangrove associates include *Hibiscus tiliaceus*, *Acanthus ilicifolius*, *Premna integrifolia*, *Clerodendrum inerme*, *Dolichandrone spathacea*, *Pandanus kaida*, *Cerbera manghas*, *Acrostichum aureum*, and *Annona glabra*. The overall Shannon diversity (*H*') for the mangrove stand was calculated at 1.35. More than 60% of mangroves are between the girth class of 1-10 cm while more than 60% of them are between the height class of 6-10 m (Figure 3-4). Most of the mangroves have been cleared in this small ecosystem and only a few isolated stands are remaining and they are also facing major threats. The lake has been divided into two parts by the Colombo-Gall main road while garbage dumping and pollution of the lake also serve as key factors for the decline of mangroves associated with

the lake. Moreover, the tidal impact in the site is minimum due to the man-made sand barrier between the lake and the sea.

Discussion

Despite small mangrove extent (~18.19 ha) in Kosgoda Lake, it supports a considerable species richness (eight species) and high diversity (*H*'=1.35). The most abundant species was *Rhizophora apiculata* while the least abundance was shown by *Sonneratia caseoloris* and *Nypa fruticans*. *Excoecaria agallocha* was the second most abundant species recorded in the site. The most common mangrove associates were *Hibiscus tiliaceus*, *Acanthus ilicifolius*, *Premna integrifolia*, and *Clerodendrum inerme*. According to the girth class and height class distribution, this mangrove ecosystem can be identified as a one in a primary successional stage as more than 60% individuals recorded were between 1-10 cm girth and 6-10 m height classes. The mangrove sites have been occupied by a dense human population and presently facing enormous human threats. Approximately 80% of mangrove areas have been already cleared for human settlements and hotel constructions. Only the mangrove stands that are unsuitable for the human settlements are remaining. The isolated stand close to the beach represents seven true mangrove species and remains as an original stage up to some level. Mangrove species *Aegiceras corniculatum* has not been recorded from the mangrove ecosystems that are found in the Madu Ganga and Bentota estuaries (Prasanna, 2008). This species is rare in the wet zone mangrove ecosystem (pers. comm. M. G. M. Prasanna).

A healthy population of *Aegiceras corniculatum* was recorded from this ecosystem. The barriers to the tidal activities such as the road and the sand reef from the beach and under these prevailing human pressures long term survival of this mangrove patch is questionable. The remaining mangrove patch close to the beach acts as a natural barrier for erosions and tsunami. These fragmented small populations tend to deplete completely over the time. At present, no conservation attempt has been taken to protect this mangrove ecosystem. Hence, proper legal actions should be implemented to protect these remaining mangrove stands in Kosgoda Lake.

Figure 1: Study area showing existing mangrove stands in Kosgoda Lake.

Conclusion

The Kosgoda Lake supports considerable mangrove diversity and richness. Eight true mangrove species and nine mangrove associates have been recorded from this small ecosystem. *Rhizophora apiculata* is dominated in this ecosystem. This mangrove ecosystem represents a primary successional stage of mangrove forests. However, presently, it is facing various threats that affect badly for them. Proper legal actions must be implemented to protect these remaining mangrove patches. Proper mangrove replanting programs together with ecological studies are recommended.

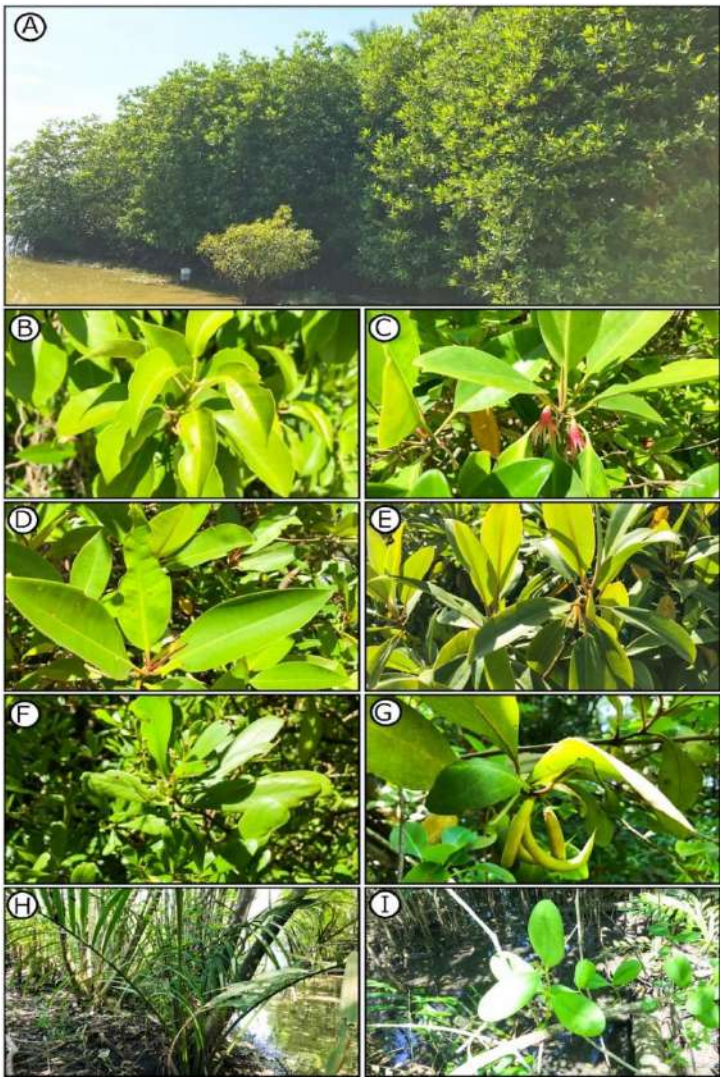

Figure 2: The mangrove vegetation in the Kosgoda Lake (A, existing mangrove stands; B, *Excoecaria agallocha*; C, *Bruguiera gymnorhiza*; D, *Rhizophora apiculata*; E, *Bruguierasexangula*; F, *Lumnitzera racemosa*; G, *Aegiceras corniculatum*; H, *Nypa fruticans*; I, *Sonneratia caseoloris*).

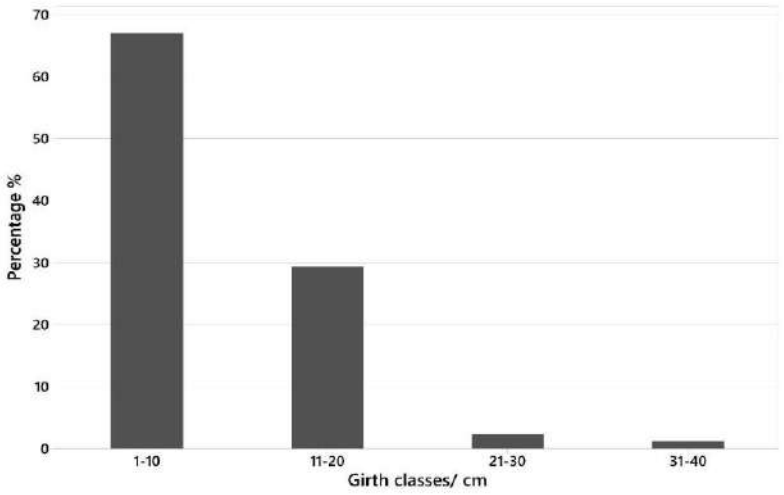

Figure 3: Girth class distribution of true mangrove species in the Kosgoda Lake.

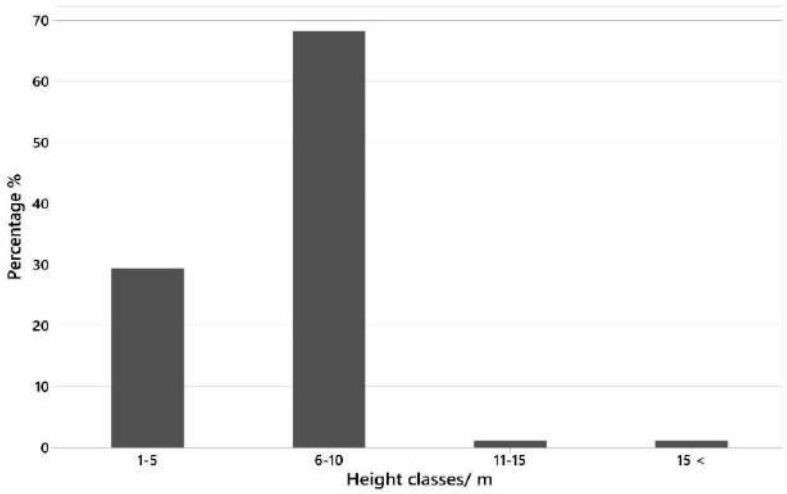

Figure 4: Height class distribution of true mangrove species in the Kosgoda

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Mating behaviour of *Cophotis Ceylanica* (Peters, 1861) (Reptilia: Agamidae), Sri Lanka

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At present 22 species of agamid lizards are found in Sri Lanka of which 20 (90.9 %) are endemic belonging to 4 endemic genera (*Ceratophora, Cophotis, Lyriocephalus and Otocryptis*) (Karunarathna *et al.,* 2020). The *Cophotis* genus is represented by 2 species, *C. ceylanica* Peters, 1861 and *C. dumbara* (Samarawickrama *et al.,* 2006). The former is known to be found in the Centrals highlands of Sri Lanka at 1,500-2,200m above sea level while the latter is restricted to Knuckles Mountain range above 1,200m (De Silva *et al.,* 2005; Manamendra-Arachchi *et al*., 2006; Samarawickrama *et al.,* 2006;). The *Cophotis* genus is one of only two known ovoviviparous agamid lizards in the world, the second being the *Phyrynocephalus* genus which is not found in Sri Lanka (Willey, 1906; Tyron, 1977; Goonewardene *et al.,* 2006). Information on natural history and *in-situ* reproductive behaviors of threatened species are important for *ex-situ* conservation measures. Agamid lizards are important part of reptile diversity and a significant number are threatened by habitat loss and illegal wildlife trade (Janssen & De Silva, 2019; Soysa *et al.,* 2021). Both *C. ceylanica* and *C. dumbara* are highly sort out in the global illegal pet trade due to their small size and are listed as nationally Endangered and Critically Endangered respectively (MOE, 2012).

C. ceylanica is a diurnal, arboreal, slow moving agamid species found on the moss covered tree trunks and branches usually 1-2 m above the ground, but sometimes found in the forest canopy up to 9 m above ground level. It has a prehensile tail which is suited

for its arboreal lifestyle. They are commonly found in montane forests and anthropogenic habitats like home gardens and tea plantations (Somaweera & Somaweera, 2009; De Silva & Ukuwela, 2020). The ovoviviparous nature of reproduction of *C. ceylanica* has been known for over a century (Willey, 1906) and has been studied in captivity at the Fort Worth Zoological Park, Texas, USA by Tyron (1977) and at the Integrated Rural Development Project (IRDP) in Nuwara Eliya by Palihawardana (1998) with mating behavior observed in captivity only by Palihawardana (1998). Copulatory behavior of *C. dumbara* has also been recorded in natural conditions (Soysa *et al.,* 2021). However, no records of mating behavior of *C. ceylanica* in the wild was found in literature. Here we report for the first time the mating behavior of *C. ceylanica* in natural conditions with photographic evidence.

The observations were made by the first author at around 1.00 pm on 26 July 2019 in the garden of the Jetwing St Andrews Hotel, Nuwara Eliya (6°58'46.7"N 80°45'50.1"E). This hotel is located at 1,825 m above sea level at the foot of the South face of the Piduruthalagala mountain range. The garden of the hotel comprises of a variety of endemic and native plants as well as some ornamental non-flowering and flowering plants including several plants of the *Callistemon viminalis* (Weeping bottlebrush) species. This plant genus is endemic to Australia but introduced to Sri Lanka as an ornamental plant. All 3 endemic agamids (*C. ceylania*, *Ceratophora stoddartii* and *Calotes nigrilabris*) found in the central hills has been observed on this plant. The flowers are bright red and fragrant and attracts bees and all 3 lizard species have been observed feeding on these bees.

While the first author was supervising routine gardening conducted by the garden staff of the hotel, he observed a pygmy lizard (male) on a branch of a bottlebrush plant 3 feet above ground. On closer observation a second pygmy lizard (female) was seen on the main trunk of the plant 1.5 feet above the ground. Both male and female were similar in size and colorations. The male was observed coming close to the female and displaying rhythmic head bobbing and showing its dewlap to the female while whipping his tail from side to side and then moved backwards. Momentarily the male then again displayed the same behavior. We quickly realized that this was a mating behavior and subsequent observations were made from a distance of about 3-5 meters to avoid disturbing them. Usually, this species

is slow moving. However, during this courtship we observed the male to be fast moving. The male showed this courtship behavior several times to get the attention of the female. The male then quickly ran towards the female and climbed on its back into a mounting position while he bit and held onto the back of her neck. The female remained almost motionless during this entire process. Subsequently the male copulated the female and both remained in copulation position (Fig 1) for about 2 minutes before separating and moving away from each other. During copulation the male subdued the female on the branch and they appeared well camouflaged on the trunk of the tree. Similar mating behavior of *C. dumbara* was observed by Soysa *et al.* (2021) in the wild. It was unclear how many times this pair had mated in this session. We observed only one copulation. After they separated the female climbed down from the tree and left while the male remained on the branch of the tree, at which point observations were terminated. Photographs were taken using Oppo A37 as a DSLR camera was not at hand. Field guide books by Somaweera and Somaweera (2009) and De Silva and Ukuwela (2020) was used to identify the lizard species.

In captivity the breeding of *C. ceylanica* has been reported to take place between March and July with mating observed in June and July (Palihawardana, 1998; Somaweera and Somaweera, 2009). Our observation concurs with this as our current observation was in July. Even though ovoviviparous behavior of *C. ceylanica* have been studied in captivity (Willey, 1906; Tyron, 1977; Palihawardana, 1998), it has not been observed in the wild previously or in this study. Furthermore, Ovoviviparous behavior of *C. dumbara* has not been observed in the wild or captivity. Very little is known about the natural history and ecology of these 2 species (Soysa *et al.*, 2021), hence a knowledge gap exists. Future studies will be beneficial to get a better understanding of the reproduction of these two species in order to develop conservation measures.

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Figure 1: Copulation of *Cophotis ceylani*

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Inappropriate disposal of pharmaceuticals: A silent killer

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Abstract

Many medicines that are purchased or received from healthcare institutions for different health conditions remain among general public as unused or expired medicines. Majority of the medicine users are unaware about the proper disposal of unused or expired medicines. Inappropriate disposal of pharmaceuticals could adversely affect living organisms and the environment. In addition to disposal, medicines can also enter the environment through many ways including large scale application of medicines on animals in farms, release of untreated wastewater and other industrial wastes containing pharmaceutical compounds into the environment and using animal dung containing these harmful compounds as fertilizers or manure. This article provides an overview of environmental, ecological and health impacts associated with improper disposal of pharmaceuticals. Existence of pharmaceutically active compounds like antibiotics, statins, anticancer medications and other potent medicines in soil, surface and underground water can affect humans as well as animals leading to problems associated with their growth, fertility and behaviour due to long-term or even low-level exposure to these compounds. However, the depth of the silent killer effect of pharmaceutical pollution due to improper disposal has not yet been addressed adequately Therefore, it is essential to take necessary measures to minimize the inappropriate discharge of pharmaceuticals into the environment by the general public and healthcare professionals.

Keywords: Pharmaceutical disposal, Pharmaceutical pollution, Health hazard

Introduction

Medicines play an important role in the treatment and prevention of various disease conditions in humans as well as animals. Pharmaceutical products including medicine and other healthcare products have been released to the environment through the extensive usage by humans for their use as well as for veterinary use. Therefore, introduction and accumulation of pharmaceutically active compounds in the environment have become a growing environmental problem, commonly addressed as "pharmaceutical pollution". According to studies, a large number of pharmaceutical products are discarded as unused or expired medicines due to a number of reasons. In many developing countries, people (or patients) dispose unused pharmaceutical products into the environment inappropriately without considering their adverse effects, even though the majority of them have a general idea about detrimental effects on human health and environment (Bashaar *et al*.,2017; Marwa *et al*., 2021).

Improper disposal of pharmaceutical waste may lead to accumulation of various biologically active compounds or toxic compounds in the environment causing unintended effects on humans, animals and microorganisms which lead to health issues associated with frequent or long term exposure to these compounds (Boxall, 2004; Insani *et al.*,2020). In addition, various veterinary pharmaceutical products that are used in the treatment of animals may also be released to the environment, and they also have a tendency to create health issues. The purpose of this article is to provide an overview of this environmental issue and to draw the public attention to health impacts related to disposal of pharmaceutical products in order to have a better, healthier human and animal populations in the future.

Sources of pharmaceutical compounds in the environment

Pharmaceutical products are used by patients to treat various diseases under medical supervision or even as self-medication to treat mild ailments. With the current increase in the incidence and prevalence of disease conditions, healthcare practitioners prescribe and dispense various medicines. These medicines are not completely consumed by patients due to various reasons including, adverse effects related to

medicines, recovery from the illness, changes in the dosage, changes in the treatment plan (substitutions), expiration of medicines, prescribing patterns and practices of physicians and dispensers, promotional practices of drug companies, quality failure of products with time and inappropriate storage and lack of patient adherence (Bashaar *et al.*,2017; Marwa *et al*., 2021). Possession of these unused medicines or expired medicines in household cabinets and cupboards may cause harmful effects on humans. These unused and expired pharmaceutical products may be misused upon storing by elderly patients, children and psychiatric patients, causing accidental poisonings and serious adverse effects (Insani *et al.*,2020). The medicines used by humans also have a possibility of entering the environment in mild quantities through improperly treated sewage and waste from household and especially from hospital premises. In addition to the disposal of unused and expired medicines, veterinary pharmaceuticals are also added to the environment unintentionally. Pharmaceuticals administered to animals undergo absorption, distribution, metabolism and finally excretion (pharmacokinetics). These excreted medicines are passed to the environment via urine or dung and thereby they might mix-up with surface water or soil. Antibacterial products that are used in aquaculture (for treatment of shrimp and fish) are also released into the environment, resulting in accumulation of antibacterial agents in the water bodies. Some veterinary pharmaceuticals have a tendency to enter ecosystems indirectly through organic fertilizers such as slurry and manure that are used in agricultural fields (Boxall, 2004).

Disposal methods of unused and expired pharmaceuticals

Research has shown that generally the community has poor knowledge about appropriate pharmaceutical disposal practices, hence inappropriate disposal of harmful medicines to the environment can be observed commonly in certain regions of the world (Insani *et al.*,2020). The main medication disposal methods employed in households include throwing of pharmaceuticals into domestic trash, flushing medications down the toilet, and burning medications (Insani *et al.*,2020). In some instances, the exchange of unused medicines among friends or relatives with similar symptoms and

returning of expired medications to a pharmacy or relevant medical office could also be observed.

When the medication disposal methods followed by the public are considered, the majority have discarded unused and expired medicines with household trash which has a higher risk of animal consumption and exposure to the environment (soil and surface water). Flushing medications down the toilet was previously considered to be the proper method. However, this can cause the contamination of underground water with harmful pharmaceutical compounds. Burning unused or expired pharmaceuticals is not the appropriate method of disposal because incomplete combustion of pharmaceutical compounds may release various toxic gases and poisonous chemical residues which may cause harmful effects in humans and animals.

Pharmaceutical contaminants

According to a number of research studies conducted in different regions of the world, it has been found that medicines belonging to classes of antibiotics, antacids, painkillers (analgesics), antianginal, antihypertensive, antidiabetic, beta blockers, oral contraceptives, and ectoparasiticides are present in varying amounts in surface water samples. Examples for antibiotics detected in surface water samples include sulfamethoxazole, lincomycin, chlortetracycline, trimethoprim and chloramphenicol. Commonly identified antacids include cimetidine and ranitidine. When pharmaceutical products enter the environment, they may be transported or distributed to soil, underground water, surface water, air or sediments (Boxall, 2004). These pharmaceutical contaminants may also undergo degradation by biological organisms present in the environment (in water bodies, soil etc.) and by abiotic reactions (Boxall, 2004). The products resulted from degradation may have lesser activity (potency) while some products may have the same potency as the parent compound. The degradation of pharmaceutical products is significantly influenced by their chemistry, biology and environmental conditions (Boxall, 2004).

Impacts of Pharmaceutical Contaminants

When pharmaceutical compounds are present in low concentrations than that of therapeutic doses, they are unable to elicit a therapeutic effect. However, they can elicit subtle effects affecting growth, fertility or behaviour even in minute concentrations of active substances. As a result, researchers have started to study subtle effects on long term and low-level exposure to active pharmaceutical compounds. According to the studies conducted so far, it has shown that accumulation of antibiotics in water bodies has led to the development of antibiotic resistance and has affected the virulence of microorganisms. Moreover, Ethinyl estradiol which is an active pharmaceutical ingredient in oral contraceptive pills has shown to disrupt endocrine function in cockroach populations (Insani *et al.*,2020). Some of the other subtle effects of pharmaceutically active compounds that have been reported include effects on maturation of oocytes and testes, impact on physiology and behaviour of insects, effects on decomposition of dung and alteration of growth pattern of aquatic plants and algae (Boxall, 2004). Furthermore, some compounds like macrocyclic lactones cause some responses like reduced feeding, disruption of water balances, inhibition of pupation, decrease of growth rate and disruption of mating of insects (Boxall, 2004). In addition to the above subtle effects, presence of pharmaceutical compounds in soil, surface water bodies and others may lead to the accumulation of pharmaceutically active compounds in living organisms through food chains (Bashaar *et al.*,2017).

Proper Disposal methods of Pharmaceuticals

According to the studies, it has been shown that most of the people in the society are unaware about proper pharmaceutical disposal practices of unused or expired medicines. The lack of adequate knowledge on proper pharmaceutical disposal practices among household members can also be seen even in developed countries due to inadequate information passing from relevant authorities and healthcare service providers (Marwa *et al.*, 2021). Although majority of people have a poor knowledge on pharmaceutical disposal practices, they are aware of consequences

associated with inappropriate pharmaceutical disposal. This is encouraging since this indicates consumers will adhere to proper pharmaceutical disposal practice if the correct disposal methods are informed to them (Bashaar *et al.*,2017; Marwa *et al*., 2021). Appropriate disposal of pharmaceutical products is very important to prevent accidental drug poisoning to children, elderly and other patients like psychiatric patients and also to prevent possible hazards to animals due to the consumption of disposed of medicines.

However, thus far there are no clear guidelines practiced for the disposal of unused or expired medicines (Bashaar *et al.*,2017). Therefore, a medication take-back method can be introduced to ensure the proper disposal of pharmaceutical products by knowledgeable pharmacists or other related healthcare practitioners (Bashaar *et al*.,2017; Insani *et al.*,2020; Marwa *et al*., 2021). In the medication take-back method, the unwanted or expired medicines possessed by the public are collected into separate containers kept at pharmacies and hospitals and then those collected pharmaceutical products are subjected to proper disposal by following standard guidelines. For example, "Return Unwanted Medicines" campaign conducted in Australia has successfully disposed 700 tons of unwanted medicines in 2015-2016 preventing inappropriate pharmaceutical disposal to the environment (Insani *et al.*,2020). When implementing medication take-back method, almost all healthcare service providers and relevant authorities should support. Majority of the population has a positive attitude on take-back (Kotchen *et al*., 2009). Strategies like paying some amount of money for unwanted drugs per prescription can also be practised to promote medicine take-back method (Kotchen *et al*., 2009). However, implementation of medication take-back method may be difficult in developing countries due to the limitation of infrastructural facilities, and costs associated with disposal methods (Marwa *et al*., 2021).

In some countries, unwanted and expired pharmaceuticals are crushed or dissolved in water and then they are mixed with undesirable substances or packed with undesirable substances and then discarded in the trash to prevent consumption by other animals or humans. The best and safest method of disposing

pharmaceuticals is incineration (Bashaar *et al.*, 2017). In incineration, pharmaceutical wastes are burnt completely at a high temperature, to oxidize active compounds rapidly. In addition to above mentioned proper pharmaceutical disposal methods, the impact of inappropriate disposal of pharmaceuticals can be minimized by making the public aware about the health consequences for humans, animals and environment, and also by treating wastewater and municipal sewage appropriately using equipment to degrade medicinal substances (Kotchen *et al*., 2009). Apart from that, pharmaceutical compounds can be removed from contaminated water by applying physical processes such as volatilization (sorption), biological degradation or chemical reactions (Boxall, 2004).

Conclusion

The presence of pharmaceutically active compounds in the environment especially in soil, surface and underground water is an emerging environmental problem which can be observed in many regions of the world. These pharmaceutical compounds enter the environment through inappropriate disposal of unused and expired medicines, disposal of improperly treated waste water and sewage containing pharmaceutical compounds. Presence of pharmaceutical compounds in the environment can cause detrimental health issues among living organisms. It can be observed that inappropriate disposal of pharmaceuticals is common among people due to lack of knowledge on appropriate pharmaceutical disposal practices. Therefore, these findings highlight the necessity of strategies to leverage knowledge on disposal and management of unwanted pharmaceuticals by healthcare professionals and ordinary people and a proper pharmaceutical disposal plan to be practiced to minimize health-related and other impacts of inappropriate disposal of pharmaceuticals.

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Microplastic contamination of commercial food-grade salt and raw salt in Sri Lanka

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We Sri Lankans unintentionally eat approximately 158 Micro plastics (MPs) per year via sea salt only. This is a distressing finding as salt is an essential part of the human diet. MPs are small plastic particles less than 5 mm in size and it is a ubiquitous pollutant which originates inland and mostly ends up in the ocean. They can be divided into two categories based on their origin as primary MPs and secondary MPs. Primary MPs are purposefully manufactured MPs for applications such as personal care products, and secondary MPs are formed by breaking up plastic items into small particles by ultraviolet light and mechanical wave forces. These MPs can be further classified based on their physical form as fibres, sheets, fragments and spherules; fibres mainly originate from synthetic material like polyester and nylon, fragments and sheets are small plastic pieces and sheets broken off from larger pieces of plastic that continue to break down over time. Spherules are micro-sized spherical primary MPs. Sea products such as seafood, algae and most of the commercial salts across the globe are contaminated with MPs. Sea salts are typically produced in salterns by crystallisation of seawater after evaporation. Therefore, sea salt contained the highest

amount of MPs compared to lake and rock salt due to the massive contamination and accumulation of MPs in the ocean.

We have analysed the MP contamination levels in raw salt directly obtained from three salterns in Sri Lanka and in commercial salt brands available in the Sri Lankan market. For the extraction of MPs from salt, first, we dissolved the sample in pre-filtered water, and the suspension was filtered through a 65 µm mesh. The solids collected on the mesh were subjected to wet peroxide oxidation to remove organic material present in the sample. Afterwards, density separation was performed using NaCl, and MPs were extracted onto a membrane filter (0.45 µm) and enumerated under a stereomicroscope. Fourier transform infrared (FTIR) spectroscopy was used to identify the polymer types of the detected MPs. We have analysed 24 salt samples including 19 commercial salt brands, one rock salt brand, one lab-grade NaCl brand and three non-purified raw salt samples. Of the commercial salt brands, 11 were table salts and eight were crystal sea salts. All salt samples were contaminated with MPs. The highest amount of MPs was recorded in raw salt followed by food-grade table and crystal salts. Raw salt from Hambantota had a significantly higher concentration of MPs (3345.7 items/kg) when compared with raw salt from Puttalam (272.3 items/kg) and Elephant Pass (36.3 items/kg). The difference in the MPs levels in the three salterns could be due to anthropogenic activities and ocean currents. In commercial salt samples, the average MPs content ranged from 17.0 – 122.5 items/kg in sea salt, 64 items/kg in rock salt and 253 items/kg in lab-grade NaCl. Raw salt contained a higher amount of MPs compared to food-grade salt manufactured at the same saltern. During the production of raw salt from seawater, the seawater is not filtered to remove debris other than manually removing the visible particles and washing with a saturated salt solution.

The population density of the surrounding area has a positive correlation with the plastic pollution of the environment. Hambantota saltern is located on the southern coast of Sri Lanka, a popular tourist destination and a highly populated as well built-up area. Moreover, extensive fishing in the area and the harbour contribute considerably to MP pollution. In all types of salts, there were differences in the quantities of the various physical forms of MPs with the highest amount being fibres followed by fragments, sheets and the least being in the form of spherules. MPs also showed a variation by colour, and transparent fibres and sheets were

predominant. About 40% of fragments in commercial salts were blue, while 48% of fragments in raw salts were white. Spherules were either transparent or white. Other colours seen in MPs were red, black, brown, green and orange colours. In general, the sizes of the MPs ranged from 65 to 2500 μm in all salt samples. According to the FTIR analysis, all the tested particles were confirmed as MPs. Out of the 23 types of polymers identified, LDPE, resin dispersion and HDPE were the most numerous in commercial salt brands. Moreover, according to the WHO, the average salt intake per person should be 5 g per day. However, Sri Lankan community salt consumes a higher amount of 8.3 g per day, mostly as sea salt. Consumption of 5 g per day contains 95 MPs per year (WHO data) and 8.3 g per day contains about 158 MPs/year. Recently researchers stated that, if MPs get ingested, they may accumulate or become embedded in the gastrointestinal tract as they are resistant to chemical degradation and mechanical clearance. Due to the hydrophobic properties of MPs, they may absorb and concentrate hydrophobic organic contaminants such as polycyclic aromatic hydrocarbons. Also, MPs have the ability to accumulate heavy metals. Therefore, MPs may act as vectors for these hazardous compounds to enter the human body. Therefore, the awareness of MP contamination of food products is vital. Since MP is an anthropogenic contaminant, reduction, reuse and recycling of plastics can reduce the MP contamination risk of food. Further studies are needed to develop methods to remove MPs, monitor MPs in food products, and assess the health impact on MPs.

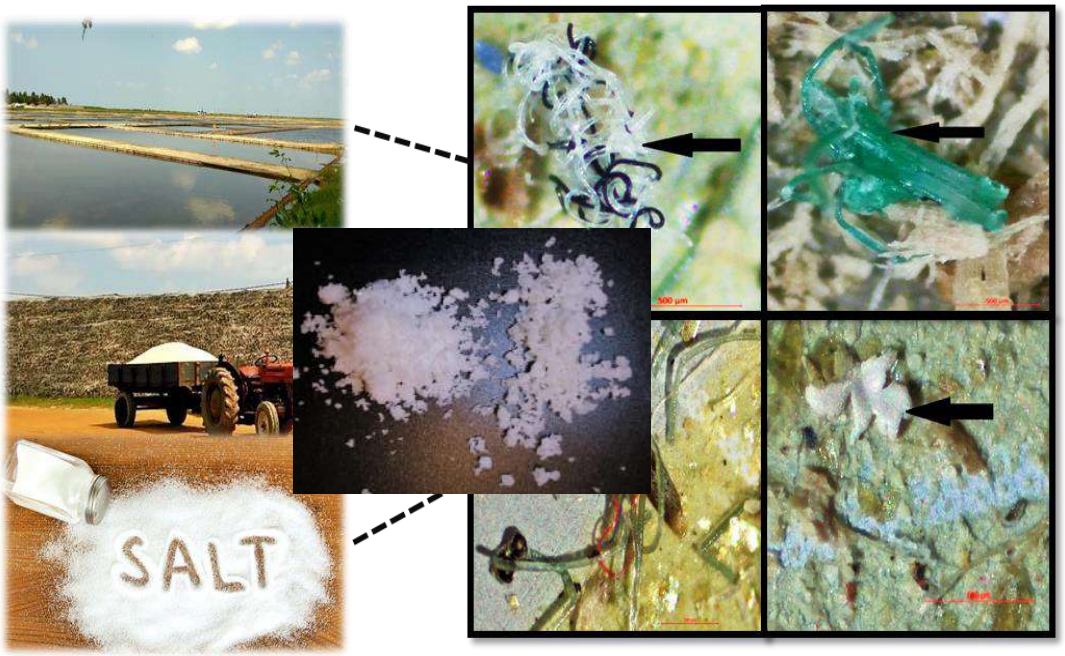

Figure 1: Micro plastics extracted from commercial and raw salt from Sri Lanka

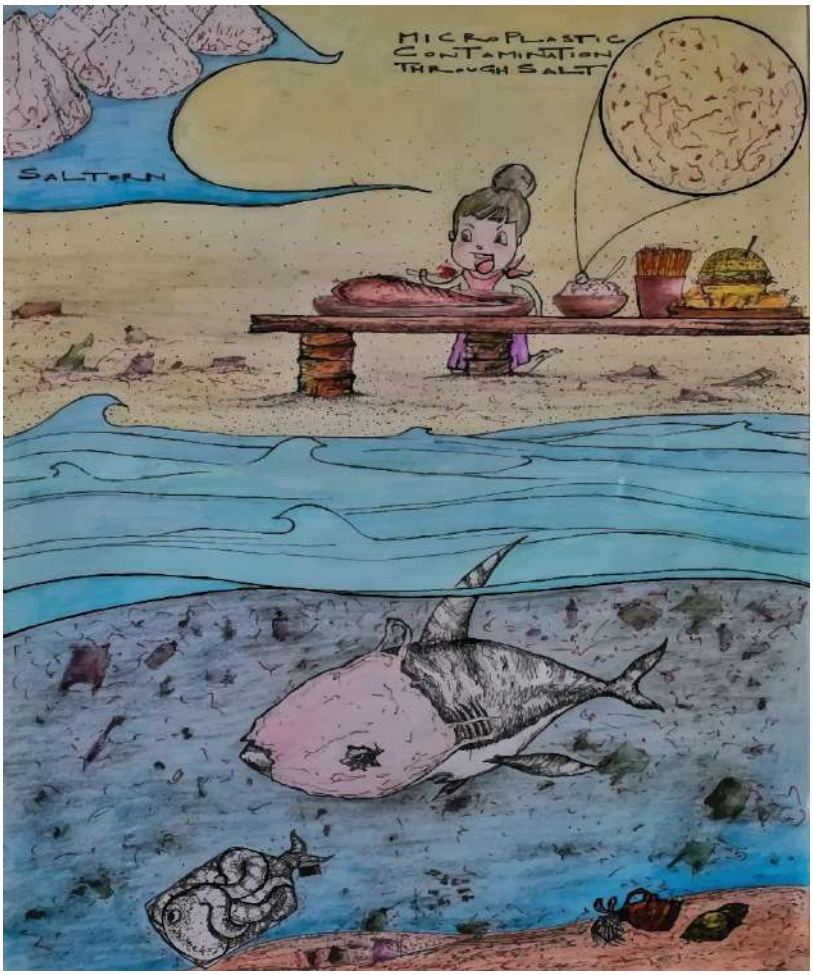

Figure 2: Illustration of micro plastic contamination of commercial food-grade salt and raw salt in Sri Lanka by G.K. Kapukotuwa

Common Mime (*Papilio clytia)* laying eggs

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Common mime is a swallowtail butterfly which is an excellent example of mimicry. Both sexes occur in two forms. Form **Dissimilis** mimics the patterns and the colours of the blue tigers (*Tirumala sp.*) while the form **Clytia** mimics the crows (*Euploea sp.*) as the one in this picture. The ones they mimic are from the Nymphalidae family and have moderately fast flying patterns. The mimes also show such flight but when alarmed, fly much faster as other Papilionidae butterflies do. The one in the capture was laying eggs on one of its host plants, the මෙන්ති (*Litsea glutinosa*). In the second image, you can see a close up of an egg laid. Their pupa is also known to be quite interesting as it mimics a dried twig.

Details from "Common butterflies of Sri Lanka" by Himesh Dilruwan Jayasinghe, page 42.

Figure 1: Common Mime butterfly laying eggs (Observed at the home Garden-Kandy on 16/04/2022, at 4.30 pm)

Figure 2: Common mime egg

Pheromone signalling of insects

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Insects communicate by producing chemical signals. Pheromone is one example. Usually, that is produced by females to attract males. The type of pheromone is specific from species to species to ensure the attraction of males who are only matching and suitable. But, the attraction of males is not the only function of pheromones. It has some other functions like:

- aggregating to take advantage of food resources,
- protecting sites of oviposition,
- escaping predation.

Pheromones may convey different signals when they are presented in combinations or different concentrations. Pheromones differ from sound and sight signals in several ways.

- Pheromones travel slowly.
- Do not fade quickly.
- Effective over a long-range.
- Direction is not limited to straight lines.

The males of giant silkworm family moths can identify the presence of females up to 30 miles. Also, male cecropia moths are estimated to detect and respond to a few hundred molecules of pheromone in a cubic centimetre of air. There is another interesting feature of **sex pheromones of mealworm beetles when attracting males to females**. The first male to mate with the female then covers the signal with another pheromone that prevents the female from mating with other males.

Now let's see the **role of pheromones in honey bee hives**. The queen secretes a glandular substance (pheromone). It passes among workers of the beehive so that it coordinates all the activities of workers.

There is another interesting feature about **pheromones which are used by parasitic wasps**. They find their hosts, scale insects through pheromones. Then these parasitic

wasps lay eggs on the bodies of the scale insects and the wasp larvae that emerge feed on the host insect.

Female sex pheromones work to ensure the existence of a species. But it can be sometimes detrimental to male insects. For example, the Bolas spiders manufacture and release pheromones which are similar to the female pheromones of certain night-flying moths. The male moths are attracted to the signal unaware that they are going to be dinner for the spiders. Pheromones are also used by humans to produce pheromone traps in integrated pest management strategies. These traps are developed along three ways, to monitoring the insect population, control of insect populations by mass trapping and/or by causing mating disruptions.

Please, just let me breathe…

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Oh! Where am I?
What is this place?
Do I belong here?
I just can't see anything…

I heard birds sing
But where have they gone?
I can't hear anything
Just the ear-breaking noise…

I saw beautiful flowers and butterflies
Flying here and there, from flower to flower
Where are they now?
I only see the darkness around me…

Where are the blue skies and cotton clouds above me?
Have they left me without a single word or note?
Or have I been kidnapped?
By some dark soul...?

Where am I?
Oh, Mom! Oh, Dad?
Help me! Save me!
I can no longer breath…

Green forests are burnt into ashes…
Beautiful creatures are turned into skeletons…
Wavy blue oceans are all dried out into cracked grounds…
Sweet smelling breeze is no longer smelling sweet…

Have I lost my world?
There's nothing I can recognize…
Have I entered into a different world?
Is this an alien world?

Oh! My dear people…
It's our mother earth!
What have you done?
Please let me breathe just once!

Going green or growing grey?

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Fiery flames engulfed the greenery and billowing smoke ascended to the heavens, signalling destruction. As the Amazon stood in embers, people could only gaze in shock at this monumental place being incinerated. About 7000 square miles of land were obliterated. The next moment, the internet blows up with the news summoning the attention of the globe but how many of the reactions evoked were out of devastation? Because they certainly should be.

We've come to a time where reports of such catastrophic events have become a norm. Whether it be on a minute level or a large scale, the damage that is done to nature seldom fails to make the headlines. Yet the world moves forward and industrialization thrives. With the effective coverage of earth's destruction, is awareness at all progressing? Human activities are certainly climbing up but our planet is sinking. Sadly, the former is the catalyst for the latter, and so many of us have become desensitized to the writhing pain that nature is in. There is a long history behind how we reached this point of indifference towards the very thing that sustains us. But nonetheless, humans have become very negligent of their duty towards Mother Nature. In fact, they've become its worst enemy. It is without doubt that we have lost our appreciation for the great outdoors. How often do we look up and admire the vast expanse of blue? Or even the flamboyant colours of flowers? Nature is a marvellous piece of art. Every element coexists in harmony and is connected to the other. From the lush green flora to the active wildlife, they all create wonders that we so easily overlook. Man can always seek refuge in the safe havens of the natural world and depend on it for solace and respite. The scene of a blood red sun sinking into the horizon or the rolling waves of an infinite ocean is guaranteed to give us at least a temporal peace of mind. It is special. Yet, a very few have any sense of gratitude left for it. With advancement in lifestyles, people's priorities

have shifted. Their perspectives have changed. Their motives revolve around personal gain. Technology is at the forefront of the biggest projects on earth and humans have become consumed by the prospects of success and competition, no matter what the cost. This mind-set has led to actions that have been absolutely detrimental to nature. People now use their skill and intelligence to exploit what lies in their hands to protect. They claim authority over innocent lives that cannot fend for themselves. Forests are cleared to make way for more and more concrete. The homes of dozens of helpless creatures are wiped out in seconds and their cries go unheard. A vast majority are completely oblivious to the number of deaths that are caused merely to forward a convenience-based agenda. Children of today are so distanced from nature that its destruction is not even the least of their concerns. But no one can deny the harm that is being done. We see the effects of it every single day. From oil spills contaminating water bodies, to the melting polar ice caps of the arctic, all these events speak volumes on the threat posed by human activity to nature. Not to mention the rising rates of mass animal deaths. The numbers speak for themselves and paint a very grim picture of the human race.

Between 1990 and 2016, the world lost 502,000 square miles (1.3 million square kilometers) of forest, according to the World Bank—an area larger than South Africa. Since humans started cutting down forests, 46 percent of trees have been felled, according to a 2015 study in the journal Nature. About 17 percent of the Amazonian rainforest has been destroyed over the past 50 years, and losses recently have been on the rise. The Earth's glaciers are now losing up to 390 billion tons of ice and snow per year, according to studies. Global warming has caused over 3 trillion tons of ice to melt from Antarctica in the past quarter-century and tripled ice loss there in the past decade, another study, released in June, said. So far this year, there have been around 405 known mass animal deaths in 69 countries.

We seem to have reached a point of no return, and our alienation from our amazing planet is escalating. But if we took a moment to contemplate the repercussions of our actions on all life including our own, we would realize that there's so much that can be done to remedy the situation even to a certain degree. The smallest actions have great impacts, whether good or bad. Not everyone has to work their way up to the level of a conservationist in order to create change. Even the simple activities of everyday life

could be done differently so as to reduce the harm they inflict upon the planet. For instance, if everyone ceased to use plastic, the statistics would change drastically. If we channelled our skills and resources towards conserving what we have left and redeeming what we have lost on our planet, there would be major progress. As time has passed, such prospects of a redeemed earth have begun to border impossibility. However, even though on a small scale, efforts are being made by a precious few to restore nature to its original glory and to reinvigorate the enthusiasm that humans once had towards it. This minority deserves appreciation and a greater platform. I'm lucky enough to witness every day from one of my friends. Her passion for nature, fascination of even the tiniest creatures and most of all, her concern about the fate of earth inspire me and many others. Our focus is diverted to trivial matters on a daily basis and the mass media contributes largely to this. But if those few voices of concern were given a chance to reach more people, how great could the outcome be! We couldn't be certain of the rate of progress, but we could be certain of progress. Even slowly, we would start moving in the right direction.

As humans we are so fortunate to possess such remarkable abilities. These abilities we have been bestowed from above can be used to do so much good towards the other great gift we have, instead of depriving it of life. That other great gift is Nature. Hand in hand, we could accomplish many worthwhile goals that would liven the planet and make it one that all beings could share harmoniously. To do so ought to not only be a desire, but a moral obligation. Because, in the words of the great naturalist, John Muir, "In every walk in with nature, one receives far more than he seeks.

Nature Photo Gallery


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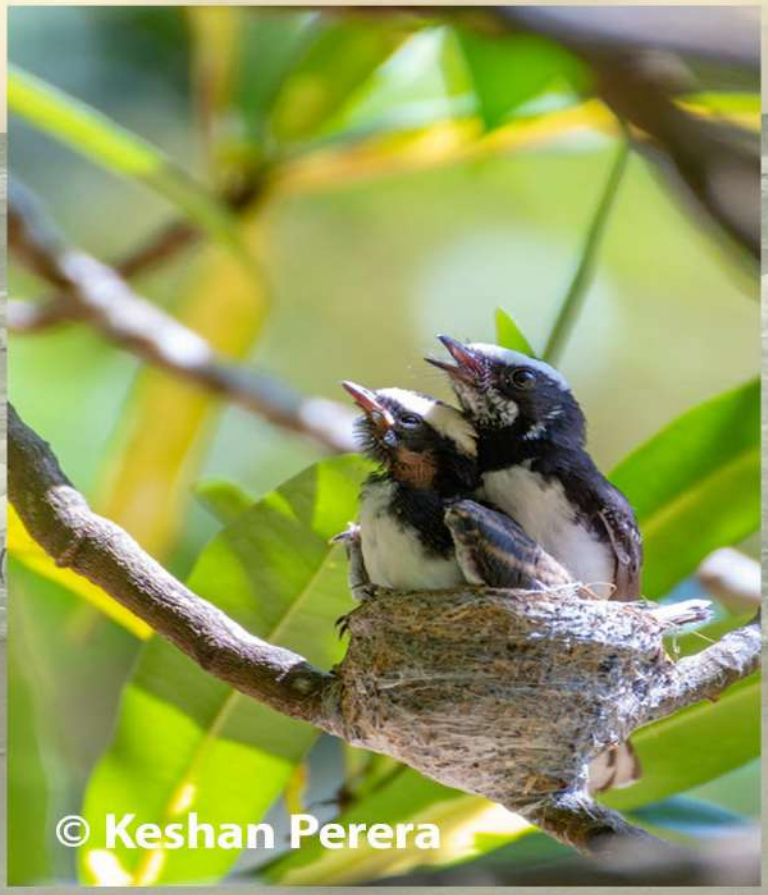
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Nature Photo Gallery

Air pollution and its challenges

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The Earth's atmosphere of Earth is the layer of gases, commonly known as air, which surroundings the planet. That atmosphere protects life on Earth. But with the industrial revolution, our energy consumption has increased exponentially and the number of vehicles has rapidly increased in the last two decades. Therefore, air pollution is occurring on a wide range all over the world. Air pollution can be defined as the presence of toxic chemicals or compounds in the air, at levels that pose a health risk. Drastic increases in air pollution are a major problem for human health in most developed and developing countries.

Figure 1: Highly industrialized city in China

(Source: https://pixabay.com/images/search/power%20plant/)

The main reasons for air pollution can be considered as the huge amount of gas and particulate matter emitted from industries, thermal power plants and automobiles. Other than that air pollution can be caused by agricultural activities, mining operations, and household cleaning products. The major air pollutants can be summarized as given in Table 1.

Table 1: Major air pollutants

Class of pollutants	**Example**
Oxides of Carbon	Carbon monoxide, carbon dioxide
Oxides of Nitrogen	Nitric oxide, nitrogen dioxide
Oxides of Sulfur	Sulfur dioxide, sulfur trioxide
Particulates	Dust, soot
Inorganic compounds	Lead
Photochemical smog	Ozone, (peroxyacyl) nitrates
Hydrocarbons	Benzopyrene, benzene

There are five main air pollutants based on the atmospheric concentration.

1. Carbon Monoxide (CO)
2. Sulfur Dioxide (SO_2)
3. Nitrogen Dioxide (NO_2)
4. Ozone (O_3)
5. Particulate matter (PM 10)

Health effects of air pollution

Air pollution can harm us when these air pollutants accumulate in the air in high enough concentrations. Millions of people live in areas where urban smog, particle pollution, and toxic pollutants pose serious health concerns. People exposed to high enough levels of certain air pollutants may experience:

- Irritation of the eyes, nose, and throat

- Wheezing, coughing, chest tightness, and breathing difficulties
- Worsening of existing lung and heart problems, such as asthma
- Increased risk of heart attack
- Long-term exposure to air pollution can cause cancer and damage to the immune, neurological, reproductive, and respiratory systems. In extreme cases, it can even cause death.

Environmental effects of air pollution

Along with harming human health, air pollution can cause a variety of environmental effects. **Acid rain** is the precipitation containing harmful amounts of nitric and sulfuric acids. These acids are formed primarily by nitrogen oxides and sulfur oxides released into the atmosphere when fossil fuels are burned. In the environment, acid rain damages trees and causes soil and water bodies to acidify, making the water unsuitable for some fish and other wildlife. It also speeds the decay of buildings, statues and sculptures that are part of our national heritage.

Photochemical smog, more commonly known as haze, is caused when sunlight encounters tiny pollution particles in the air. Haze obscures the clarity, color, texture, and form of what we see. Some haze-causing pollutants, mostly fine particles, are directly emitted to the atmosphere by sources such as power plants, industrial facilities, automobiles, and construction activities. Others are formed when gases emitted to the air form particles as they are carried downwind.

Ozone depletion; Ozone is a gas that occurs both at ground-level and in the Earth's upper atmosphere, known as the stratosphere. At ground level, ozone is a pollutant that can harm human health. In the stratosphere, however, ozone forms a layer that protects life on earth from the sun's harmful ultraviolet (UV) rays. Thinning of the protective ozone layer can cause increased amounts of UV radiation to reach the Earth, which can lead to more cases of skin cancer, cataracts, and impaired immune systems. UV can also damage sensitive crops, such as soybeans, and reduce crop yields.

Global climate change; The Earth's atmosphere contains a delicate balance of naturally occurring gases that trap some of the sun's heat near the Earth's surface. This ‘greenhouse effect’ keeps the Earth's temperature stable. Unfortunately, evidence is mounting that humans have disturbed this natural balance by producing large amounts of some of these greenhouse gases, including carbon dioxide and methane. As a result, the Earth's atmosphere appears to be trapping more of the sun's heat, causing the Earth's average temperature to rise - a phenomenon known as global warming. With increased temperatures worldwide, melting of ice and icebergs from colder regions result in an increase in sea levels. Global warming also causes displacement and loss of habitats.

Effects on wildlife; Toxic pollutants in the air, or deposited on soil or surface waters, can impact wildlife in a number of ways. Like humans, animals can experience health problems if they are exposed to sufficient concentrations of air toxins over time. Studies show that toxic air contributes to birth defects, reproductive failure and diseases in animals. Persistent toxic air pollutants, especially those that break down slowly in the environment, are of particular concern in aquatic ecosystems. pollutants accumulate in sediments and may bio magnify in tissues of animals at the top of the food chain to concentrations many times higher than in the water or air.

Solutions to reduce air pollution

1. Use public mode of transportation.
2. Reduce the burning of fossil fuels.
3. Reduce intensive use of agricultural chemicals and burning of agricultural residues.
4. Reduce and properly dispose of waste.
5. Understand the concept of Reduce, Reuse and Recycle.
6. Be mindful of hazardous chemicals that cause indoor pollution.
7. Use energy-efficient devices (CFL bulbs)
8. Emphasis on clean energy resources (Clean energy technologies like solar, wind and geothermal).

Therefore, it is clear that air pollution is one of the major health and environmental problems in the world. So, it is an urgent necessity of environmental action plans to

control these pollutants to create a better living environment.

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A confession

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Though it seems a bit hard to understand,
Why this disastrous pandemic was brought upon us?

One might argue that she wanted us to strand,
But the real truth lies beneath all care and fuss…

The grass seems greener and the trees stand still,
Fulgent rivers flow undisturbed, endowing a mosaic chill,

The occasional predator fed on weak prey,
But it's all fair play when it comes to her way…

Mephitic air has disappeared,
Refulgent blue skies reappeared,
It seemed as if the end of mankind was neared,
With it the annihilation of earth was veered,

We thought we've achieved the finest evolutionary brand,

But, the real truth became clearer thus and thus…
Oh! Great Mother Nature, it hurts to understand,
That you smile a lot brighter without us…

The jungle within the concrete jungle

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Colombo, the commercial capital city of our country, is often regarded as a 'concrete jungle'. However, it is the only capital city in the world to be accredited as a RAMSAR wetland city. This honour and the responsibility of having a wetland city as our commercial capital is a blessing for both the city and nature.

The wetland complex of Colombo is spread across six urban council areas; Colombo, Sri Jayawardenapura, Dehiwala-Mount Lavinia, Kaduwela, Maharagama and Kolonnawa. These areas account for roughly 22600 hectares, out of which 1600 hectares have been identified as wetlands. The RAMSAR convention defines a wetland as, *"*… areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres." By being a wetland city, the inhabitants and the local government of the city should encourage the conservation of the wetlands within and surrounding the city limits.

Colombo has been historically known as a wet, lowland area. The improper use of these sensitive areas for urban development and the disregard towards the importance of wetlands for a long time have contributed to the unfortunate degradation of Colombo wetlands. Fortunately, with the recognition as an international wetland city in 2018, Colombo wetlands have finally been under proper maintenance. An urban wetland offers a vast range of benefits to the country, to the city and to the urban wildlife.

Urban wetlands act as a natural flood buffer. It has been estimated that the economic benefits provided by the Colombo wetland complex by managing flood situations exceed 15 billion rupees per year. These wetland networks can hold an enormous amount of water which prevents flash floods in the city.

Moreover, the environmental pollution caused by the highly urbanised Colombo is somewhat mitigated by these wetlands through reducing temperature and absorption of carbon dioxide.

The Colombo wetland complex includes a canal network. These waterways were used for transportation during the colonial era. Nowadays, these canals are widely neglected and subjected to high levels of pollution. These systems can be revived to be beneficial again. Currently there is a small industry of inland fisheries and transportation based on the canals which should be further improved.

The urban wetlands of Colombo are home to a surprisingly rich biodiversity. One might not expect Colombo to be home for a thriving population of Fishing cats and Marsh Crocodiles. However, that is exactly the case. Colombo wetland complex offers a much needed habitat for not only Fishing cats and Marsh Crocodiles but also for a vast range of mammals, birds, reptiles, amphibians, fish and insects. Many water birds, both resident and migratory, use these wetlands as a natural habitat. It is a common sight to see various species of ducks, storks, pelicans, lapwings, herons and egrets roaming in these areas.

Grey Headed Swamphen - Sri Jayawardenapura (D.T. de Alwis)

The urban wildlife of Colombo is relatively safe from illegal hunting and poaching compared to the other areas of the country. However, living in a highly urbanised

environment has presented them with a number of different issues to deal with. The light pollution of the city has caused disturbances in the lifestyle of many nocturnal animals. The general environmental pollution has been a threat to these amazing creatures as well. Water pollution is a main concern for these wetland inhabitants since water plays a major role in their lives. Hence, it is important to care for these animals which add colour and diversity to the otherwise dull and boring urban Colombo.

Marsh Crocodile - Thalawathugoda (D.T. de Alwis)

Colombo is developing day by day. A whole new landscape is being built within the Port city. Numerous skyscrapers are being raised to the sky. Along with all these development projects and high urbanisation, will these wetlands survive? It is an important question and the answer should always be ‘yes’. If these wetlands were taken care of along with the rapid urbanisation, Colombo will thrive as a beautiful and ecologically important wetland city again.

Emerging and re-emerging viral zoonoses

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Emerging and re-emerging zoonoses are infectious diseases which are newly recognized in a population or have existed before but are rapidly increasing in incidence or geographical range. Zoonoses are defined as those diseases or infections that are naturally transmissible from vertebrate animals to humans. They are caused by pathogens such as viruses, bacteria, fungi, and parasites. Among them many viral pathogens that cause emerging diseases have an animal origin.

Both domestic and wild animals can act as reservoirs for the emerging and re-emerging diseases of humans. Nearly 75% of the infectious diseases that have emerged over the past two decades have a wildlife source. There are several factors that have been identified for the emergence of viral zoonotic diseases. Some of them are international travel; global trade; increasing interactions among humans, wildlife, and domesticated animals; human behavior; rapid microbial adaptation; changes in climates and ecosystems; and changes in livestock management methods. Wildlife is affected by deforestation, expansion of agriculture to previously undisturbed areas and large-scale wildlife trade. All these alter the normal circulation of viruses and lead to increased contact between humans and virus-carrying animals.

These zoonotic infections are important because new pathogens from animals particularly viruses remain changeable and continue to emerge and spread across the countries. In addition, these diseases are also a concern to global health owing to their epidemic potential, high morbidity and mortality, the absence of specific treatment and vaccines to control the spread of most of these zoonotic diseases. It also affects global health security since the world is tightly inter-connected. Eventually, they cause high

burden on health systems, more notably they cause serious economic losses for countries in terms of the loss of trade in animals, travel and the loss of economic opportunities for people through livestock loss. Some of the recent emerging and re-emerging viral zoonoses include SARS, Middle East respiratory syndrome coronavirus (MERS-CoV), Ebola, HIV and Avian Influenza reported in the recent past.

During 2002 and 2003, a novel viral respiratory disease emerged in humans in the southern region of the People's Republic of China. The disease had a severe, acute, sometimes life-threatening respiratory syndrome, which it names stands for: severe acute respiratory syndrome or SARS. This disease was found to be caused by a novel coronavirus, unrelated to coronaviruses that were commonly associated with human infections, or known to infect livestock. The disease was directly contagious from person to person, and became rapidly circulated by international travel. It is not yet known whether masked civet (*Paguma larvata*) or other animals like bats are the reservoir for this virus, or are just transient permissive hosts. According to the World Health Organization (WHO), a total of 8,098 people worldwide became sick with SARS during the 2003 outbreak. Of these, 774 died.

Middle East respiratory syndrome (MERS) is another zoonotic viral respiratory disease caused by a novel coronavirus that was first identified in Saudi Arabia in 2012. Approximately 35% of MERS-CoV infections have been attributed to human-to-human infections in health care settings. However, current scientific evidence suggests that dromedary camels are a major reservoir host for MERS-CoV and an animal source of MERS infection in humans. But, the exact role of dromedaries in transmission of the virus and the exact route(s) of transmission are unknown.

Ebola virus disease (EVD), one of the deadliest zoonotic viral diseases which causes fatal haemorrhagic fever was discovered in 1976 in Central Africa. Scientists think people were initially infected with Ebola virus through contact with an infected animal, such as a fruit bat or nonhuman primate. African fruit bats are likely involved in the spread of Ebola virus and may even be the reservoir host. Scientists continue to search for conclusive evidence of the bat's role in transmission of Ebola. Since its discovery in 1976, the majority of cases and outbreaks of EVD have occurred in Africa. The 2014-2016 Ebola outbreak in West Africa began in a rural setting of south-eastern Guinea, but spread to urban areas and

across borders within weeks, and became a global epidemic within months. The virus spreads through direct contact such as through broken skin or mucous membranes in the eyes, nose, or mouth. No vaccines have been discovered yet; only supportive therapy is provided.

Human immunodeficiency virus/AIDS is caused by two of the 26 simian immunodeficiency virus (SIV) strains known to occur in African primates. It is reported that HIV-1 and HIV-2 viruses have evolved from a chimpanzee (*Pan troglodytes*) strain and a Sooty mangabey (*Cercocebus torquatus*) strain, respectively. The available evidence and genetic analysis suggest that transmission of these SIV strains to humans was a rare event, but one that has occurred on at least seven separate occasions over the past century. These initial transmissions in equatorial Africa appear to be linked to hunting apes and using them for food. From these transmission events, virus strains which were both highly adapted to humans and contagious among humans evolved as HIV-1 and HIV-2, and these are now maintained and spread in human populations, independent of their simian origin.

Influenza A viruses (flu) are responsible for highly contagious acute illness in humans, pigs, horses, marine mammals and birds, occasionally resulting in devastating epidemics and pandemics. Phylogenetic studies suggest that aquatic birds could be the original source of the genetic material of all influenza A virus in other species. There are four pandemics that have happened in the past 100 years in 1918, 1957, 1968 and 2009 respectively. But experts agree another one is unavoidable. The most serious of these pandemics occurred in 1918, during which an estimated 20 to 50 million people died.

Many of these infections pose many problems because they are difficult to manage clinically, extremely expensive to treat in resource-poor areas, have a rapid global spread, nearly impossible to eliminate once stable transmission among humans has been established, or capable of inducing fear and substantial economic losses. Therefore, many different measures should be taken to control or prevent occurrence of such diseases. Some of the measures should include additional research to understand zoonotic agents and host biology, improving of laboratory facilities to conduct research on highest risk pathogens, expanding surveillance systems to give early warnings for emerging zoonoses and monitoring. Governments should take necessary protective measures as soon as possible when

there is an outbreak and should distribute supplementary funding to appropriate organizations for handling emergencies. Prior knowledge, public education programmes on emerging zoonoses and public preparedness are essential since they increase the awareness among people and aid in reducing unnecessary fear. It is also crucial to give accurate information and data on any new or ongoing outbreak by relevant authorities to control and prevent the spread into other areas and other countries as well.

To conclude, viral zoonotic infections tend to affect public health as well as the economy. Thus, control of zoonotic infections should lie on the concept of "One Health" approach which is a common coordination mechanism of collective planning, implementation, public engagement, capacity building and joint process for monitoring and evaluation between animal health and human health sector. Thereby it can help to control the zoonotic infections in animal reservoirs, enable early outbreak detection, and prevent deadly epidemics and pandemics in future.

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Pet trade as an emerging threat to biodiversity of Sri Lanka

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Sri Lanka is among the 34 biodiversity hotspots identified in the world and has the highest biodiversity per unit area of land amongst Asian countries. When considering protecting this valuable biological treasure it is very important to identify potential threats and overcome them. In recent years, with the development of technology and communication, a growing demand and enthusiasm is observed in the pet trade of Sri Lanka. For example, social media can be considered as a main platform for pet trade in Sri Lanka. This pet trade can have a destructive impact on our biodiversity, mainly by means of illegal wildlife trade, exotic species invasion and indirect destruction of native species by exotic animals. Several permanent dealers and incidental dealers can be identified when observing their interactions in social media platforms. Several groups and pages can be seen operating openly without any hesitations. All species of parrots, birds of prey, peafowls, mynah species, giant squirrels and palm squirrels, porcupines, deer species and some fish species such as ruby barbs and snakeheads can be observed to be frequently traded on these platforms. As law implementation and reinforcements are in a debatable situation, illegal wildlife trade continues to grow day by day. On average, the most valued parrot species is the plum headed parakeet (*Psittacula cyanocephala*) with the price ranging from Rs. 15,000.00-25,000.00 per pair. Layard's parakeet (*Psittacula calthorpe*) followed by Alexandrine parakeets (*Psittacula eupatria*), Rose ringed parakeet (*Psittacula krameri*) and Sri Lanka hanging parrot (*Loriculus beryllinus*) are also in high demand. Prices of Sri Lankan jungle fowl (*Gallus lafayetii*) and Peafowl (*Pavo cristatus*) range from Rs. 10,000.00-15,000.00. Sri Lanka Hill Mynah (*Gracula ptilogenys)* and Common Mynah

(*Acridotheres tristi*s) are among the most traded bird species and their price ranges from Rs.2000.00-5000.00. Usually, the trading value for birds of prey range from Rs.25,000-40,000 on these platforms. Brown fish owls (*Ketupa zeylonensis*), Barn Owl (*Tyto alba*), Crested Serpent Eagles (*Spilornis cheela*), Black Eagles (*Ictinaetus malaiensis*), shikra (*Accipiter badius*) and Brahminy kites (*Haliastur indus*) have also been traded using these media networks in the recent past. Availability of hand feeding size to adult size animals makes them very popular among exotic pet keepers. It is observed that in highly urbanized areas such as Colombo and Kandy many pet shops display protected species without any concern for the law. Usually, animals which are displayed openly in these shops are parrot species and palm squirrels. Most of the time the catch site is never indicated. In most cases it is obvious that people from urbanized areas advertise the availability and trading of exotic pets. Most of the time since this trade happens through middlemen, t is very difficult to track these types of illegal trade activities.

Invasion of exotic species is not something new to Sri Lanka. but with the recent data that has been obtained, it is wise to update the status of Yellow Indian ringneck parrots, other exotic parrot species, and animals like sugar gliders as exotic species which can cause potential threats to Sri Lankan biodiversity. On four different occasions, an escaped Yellow Indian ringneck parrot interacting with local ringneck parrots was observed. Three of the observed birds were completely yellow in color and one bird had green patches on its body, suggesting that it was a hybrid between green ringneck and yellow ringneck parrots. It is very important to investigate the interactions of exotic bird species with local birds and take necessary actions to protect the genetic pool of Sri Lankan bird populations. The observations that have been made further indicates that yellow ringnecks are surviving in the wild (both rural and urbanized). Intentional release and escapes of commercial quail species to the wild are also commonly reported in Sri Lanka. There are few records of commercial quail species thriving in upcountry forest areas. However, their breeding or interactions with wild species is not clear due to scarce data. Similar situation is observed with sugar glider species but their survival in the wild is not clear. It is very important that relevant stakeholders take action to control and manage escaped exotic animals and also to control the trade of exotic species before it is too late. More research and involvement of

the authorities are essential in this sector. Building awareness, constant monitoring of exotic pet traders and issuing licenses for breeders can be supportive actions. Wildlife officers and other relevant stakeholders must be constantly updated with the available data and information because at present, it is apparent that some wildlife rangers have a poor knowledge of the current laws and how to implement necessary actions.

It is very important to address these issues with practical soulutions before it is too late to protect the Sri Lankan biodiversity.

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Fire breathing Bombardier Beetle

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Figure 1: Bombardier beetle (Source: https://www.mcgill.ca/oss/article/environment/do-not-mess-bombardier-beetle)

In the animal world, we can observe many defence mechanisms against predators. Camouflage, claws, mimicry and teeth are extremely common in many species. But there is a special defence mechanism among beetle species that spray hot boiling chemical fluid along with an audible detonation. Bombardier beetles (*Brachinus sp.*) are ground beetles that are most notable for this type of defence mechanism that gives them their name "fire breathing beetle".

There are hundreds of species of bombardier beetles on all the continents except Antarctica. They typically live in woodlands or grasslands in temperate zones but can be found in other environments if there are moist places to lay their eggs. Some have foamy and non-explosive chemicals, while others like the African bombardier beetle have explosive chemicals that can be sprayed in virtually any direction. In 1839, J.O. Westwood, an entomologist, stated that large South American species of bombardier beetles "*immediately began to play off their artillery, burning and staining the flesh to such a degree that only a few specimens could be captured with the naked hand*" (Aneshansley *et al.*1969).

When threatened, bombardier beetles expel a hot spray from their pygidial glands. Its pygidial glands have multiple parts, with a reservoir chamber, a reaction chamber, and an exit channel (Figure 3) (Schildknecht *et al.*, 1964). The reservoir chamber contains an aqueous solution of *~10% p-hydroquinone* and *~25% hydrogen peroxide* along with *~10% alkanes* as a nonreactive liquid, while the outer compartments contain a mixture of *catalase* and *peroxidases* (Schildknecht *et al.*, 1964). When attacked, the beetle squeezes some reservoir fluids into the reaction chamber triggering the forming of p-benzoquinones and explosively liberating oxygen gas, water vapor, and heat, propelling a hot spray out the exit channel. Catalase promotes the decomposition of hydrogen peroxide, while the peroxidases promote the oxidation of the hydroquinone to their respective quinones. Under the pressure from oxygen, the mixture is released out as a spray at about 100°C with a velocity of 10 ms^{-1} and a range of several centimetres with pulse repetition rates of 368 to 735 Hz (Beheshti and Mcintosh, 2007).

The discharged chemical can be aimed using the beetle's nozzle-shaped exit with high accuracy. (Figure 4) They can shoot over their head or even underneath them at predators.

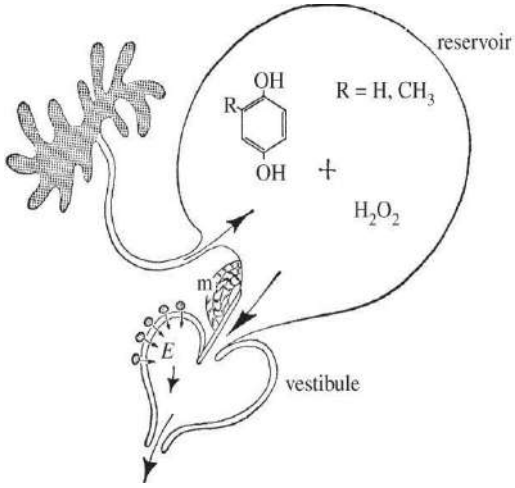
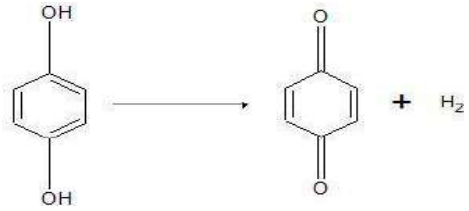


Figure 2: Diagram of the defence mechanism of the bombardier beetle. The reservoir obtains its contents from a duct that drains an outlying cluster of secretory tissue. The enzymes (E) in the vestibule are secreted by cells on the wall of the vestibule itself. The muscle (m) controls the valve between the two compartments (Aneshansley *et al.*, 1969)

Using the known concentrations of the reactants and thermodynamic properties, it's possible to predict the heat content and temperature of the spray.

The chemical reactions that take place:

$$hydroquinone(aq) \rightarrow quinone(aq) + H2(g)\ (a)$$



$$H202(aq) \rightarrow H2O(l) + \frac{1}{2}O2(g)\ (b)$$

$$H2(g) + \frac{1}{2}O2(g) \rightarrow H2O(l)\ \ (c)$$

The overall chemical reaction (d):

hydroquinone$_{(aq)}$ + $H_2O_{2(aq)}$ → quinone$_{(aq)}$ + $2H_2O_{(l)}$ (d)

Using available data, the enthalpy change of the reaction can be calculated. The enthalpy changes for reaction (a), (b) and (c) at 25 ^{0}C are ΔH_{rxn} = -94.56 kJ/mole, ΔH_{rxn} = -285.77 kJ/mole and ΔH_{rxn} = 177.40 kJ/mole respectively. Therefore, the enthalpy change of the overall chemical reaction(d) is; ΔH_{rxn} = -94.56 kJ/mole -285.77 kJ/mole + 177.40 kJ/mole = -202.93 kJ/mole. The Bombardier beetles produce -202.93 kJ of heat for each mole of hydroxyquinone during this exothermic reaction (Aneshansley *et al.*, 1969).

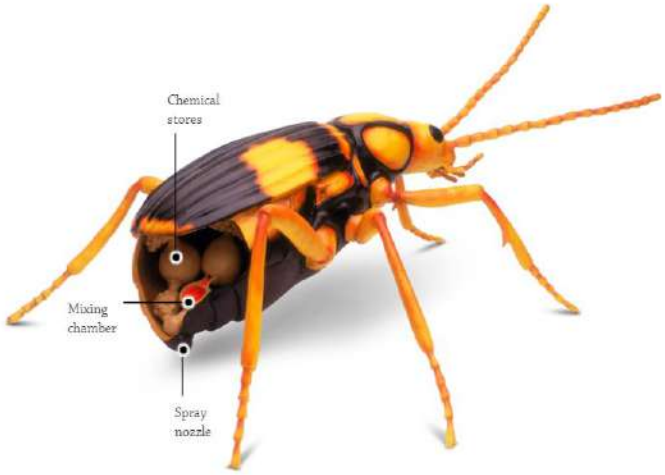


Figure 3: 3D view of Bombardier beetle's abdomen (Source: https://www.dkfindout.com/us/animals-and-nature/insects/how-bombardier-beetle-attacks/)

Bombardier beetles are capable of releasing hot chemical spray up to twenty times, with the available chemicals in the reservoir. The pressure of the chamber when the reaction occurs can increase up to 20 kPa (Vincent and Wegst, 2004). This allows the beetle to release the chemicals with high velocities and up to a range of several centimetres.

To protect the internal organs including the reservoir chamber from the resulting noxious chemical, it has valve-opening muscles which close passively from the feedback of the explosion. When the pulse is released, the pressure drop of the reaction chamber allows the valve to open and fill the reaction chamber with a new batch of chemicals for the next pulse (Sotavalta, 1953).

Even though these beetles can spray chemicals that can dissolve the predators' flesh, they have adaptations to protect their own organs from them. The pygidial glands are lined by the cuticle, a composite of chitin protein and waxes. It helps to protect the organs from extreme temperatures and pressure, and toxic chemicals during the explosions (Beheshti and Mcintosh, 2007). Spray release as a pulse also helps to cool the reaction chamber and to prevent it from overheating.

Is it possible to evolve such a beetle with explosives inside without blowing itself up in the first place? The complexity of the design of the beetles' defence system may seem like it was created perfectly for that task. Some

creationists argue that such a complicated mechanism couldn't have evolved on its own. But it's possible to envision the step-by-step evolution of the bombardier beetle mechanism from a primitive arthropod. Evidence such as the production of quinone by epidermal cells for tanning the cuticle support this. It is commonly seen in arthropods (Schildknecht *et al.*, 1964). Hydrogen peroxide, which is a common by-product of cellular metabolism strongly suggests the evolution of the bombardier beetle. Therefore, random mutations that happened over many years are most likely to evolve this unique and magnificent defence mechanism.

Figure 4: Bombardier Beetle defending itself with a controlled spray of corrosive fluid (Source: https://www.researchgate.net/publication/267370663_Potential_Applications_of_the_Natural_Design_of_Internal_Explosion_Chambers_in_the_Bombardier_Beetle_Carabidae_Brachinus/figures)

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Barbets of Sri Lanka: Feathered friends in the canopies

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Barbets belong to Order Pisiforms, containing four families, all of which are distributed in the tropics of the Old and New Worlds. There are about 91 species.

Barbets have relatively small bodies. The body is slightly obese and the head is relatively large. The neck is short, and feet are zygodactyl. American species have yellow, white, red, and black shades and streaks or specks in their bodies. In Asian and African species, there are red, green, blue, and yellow markings. Bristle feathers, which protect nostrils and eyes from dust and foreign particles are found near the nostrils and the gape and in the chin area.

Distribution

Family Capitonidae – New world Barbets/Central and South American Barbets
Family Lybiidae - African Barbets
Family Megalaimidae - Asian Barbets
Family Semnornithidae -Toucan Barbets/Central and South American Barbets

Food habits

They are mainly frugivorous and insectivorous. Beak is very strong. It helps in nesting.

Breeding

During the breeding season, males move to the female by lifting the crown feathers on the top of their heads. Often the call is believed to mark the domain.

Nesting

Barbet's beak is not as sharp as that of a woodpecker, so it uses less sturdy stems to build nests. The nest is made so that only one bird can exit and enter. Selects a tree-lined area to protect from weather disasters. These birds lay 2-4 eggs at a time. Eggs are taken care of by both males and females. Both stay

in the nests at night. Chicks come out from the eggs after 20 days. Barbets do not migrate.

Barbet species found in Sri Lanka

1. Yellow-fronted Barbet (*Psiliopogon flavifrons)*

Size and color pattern
The body size varies between that of a Red-vented Bulbul and a Common Mynah (21cm). Smaller than a Brown-headed Barbet. No sexual dimorphism is observed. The forehead is yellow in color and malar strips can be seen. Around the eye, ear coverts and the neck is blue. It has a green plumage. The beak and the legs are grey.

Distribution

This bird is an endemic resident breeder in Sri Lanka. Can be found as individuals, pairs or in small groups in low land wet zones and central highlands. Lives in forests, rural gardens and fruit orchards which are in close proximity to forests.

Food habits

Mainly frugivorous; occasionally insectivorous. Considered as a pest for fruit orchards.

Breeding and nesting

There are two breeding seasons, from February to May and August to September each year.

Nests are similar to the nests of other barbets. Lays white eggs of 28 × 21 mm in size inside hollowed barks.

2. Crimson-fronted Barbet (*Psilopogon rubricapillus*)

Size and color pattern

This bird is slightly larger than a sparrow. About 17 cm long and no clear sexual dimorphism can be observed. the forehead is crimson red while the area around the eye and the area around the neck is yellow. Ear coverts are available. The cheeks are light blue. The dorsal area, belly, and flanks are green. There is a yellow area around the eye and a black mark. There is a red patch on the breast area. The beak is black.

Distribution

Endemic to Sri Lanka. Can be found as individuals, pairs or in small groups in forests of the upper central highlands and dry and wet zone. Found in the upper canopies of forests.

Food habits

Frugivorous

Breeding and nesting

The breeding season is from January to June. They make 40-30 m tall nests of several selected plants, such as Breadfruit (*Artocarpus altilis*) and Erabadu (*Erythrina variegate)*. Eggs are white, and about 25.5 × 18.2 mm in size. Lays 2-3 eggs at a time. Dark pigments are present in the egg.

3. Brown Headed Barbet (*Psilopogon zeylanicus*)

Size and color pattern

Similar to the size of a Common Mynah and about 27 cm long in size. Head is brown. The breast area is light green or yellow green. The chin area is also brown. White streaks can be seen in the head and breast areas but they are not observed on the flanks and the belly. An orange color area of a low density of feathers (low feather coverage), can be seen around the eye and extends to the inferior region of the beak. These marks turn to orange color during breeding season and turn back to yellow color in the other seasons. They possess a large beak of brownish orange color which turns red during the breeding season. Their legs are of a brownish-orange color.

Distribution

They can be seen as individuals, pairs or in small groups in forests, rural gardens, plantations and fruit orchards other than in the central highlands in Sri Lanka. They live in the upper canopies of trees

Food habits

The adults are mainly frugivorous but the hatchlings are fed with both fruits and insects.

Breeding

Main breeding season is from February to July and the second breeding season is from August to September. They lay around 2-4 eggs of 31 × 32 mm. Eggs are off white in color.

4. Coppersmith Barbet (*Psilopogon haemacephalus*)

Size and color pattern

The size is similar to that of Crimson-fronted Barbet (17 cm). They do not show sexual dimorphism. They have a crimson forehead and large crimson breast patch. Face is black

and it has yellow patches above and below the eye. Throat is yellow. Both upper and under parts are green. But the under parts are paler than the upper part and it has streaks in dark green. They have black beak and red legs.

Distribution

They are mainly found in dry zone lowlands up to dry zone mid hills. And also found in wet zone lowland and highlands. (Kandy, Awissawella)

Food habits

Food habits are similar to those of Crimson-fronted Barbet.

Breeding and nesting

The breeding seasons are from November to May, and from July to September. The nest is a hole in a dead branch. These nest holes may be located at any height from the ground. Three off white eggs measuring about 25 × 17.5 mm are laid at a time.

Figure 01: Yellow fronted Barbet by Athula Edirisinghe; location: Rathnapura (Source – Field Ornithology group of Sri Lanka)

Figure 02: Crimson-fronted Barbet by Achini Deweniguru; location: Kiriwaththuduwa (Source – Field Ornithology Group of Sri Lanka)

Figure 03: Brown-headed Barbet by Achini Deweniguru (Source: Field Ornithology Group of Sri Lanka)

Figure 04: Coppersmith Barbet by Achini Deweniguru; location: Kumana National Park (Source – Field Ornithology Group of Sri Lanka)

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Zonation of the ocean & distribution of marine fauna

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The most mysterious and spectacular part of our planet is the ocean. Have you ever wondered about life in the ocean? Even at the greatest ocean depths, which reach nearly 11 kilometers in the Marianas Trench of the western Pacific Ocean, heterotrophic organisms are found but photosynthetic organisms are confined only to the upper few hundred meters of the ocean.

However, the zonation of the ocean can be seen with its own dominant creatures. It is divided according to the proximity to land and the depth of water. The bottom of the ocean is known as the benthic zone, while the pelagic zone extends from the ocean floor to the surface. The neritic zone is the part of the pelagic zone which extends from the high tide line to the ocean bottom less than 200 m deep while water deeper than 200 m is referred to as the oceanic zone. The oceanic zone is subdivided into epipelagic, mesopelagic, bathypelagic and abyssopelagic zones. The neritic zone can be partitioned based on the tidal levels. The upper band is known as the intertidal zone, encompassing the region from the wave splash zone to the low tide mark. The highest zone within the area above the high tide mark that receives only wave splash and sea-water mist. The next zone is the mid littoral layer which includes the majority of the intertidal zone and receives periodic exposure and submersion by tides. The lowest zone, infra-littoral zone, includes the lowest levels exposed by extreme spring tides and extends into the sub tidal zone, marking the beginning of the marine environments.

The ***littoral*** zone is the region of a body of water that is near the shore. It is generally considered to extend from the high water mark to the continental shelf. Because of its close association with terrestrial systems, the littoral zone is nutrient rich and highly productive. Fish in these areas, such as coral reef fish, often become highly specialized feeders because of the diverse and abundant

food sources. Sea weeds, algae, barnacles and shrimps are also found in this zone.

The ***Benthic division*** has 4 main zones namely, sublittoral, bathyal, abyssal and hadal zone. The sublittoral zone extends from low tide to 200 m on an average. Different types of oysters, starfish, sea urchins, corals, crabs and anemones lie here. They are provided with sunlight and food but there are also many predators. Corals are one of the living things in this zone. One fourth of the world's fish species use corals and coral reefs for food and shelter. The sublittoral zone's temperature averages at 4 degrees Celsius. Atmospheric temperature ranges from 1-20 degree Celsius. Most animals get their food from each other, plants, phytoplankton, zooplankton or other dead sea organisms. Around 200 m-1000 m depth bathyal zone is found. From 1000 m-6000 m abyssal zone and at depths greater than 6000 m the hadal zone is found

The surface layer of the ocean is known as the ***epipelagic*** ocean and extends from the surface to 200 m. As sunlight can penetrate through this, it is also called the sunlight zone because this is where most of the visible light exists and facilitates photosynthesis. With light, heat exists. This heat is responsible for the wide range of temperatures that occur in this zone. All these support the flourishing of seaweeds and photosynthetic algae. Major carnivores such as tuna, dolphins and other predatory species are also found in this region. Moreover, jellyfish and turtles are also inhabitants of the epipelagic zone.

Below the epipelagic zone is the ***mesopelagic*** zone, extending from 200 m to 1000 m. The mesopelagic zone is sometimes referred to as the twilight zone or the mid water zone. The light that penetrates to this depth is extremely faint. It is in this zone that we begin to see the twinkling lights of bioluminescent creatures. However, not much light falls on this zone. The little light that does penetrate is not enough for photosynthesis but enough to see during daytime. Carnivores such as sharks, squids and crabs are found here. Filter feeders and grazers are also found among them.

The next layer is called the ***bathypelagic*** zone. Midnight zones or the darkest zone are also used to define this zone due to total absence of light. This zone extends from 1000 m down to 4000 m. Here, the only visible light is the light produced by the creatures themselves. The water pressure at

this depth is immense. In spite of the pressure, a surprisingly large number of creatures can be found here. Carnivores sit and wait for prey. For that, they possess long jaws. Viperfish, sea star and octopus live in bathypelagic environments.

The next layer is called the ***abyssopelagic*** zone or simply as the abyss. It extends from 4000 m to 6000 m. The temperature is around 2-3 degree Celsius near freezing and there is no light at all. Tremendous water pressure and low oxygen concentrations are observed here. Low food and nutrition availability in this zone have lowered the number of creatures. However, deep water squids, angler fish and basket stars can be found in this region.

Beyond the abyssopelagic zone lies the forbidding ***hadal-pelagic*** zone. This layer extends from 6000 m to the deepest parts of the ocean. Deep water trenches and canyons are mostly found in this zone. The temperature of the water is just above freezing and the pressure is an incredible 8 tons per sq. inch. In spite of the pressure and temperature, life can still be found here. Invertebrates such as starfish, tube worms and sea cucumbers can thrive at these depths. Most of these species lack skin color.

We know very little about our ocean despite the roles that the ocean plays in the water cycle and fish industry. Further, most of our knowledge spread up to shallow waters. However, deeper waters remain a mystery even if we are relying more for food and drug sources. For that, ocean exploration is needed, which is about making discoveries and searching for things that are unusual. Zonation of the ocean and distribution of marine fauna will give you a good understanding while exploring the deep ocean without disturbing the marine ecosystem that we do not purposely concern.

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Why do animals sometimes eat their babies?

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For a mother, killing and eating her babies could be the cruelest behavior that an animal can practice. But this behavior does exist among some animal groups in the animal kingdom as means of survival. This phenomenon of killing one's offspring is known as "filial infanticide", and if the parents eat their yearlings, it is referred to as "filial cannibalism". Even though the exact reason for this behavior has not been confirmed yet, scientists predict that this behavior could offer long-term survival opportunities for the particular species and that could be the reason why this behavior continues to appear in succeeding generations of that species.

Usually, this act is done by the parent who takes care of the young, under various circumstances. Since, in some species, the mother attends to the offspring and in other cases, the father takes care of the offspring, it could be either the mother or the father committing the killing of the young. Depending on the situation these cannibalistic parents either eat part of the brood which includes one to several individuals or eat the whole brood. Even though it seems unacceptable, several animal groups including domestic cats, hamsters, pigs, some birds (e.g. White strokes), reptiles, primates, and even some insects (e.g. Assassin bugs), practice this behavior. As described by scientists, it is completely normal behavior that also offers several benefits to the cannibalistic parents, remaining offspring, and future broods.

Taking care of the young and nursing them is a long-term process, which has a high energy cost. Naturally, the parent which acts as the caretaker of the young instinctively care for the brood. But sometimes, when the nursing parent does not have sufficient energy, it eats one or several individuals from its litter, which provides adequate nutrition to nourish the remaining young and keep them alive. This behavior has been seen among some stray cats that do not receive adequate amounts of food during the nursing period.

Some bears and cats cannibalize on stillborn or those offspring with birth defects. This enables the parent to obtain more nutrition which is then passed to the surviving litter through milk, enhancing their survival chance.

When the size of the litter is too large, hamsters usually eat some of their offspring. Thereby the mother hamster ensures the survival of the other individuals in the brood providing them with enough nutrition, and care. Using a simple experiment, scientists have tested this behavior of hamsters and their optimum litter size. According to their observations, a hamster mother with eight to nine cubs tends to eat two of them on average. When scientists experimentally added two more cubs to the litter, the mother hamster ate four of the offspring on average and when experimentally removed two cubs from the litter, the mother hamster did not cannibalize any of her offspring, to maintain the optimum litter size. This reveals that filial cannibalism is practiced when the litter size is too large to take care of and imposes a risk to the survival of the whole brood by reducing the amount of nutrition and energy per individual in the litter. So instead of risking the entire brood, the mother hamster cannibalizes a few individuals and ensures the survival of the other six or seven cubs.

However, some animals, such as long-tailed sun skinks, eat their whole brood when they are threatened by a predator. Here, they prevent the chance of the whole brood being eaten by the predator. Moreover, the skink gets all the nutrition and energy that it can expend later for a new brood. So, this behavior also indirectly enhances the survival of this skink species and ensures the passing of their genes to the next generation when the conditions are favorable.

Furthermore, the male sand gobies take care of some of the clutches of eggs belonging to several females within a very short period. To mate again, the male goby has to wait until all the eggs are hatched. Under this situation, sometimes male gobies eat their whole brood to create new mating opportunities. This may seem inconvenient, but the male gobies always go for better mating opportunities, so, the size and the quality of the clutch can be better than the previous clutches.

According to the above examples, it can be seen that, to maximize the opportunities, resources, and energy that are required for their survival and to ensure the passing of their genes to the next generations, some animals in the animal kingdom practice filial cannibalistic behavior, which is also another

remarkable strategy driven by nature. So, next time when you see a mother cat cannibalizing her babies, think twice before judging her.

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Butterfly gardening – A project by Zoologists' Association

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Butterfly gardening is a method of conservation of lepidopterans by providing and maintaining a habitat within human settlements. Gardening is a simple concept for mental satisfaction and education and also with several advantages for both human society and nature. The concept behind butterfly gardening can be described as the supply of few improvements and special needs specific to lepidopterans. Butterflies have a complete life cycle comprising four stages. Those four stages are eggs, larvae, pupae, and adults. Habitats for each stage of the life cycle are provided in an ideal butterfly garden. Butterflies are ecologically important as pollinators. Ninety percent of flowering plants and 35% of crop plants rely on animal pollination and a fraction of them is pollinated by butterflies. Their species diversity is declining due to habitat degradation. Moreover, the use of pesticides and herbicides is a threat to them. Therefore, the reconstruction of butterfly gardens is an elegant and alternative solution for the conservation of butterflies.

To fulfill the above benefits, a butterfly garden was constructed at the premises of the Faculty of Science, University of Peradeniya as a collective effort by Zoologists' Association, academic staff, non-academic staff, and volunteers. When constructing a butterfly garden there are a few guidelines to follow. An appropriate site selection is the first and one of the most critical steps in this procedure. Usually, any place from a home garden to a public city park can be allocated. But characteristics of the site such as soil status, light conditions, naturally existing fauna and flora, and water supplements have to be considered since those conditions affect the growth of the larval host plants and adult feeding plants. The natural arrangement of the site was preserved during the site preparation process. The selected site for the project has a part that is exposed to intense sunlight and also a shaded area with rich vegetation.

Figure 1: Natural features of the site

Figure 2: Selected site before preparation

Next the common butterflies of the area were identified. This step is very important when it comes to the selection of host plants. A butterfly host plant is a plant that larval stage/ caterpillars feed on. According to the common butterflies, host plants were selected. Most of the host plants and feeding plants were collected from the lower Hanthana area and others were donated by volunteers. Most of the selected plants were endemic or native plants and few were exotic. A few examples of the selected larval host plants are included in Table 1.

Table 1: Few larval host plants of butterflies planted in the butterfly garden

Common Butterflies		**Larval Host Plants**	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
Blue Bottle	*Graphium sarpedon*	Bobu	*Symplocos cochinchinensis*
Blue Mormon	*Papilio polymnestor*	Jambola	*Citrus grandis*
Chocolate Soldier	*Junonia iphita*	KatuKarandu	*Barleriaprionitis*
Common Grass Yellow	*Eurema hecabe*	Ehela	*Cassia fistula*
Common Mormon	*Papilio polytes*	Karapincha	*Murrayakoenigii*
Common Rose	*Pachliopta aristolochiae*	Sapsanda	*Aristolochiaindica*
Glassy Tiger	*Parantica aglea*	KiriAguna	*Tylophorapauciflora*
Lemon Pansy	*Junonia lemonias*	Niramulliya	*Hygrophilaschulli*
Leopard	*Phalanta phalantha*	Uguressa	*Flacourtiaindica*
Lime Butterfly	*Papilio demoleus*	Dehi	*Citrus limon*
Plain Tiger	*Danaus chrysippus*	Wara	*Calotropis gigantean*
Tailed Jay	*Graphium agamemnon*	KatuAnoda	*Annonamuricata*

Nectar plants or the adult feeding plants selected were common flowering plants and the most favorable plants for butterflies. But almost all were exotic plants such as Zinnias (*Zinnia elegans*).

As the next step, land preparation was done. Land preparation consisted of several steps. First, unnecessary and invasive plants on the site were removed. The natural arrangement of the site and a few plants of the natural vegetation were preserved during the site preparation process to conserve the site's nature. A site map was prepared considering all the factors mentioned above. Plants were placed according to the plan of the site. The plants that need intense sunlight were planted in an area that is exposed to sunlight, especially the flower beds. A pathway was arranged through the garden to reduce the damage to plants from visitors.

Figure 3: The site after preparation and plantation

Big trees were planted in corners of the site to reduce the shading to other plants in the middle of the garden. A shaded area was selected to provide fruits for the fruit-sapping butterflies such as Common Evening Brown (*Melanitis leda*) and Medus Brown (*Orsotriaena medus*). A mud puddle was constructed for mud sipping; Mud sipping or mud puddling is a behavior shown by butterflies, especially males, to gain nutrients such as sodium salt since flower nectar does not contain many nutrient salts enough for their migration behavior. Mud puddles help to attract many butterflies to the garden.

Figure 4: Butterfly garden after about two months from plantation

Figure 5: Medus Brown on a fruit peel

The next most important step is maintaining the garden. Watering is compulsory until the plants are rooted. Due to the dry season, the garden was watered twice a day till the plants matured. If larvae or eggs were present, those were replaced safely to another habitat. But very importantly the site should not be cleaned unnecessarily, because that could disturb the natural habits of the lepidopterans. The mud puddle was maintained daily and the fruits from the university premises themselves were supplied continuously.

Figure 6: *Lycaenidae* on a leaf

Figure 7: Plains Cupid on *Gomphrenaglobosa*

After considerable effort and daily maintenance, several butterfly species used gardens (Table 2) and also bees as well. Therefore, the garden improved into a Butterfly & Bee Garden with the introduction of a Bee hotel. Observing and adding improvements is also a necessary process. We could also introduce a pond for dragonflies and a bird bath for supply requirements for other fauna as well.

Table 2: Butterflies observed on 11.02.2020, after about two months of plantation

Name	**Abundance**
Dark Cerulean	6
White Four-ring	3
Common Grass Yellow	3
Peacock Pansy	2
Chocolate soldier	2
Lemon Emigrant	2
Common Rose	1
Plain tiger	1
Glassy Tiger	1
Common Crow	1
Common Palmfly	1
Plains Cupid	1
Babul Blue	1

Finally, to conclude, Butterfly gardening is an elegant solution for conservation. Therefore, encouraging the society to work on projects like these and offer their contribution to protecting these amazing creatures would be one step closer to conserving the butterfly fauna of Sri Lanka.

Figure 8: Red pier rot caterpillar On *Bryophyllum sp.*

Figure 9: A Bee visit to the garden

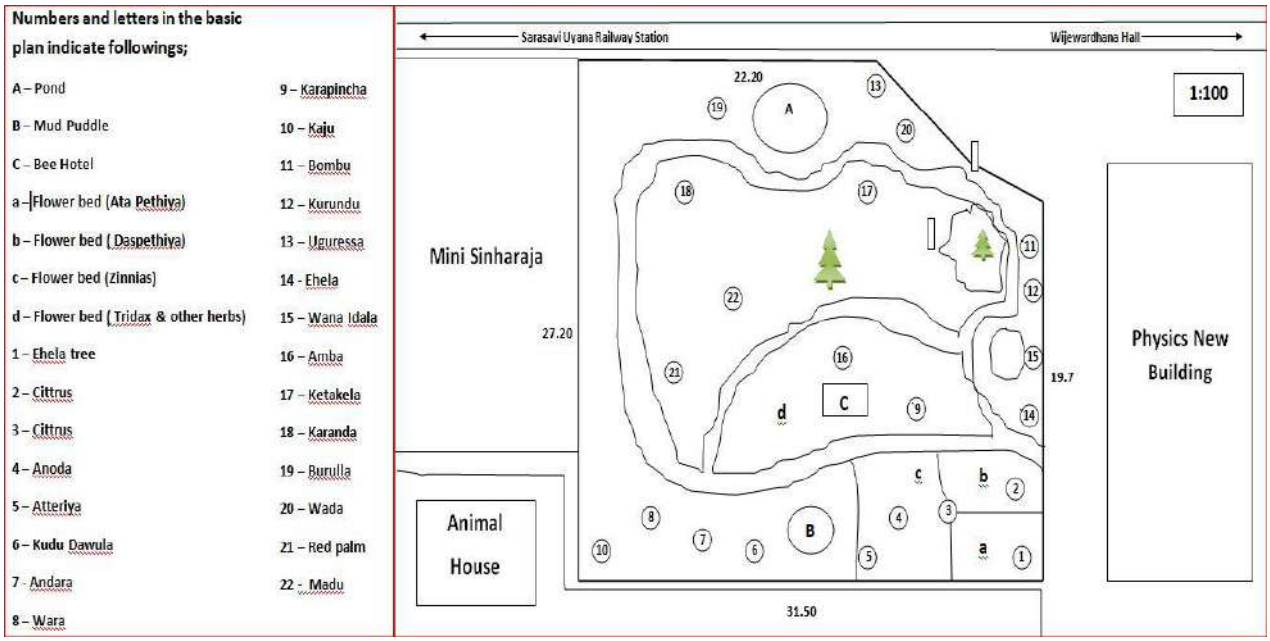

Figure 10: Plan of the Butterfly & Bee Garden

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