The Fauna of Sri Lanka:

Status of Taxonomy, Research and Conservation

Edited by
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Battaramulla, Sri Lanka

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Message from the Country Representative of IUCN Sri Lanka

In the year 2004, after a lapse of nearly two decades, The World Conservation Union (IUCN), in collaboration with the Biodiversity Secretariat of the Ministry of Environment organized a series of national workshops on the status of fauna in Sri Lanka.

The intention of organizing these workshops was to upgrade and disseminate the knowledge pertaining to taxonomy, ecology and research on the fauna of the island through presentations made by eminent scientists and naturalists, based on recent research. Since a wealth of information was presented at these workshops, IUCN recognized the need to compile this valuable knowledge and information into a single comprehensive publication, which could be used by a variety of stakeholders, including policy makers, protected area managers, researchers, conservation biologists, environmentalists and students.

Most of the scientists who presented papers at these national workshops came forward voluntarily to write up full papers on their research in relation to taxonomy, ecology and the conservation of fauna in Sri Lanka. Thus, this publication includes updated information on all groups of inland vertebrate fauna, selected groups of inland invertebrate fauna and selected groups of marine fauna.

We wish to thank all the scientists and naturalists who contributed towards this publication and sincerely acknowledge the group of peer reviewers that included Sri Lankan and foreign scientists who assisted us to review each paper in order to enhance the technical quality of this publication.

We sincerely hope that this publication would be used by various stakeholders for the conservation of fauna in Sri Lanka.

Mrs. Shiranee E Yasaratne
Country Representative
The World Conservation Union (IUCN)
Sri Lanka

Message from the Secretary of the Ministry of Environment, Sri Lanka

It is with great pleasure that I write this message for this comprehensive publication on the status of fauna in Sri Lanka, on behalf of the Ministry of Environment. Being the government focal member, the Ministry of Environment has been actively involved in biodiversity conservation activities in collaboration with IUCN – The World Conservation Union in Sri Lanka, during the past two decades. Such collaborations have resulted in several valuable outputs, including publications such as the 1999 Biodiversity Conservation Framework for Action, and several workshops to raise awareness and/or build capacity to conserve the rich biodiversity in the island. The Ministry decided to co-finance the printing of this publication through financial assistance from the ADB/GEF funded Protected Area Management and Wildlife Conservation Project, in order to disseminate it and provide information on the current status of fauna in Sri Lanka, among a wider group of stakeholders including researchers, students, teachers and policy makers. I am confident that this publication would contribute towards promoting research on the different groups of fauna in the island, and also be used to develop and implement relevant conservation policies. I wish to thank all the researchers who contributed with very interesting papers on the status of different groups of fauna, in order to make this publication a success.

Mr. Jayalath R. W. Dissanayake
Secretary
Ministry of Environment
Sri Lanka

Dedication

This publication is dedicated to the memory of late Prof. Felix Prashantha Amerasinghe, a brilliant research scientist and an exemplary university academic who contributed immensely towards the development of natural sciences in Sri Lanka.

Although initially selected to enter medical college, Prof. Amerasinghe, in his youth, opted to pursue biological sciences as an undergraduate at the University of Ceylon, Peradeniya, Sri Lanka, where he obtained a First Class Honours Degree in Zoology. Subsequently, he obtained a Ph.D. in Entomology from the University of Bristol, UK. He commenced his university teaching career in 1972 as an Assistant Lecturer at the Department of Zoology, University of Peradeniya, Sri Lanka, where he served for nearly three decades. In 1996, he was appointed Professor of Applied Zoology and between 1998 and 1999, held the position of Head of the Department of Zoology, University of Peradeniya, Sri Lanka. Between 1990 and 1992, Prof. Amerasinghe also served as a Visiting Associate Professor at the Department of Entomology, University of Maryland, USA. He was a dedicated teacher who possessed unique teaching skills that encouraged and stimulated students to develop an interest in biology.

As a research scientist, Prof. Amerasinghe specialised primarily in the field of Medical Entomology. He was very methodical and systematic in his research work, with extra-ordinary commitment to deliver scientifically objective and high quality outputs. During his research career spanning 35 years, he was able to publish more than 80 peer-reviewed papers in reputed national and international journals, and also present more than 50 papers at national, regional and international conferences. He believed in applied research that would benefit the country and the world at large. He made an invaluable contribution to the field of Medical Entomology, through his pioneering research work on mosquito ecology and taxonomy. The findings of his enduring research work enabled the government of Sri Lanka to design and implement effective malaria control programmes, especially in the Mahaweli irrigation systems. Apart from his primary research interests related to Medical Entomology, he also pursued an interest in the field of ecology and biodiversity as an ardent naturalist. Some of his unique research related to these fields include the study of food habits of the Sri Lankan Leopard, and description of the structure and identification of the hairs of the mammals of Sri Lanka.

He supervised the research work of several undergraduate and postgraduate students in Sri Lanka, where his able guidance enabled them to complete their research successfully and pursue their careers in the field of biology. He always encouraged creative thinking amongst students, and promoted constructive criticism and positive approaches in designing and implementing research work.

Prof. Amerasinghe held several professional affiliations, in national and international scientific bodies. A few that highlight his reputation and credibility as a scientist include being a Fellow of the National Academy of Sciences of Sri Lanka, Fellow of the Institute of Biology, Sri Lanka, Fellow of the Royal Society of Tropical Medicine & Hygiene, and Member of the Entomological Society of America. He also held chairmanship of committees and councils in several professional associations and national institutes in Sri Lanka.

His expertise was regularly sought by many international organizations, including the World Health Organization (WHO), Food and Agriculture Organization (FAO) and the United Nations Environment Programme (UNEP), where he was hired as an advisor on assignments related to vector control. He was invited to be one of the Lead Authors of the Millennium Ecosystem Assessment and was also a member of an international working group on a WHO/UNEP-commissioned project on Biodiversity and Human Health. He carried out several short-term consultancies in countries such as the Philippines, Pakistan, Thailand and India.

At the time of his unexpected demise, he held the position of Theme Leader overseeing the global research program related to the Water, Health and Environment Theme of the International Water Management Institute (IWMI), a CGIAR-supported research institute with headquarters in Colombo, Sri Lanka. During his six year tenure at IWMI, he initiated a collaborative partnership with The World Conservation Union through a unique project integrating biodiversity conservation aspects into an irrigation development scheme in Southern Sri Lanka. This was the first time in Sri Lanka where conservation concerns were addressed parallel to the implementation of a large-scale irrigation development and agricultural settlement scheme. Prof. Amerasinghe managed to introduce the concept of eco-agriculture into this project.

Prof. Amerasinghe received several national and international research awards and honours, for his unique research work. In 2001, he brought immense honour and glory to his motherland by being included in the First Edition of the "2000 OUTSTANDING SCIENTISTS OF THE 21ST CENTURY" published by the International Biographical Centre, Cambridge, England.

His untimely demise, which left a vacuum in the field of biological research in Sri Lanka, is an irreplaceable loss to the scientific community of the world.

Acknowledgements

The World Conservation Union gratefully acknowledges the scientists and naturalists who contributed their findings through scientific papers towards making this publication possible. The Union would also like to thank the following scientists who reviewed the papers in this publication for technical content: Dr. Pamela Rasmussen, Michigan State University Museum West Circle Drive, East Lansing, MI, USA; Prof. Colin P. Groves, School of Archaeology & Anthropology, Australian National University, Canberra, Australia; Dr. Indraneil Das, University of Sarawak Malaysia, Kota Samarahan, Sarawak, Malaysia; Mr. Sanjay Molur, Zoo Outreach Organization, Coimbatore, India; Prof. Jayanthi Edirisinghe, Department of Zoology, Faculty of Science, University of Peradeniya, Sri Lanka; Dr. Michael van der Poorten, Wariyapola, Sri Lanka; Mr. Rohan Pethiyagoda, Wildlife Heritage Trust, Sri Lanka; Mr. Jerker Tamelander, Regional Marine Programme, Asia Regional Office, Colombo 7, Sri Lanka; Dr. Sriyanie Miththapala, IUCN - Asia Regional Office, Colombo 7, Sri Lanka and Dr. Channa Bambaradeniya, Regional Species Programme, IUCN - Asia Regional Office, Colombo 7 Sri Lanka.

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Editorial

Species Richness of Fauna in Sri Lanka: Current Status and Future Prospects

Taxonomic research on the faunal groups of Sri Lanka has undergone a tremendous growth since the 1990s, initiated by a handful of Sri Lankan naturalists and taxonomists. This has resulted in the discovery and scientific description of several new species of invertebrate and vertebrate fauna. In particular, the numbers of amphibian and freshwater crab species have increased considerably, due to intensive scientific surveys of these groups. The number of amphibian species recognised by Kirtisinghe (1957) has undergone a three-fold increase (102 species at present), as a result of the work carried out during the past decade by Dutta and Manamendra-Arachchi (1996); Manamendra-Arachchi and Pethiyagoda (1998); Manamendra-Arachchi and Pethiyagoda (2005); Meegaskumbura and Manamendra-Arachchi (2005). Similarly, over the past 12 years, a surge in interest of research on Sri Lanka's freshwater crabs has resulted in the discovery of more than 40 new species (Ng, 1994, 1995a, b; Bahir, 1998, 1999; Ng and Tay, 2001; Bahir and Ng, 2005; Bahir and Yeo, 2005). It is interesting to note the discovery of new species even among popular groups of vertebrates such as birds (Warakagoda and Rasmussen, 2004) and mammals (Groves and Meijaard, 2005), after a lapse of more than 100 years. It is also encouraging to note that a few researchers have begun to focus on lesser-known invertebrates such as insects, spiders and land snails in the island, leading to the discovery of new species (Karunaratne, 2004; Wijesinghe, 1991a, 1991b; Benjamin, 2000; Benjamin and Jocqué, 2000; Benjamin, 2001; Naggs *et al*., 2005).

Although many species of fauna have been described recently in Sri Lanka, there was no attempt to collate updated information in the form of a single publication, in order to facilitate and enhance research, education, awareness and conservation activities. This publication is intended to collate and present updated information on the status of taxonomy, research and conservation of different groups of fauna in Sri Lanka. Based on the papers appearing in this publication, the current species richness among different groups of fauna in Sri Lanka is presented in Table 1.

Table 1. Species richness of inland and marine fauna in Sri Lanka. (The number of endemic species is presented in parenthesis)

Group	Number of Species
Invertebrate Fauna	
Bees	148 (21)
Dragonflies (Odonates)	120 (57)
Aphids	84 (2)
Ants	181
Butterflies	243 (20)
Ticks	27
Spiders	501
Freshwater Crabs	51 (51)
Land Snails	246 (204)

Group	Number of Species
Vertebrate Fauna	
Freshwater Fish	82 (44)
Amphibians	102 + (88+)
Reptiles	184 (105)
Birds	482 (33)
Mammals	91(16)
Marine Fauna	
Echinoderms	213
Marine Molluscs	228
Sharks	61
Rays	31
Marine Mammals	28

This recent research also highlights a higher degree of endemism than hitherto estimated among most groups of fauna in the island. Among the inland indigenous vertebrate species (i.e., excluding marine forms and migratory birds) described currently, 43% are endemic to Sri Lanka. A higher percentage of endemism is evident among the freshwater crabs (100%), amphibians (86%), and land snails (83%), with many of them being point endemics. Most of this endemic fauna are restricted to the wet zone of the island. Even though Sri Lanka has experienced prolonged land connections with India during much of the Pleistocene period, recent molecular investigations have revealed a unique endemic insular radiation, especially among the less mobile faunal groups such as tree-frogs (Meegaskumbura *et al*., 2002), agamid lizards (Macey *et al*., 2000; Schulte *et al.*, 2002) and skinks (Austin *et al*., 2004).

Several measures are needed to further enhance our current knowledge and understanding on the richness of fauna in Sri Lanka. Although there are several theories pertaining to the biogeographic evolution in Sri Lanka and India, none of them have been able to unravel gaps and pecularities in the geographic distribution of taxa, and many of the evolutionary processes are yet to be understood adequately. Therefore, researchers from the two countries should pursue in collaborative studies related to biogeography. As highlighted in some papers of this publication, comprehensive taxonomic revisions need to be carried for several groups of fauna, and a close collaboration between taxonomists in India and Sri Lanka is a prerequisite to such taxonomic revisions. Careful examination - both morphological and molecular - of Indian and Sri Lankan faunal specimens, through collaborative and synchronised taxonomic investigations, is necessary to address problems related to taxonomy. The lack of a well-maintained national faunal repository in Sri Lanka is a major obstacle to taxonomists studying different groups of fauna. The type specimens of many faunal taxa described to date are located in museums of the developed world, which can be accessed only by a handful of taxonomists and naturalists. Therefore, attempts should be made to upgrade the faunal repository of the National Museum of Sri Lanka, and encourage researchers to deposit type specimens there. This would certainly encourage young researchers to become involved in the study of fauna in Sri Lanka.

With current trends in development, many ecosystems and with them, their species, are under severe pressure, if not under threat, from human activities. Continued taxonomic research will provide a sound scientific foundation on which conservation and management decisions about the fauna of Sri Lanka can be based.

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Section 1:

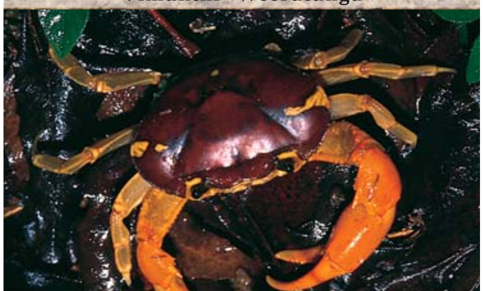
Status of Invertebrate Fauna in Sri Lanka

Scolia aureipenniformes
Naalin Perera

Tetrathemis yerburiya
M. Bedjanic

Nephila maculata
Naalin Perera

Pathysa antiphates
Vimukthi Weeratunga



Oziotelphusa hippocastanum
Wildlife Heritage Trust

The Fauna of Sri Lanka (2006): 3-11

An Overview of the Taxonomic Status of Class Hexapoda (Insecta) in Sri Lanka

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Abstract

A project initiated to compile a list of all insect species recorded from Sri Lanka found the names of 11,144 species belonging to 30 insect orders, the only order not represented in Sri Lanka being Grylloblattodea. The number of insects recorded from Sri Lanka is 53% of all known organisms in Sri Lanka and 81% of the known animal species, according to the biodiversity data given in Statistical Compendium 2000. Our knowledge of Sri Lankan insects, however, varies widely according to the order. The five apterygote orders are probably the least studied; no attempts to systematically collect or comprehensively study Sri Lankan material belonging to any of these orders were found.

There seem to be four impediments for research on insect taxonomy in Sri Lanka. They are (a) lack of passionate amateur entomologists and trained taxonomists, (b) lack of well-curated insect collections in the country and poor accessibility to existing collections, (c) lack of well -organized training in systematic entomology, and (d) lack of comprehensive literature collections.

Key words: *Insects, Taxonomy*

Status of Insect Taxonomy in Sri Lanka

Taxonomy is the science of discovering, describing and classifying species. The taxonomic knowledge of a group of organisms in a country or region includes the number of described species in that country or region, their names, their place in a systematic classification and the means for their identification. It has been claimed by some writers that insects are a taxonomically poorly known group in Sri Lanka. For example, while reporting the presence of over 5,000 species of plants in Sri Lanka the authors of several recent publications on biodiversity and the environment display awareness of the presence of only a very few insect groups in Sri Lanka; the number of insect species recorded from Sri Lanka according to these publications ranges between 900-1,200 (SOBA, 1994; Statistical Compendium 2000; State of the Environment 2002). This, however, is not an accurate representation of the state of the taxonomic knowledge of Sri Lankan insects, nor a true picture of the actual diversity and richness of Sri Lanka's insect fauna. Even as far back as 1861 Walker listed 2,007 species recorded from the country belonging to nine insect orders (Tennent, 1861), and Haly (1890) listed 1,510 beetle species alone in the collection of the Colombo Museum. Since then numerous entomologists have added significantly to the taxonomic knowledge of Sri Lankan insects. Among them E.E. Green, G.M. Henry, C.H. Fernando and C. V. Krombein have made notable contributions. For most groups of Sri Lankan insects this information is widely scattered in the vast taxonomic literature going back to the mid 19th century. For only a very few groups are there comprehensive accounts available dealing with the Sri Lankan species.

Wijesekara and Wijesinghe (2003) made an attempt to compile a list of all insect species recorded from Sri Lanka. Although a list was not published they found the names of 11,144 species recorded from Sri Lanka belonging to 30 insect orders, the only order not represented in Sri Lanka being the Grylloblattodea. This number is 53% of all known organisms in Sri Lanka and 81% of the known animal species, based on the data found in Statistical compendium 2000. This information is currently being used to compile a database of all known Sri Lankan insects. The database will consist of the valid name, synonyms, literature references, distribution, and where available photographs of all Sri Lankan insects. This work has been financed by the Council for Agriculture Research Policy (CARP) in Sri Lanka. The objective of this paper is to present the status of taxonomic knowledge of Sri Lankan insects under each insect Order represented in Sri Lanka. The orders are not listed in any particular systematic sequence.

Apterygote Orders

Of all the insect orders represented in Sri Lanka the five apterygote orders are probably the least studied. There has been no attempt to systematically collect or comprehensively study Sri Lankan material of any of these orders. Our knowledge of these orders in Sri Lanka is based on random descriptions of species by various taxonomists based on material found among the collection of other insects from Sri Lanka. Information on these orders can be found in Ritter, 1910-1; Imms, 1912; Nosek, 1976; Fernando, 1958; Pages, 1984; Silvestri, 1913 and Wygodzinsky, 1957. Number of species known to occur in Sri Lanka under each order is given by Wijesekara and Wijesinghe (2003).

Smaller Pterygote Orders

Ephemeroptera, Odonata, Orthoptera and Phasmatodea

The order Ephemeroptera is represented in Sri Lanka by 46 species in 8 families. This is a relatively well-studied insect group in Sri Lanka. Hubbard and co-workers studied the systematics, phylogeny and ecology of this order from Sri Lanka (Hubbard and Peters, 1978; Hubbard, 1983; Hubbard, 1985). Many taxonomists have studied Sri Lankan Odonata, too. De Fonseka (1998) compiled the taxonomic knowledge of this group from Sri Lanka according to which there are 117 species in 12 families representing this order. It should also be regarded as a better studied group in the country. A recent revival of interest on this group is evident, by the work initiated by Bedjanic (2002, 2004). Some notable taxonomic work on Sri Lankan Odonata includes Laidlaw, 1924; Fraser, 1933; Laidlaw, 1951 and Lieftinck, 1955.

G.M. Henry (better known in Sri Lanka for his work on birds) is mainly responsible for our considerable knowledge of the Orthoptera of Sri Lanka (Henry, 1933, 1934, 1937, 1939, 1940, 1942, 1944). In addition, Chopard (1936) and Sandrasagara (1949) have studied Sri Lankan Orthoptera, including the families Acrididae and Gryllidae. Phasmatodea of Sri Lanka is also well known. In the most recent study of this group, Henneman (2002) recorded 69 species from this country. This study is a good example of how things are with most of the insect taxa in Sri Lanka. Hennemann collected Phasmatodea in only 4 locations, Kandapola, Gelioya, Hunnas falls and roadside on the way to Hunnas falls from Kandy. Studying this material he revised some groups of the Order and found many synonyms and few new species. Similar studies are needed for many insect groups of Sri Lanka.

Blattaria, Mantodea, Dermaptera, Isoptera and Embioptera

There are records of 66 species of Blattaria (cockroaches) from Sri Lanka. However no exclusive taxonomic studies on Sri Lankan cockroaches have been conducted so far, leading to a relatively poor knowledge of this group. Present knowledge consists of scattered descriptions of species in world literature. Unlike cockroaches, the order of praying mantises (Mantodea) is better known (Henry, 1931, 1932; Beier, 1956).

The knowledge of Dermaptera of Sri Lanka is fairly complete. Earlier records of Sri Lankan species were first compiled by Burr (1901), and Brindle (1972) revised this Order for Sri Lanka. There are records of 56 species of termites from Sri Lanka. Green in 1913 first compiled a catalogue of Isoptera for Sri Lanka. Since then, except for additions of a few new species and records, no comprehensive taxonomic work dealing exclusively with Sri Lankan termite species has been published. The tea research institute of Sri Lanka (TRI) is conducting studies on Isoptera but their main concern is on ecology and control of pest species. Knowledge of Embioptera is limited to 4 species, which Ross recorded in 1979. Ross (personal communications) is in the opinion that many more species could be present in this country.

Plecoptera, Zoraptera, Psocoptera, Pthiraptera, Thysanoptera, Neuroptera, Mecoptera and Siphonaptera

Taxonomic knowledge on Plecoptera, Zoraptera and Pthiraptera in Sri Lanka is very poor and limited to scattered description of species. Zwick (1980) studied the Plecopteran genus *Neoperla* from Sri Lanka. It is necessary to conduct systematic studies on these groups to improve our knowledge. New (1977) studied two Psocopteran families, Epipsocidae and Pseudocaeciliidae, from Sri Lanka. There is very little information on thrips (Thysanoptera) of Sri Lanka. Schmuts in 1913 reported all known thrips from Ceylon and since then only Oda et al have done any exclusive work on Sri Lankan thrips. The study of Oda et al. (1997) was limited to a small collection from Sri Lanka. Very little information limited again to isolated descriptions of species is available on Sri Lankan Neuroptera, Mecoptera, and Siphonaptera which indicate the need for taxonomic study of these groups. Meinander (1982) studied the Neuropteran Family Coniopterygidae of Sri Lanka.

Hemiptera, Homoptera, Trichoptera and Strepsiptera

There are over 794 species of Hemiptera recorded from Sri Lanka (Wijesekara and Wijesinghe, 2003). The only comprehensive work is that by Distant (1902-1918) in the Fauna of British India series. His seven-volume work needs to be used carefully as it contains numerous errors. However, many others have studied various families of Hemiptera from Sri Lanka. Even so many large families such as the Pentatomidae and Reduviidae are yet to be comprehensively studied. Slater (1972) studied a collection of Lygaidae from Sri Lanka and gave a checklist for the Family. Wijesekara and Henry (1999) have started to work on Miridae of Sri Lanka and the study is being continued with the intension of revising the Family. In addition a Catalog of Hemiptera of Sri Lanka is being compiled as a collaborative work between the Sri Lanka Department of Agriculture and United States Department of Agriculture.

The status of Homoptera is similar to that of Hemiptera. Some groups have been studied but a comprehensive work for the Order is lacking. There are few major studies on this group: Reen, 1896-1922 (Coccoidea); Goot, 1918 (Aphidae); Fenna, 1975 (Delphacidae); Pringle, 1955 (Cicadidae); and Melichar, 1903 (Homoptera). Trichoptera is another group that has been fairly well studied. Schmid (1958) and Malicky (1973) did exclusive studies of Sri Lankan Trichoptera. There are several recent works including a checklist of Strepsiptera of Sri Lanka (Kathirithamby, 1994; Kifune, 1997). However there has not been any systematic collection of this group in the country.

Larger Pterygote Orders

Diptera

The order Diptera is the fourth largest insect order in Sri Lanka, consisting of 1,341 species (Wijesekara and Wijesinghe, 2003). A substantial amount of taxonomic work has been done on various families of Diptera in Sri Lanka. Notable studies include Amerasinghe, 1983, 1987, 1989, 1990, 1991 (Culicidae); Burger, 1981 (Tabanidae); Camras, 1957 (Conopidae); Davies and Gyorkos, 1987-1989 (Simuliidae); Hardy, 1971 (Bibionidae); Oldroyd, 1957 (Tabanidae); Wijesekara, 2002 (Agromyzidae), etc. There are many more families yet to be studied from Sri Lanka.

Hymenoptera

Hymenoptera is the third largest insect order in Sri Lanka. It is considered that Hymenoptera is a better-studied group in Sri Lanka. But it is no better studied than other larger insect orders represented in the country. Hymenoptera is a large Family divided in to 20 super families. Symphyta is not well represented in the country. Smith (1982) studied the Symphyta. Most of the work on Sri Lankan Hymenoptera has concerned three superfamilies of Apocrita. Recent work has been mainly based on the Smithsonian Institution project ‘Biosystematic Studies on Ceylonese Insects’ led by Dr. K. V. Krombein. Krombein (1978-1998) revised many groups of Apocrita from Sri Lanka. The informal division Parasitica includes mostly micro Hymenoptera and they are very specious. Very little work has been done on micro Hymenoptera of Sri Lanka. Even economically very important groups like Ichneumonoidea are yet to be systematically studied. Notable works on Sri Lankan Parasitica include Dessart, 1975, 1988 and Wijesekara and Schauff, 1994. Recent initiatives have also been taken to study the other hymenopteran groups in Sri Lanka. For instance, Dias (2002a, 2002b, 2003) has initiated work on ants, while Karunaratne (2004) has done a comprehensive study on the taxonomy and ecology of bees of Sri Lanka.

Lepidoptera

The order Lepidoptera is the second largest insect Order in the county with 2,158 species (Wijesekara and Wijesinghe, 2003). It is divided into 32 superfamilies. The only group we know well is the butterflies, most of which are in the superfamily Papilionoidea. Many taxonomists have worked on the butterflies of Sri Lanka and a fair amount of taxonomic studies and identification guides are available for the group (Ormiston, 1924; Woodhouse, 1952; d'Abrera, 1998). Since Hampson's (1892-1896) account of Sri Lankan Lepidoptera in the Fauna of British India very little work has been done on moths and other microlepidoptera of Sri Lanka. Recent works on of Sri Lanka Lepidoptera other than butterflies include Wu and Pack, 1998, 1999; Buttiker, 1962; Diakonoff, 1982 and Orhant, 1981.

Coleoptera

The Coleoptera of Sri Lanka includes at least 3,033 species. The taxonomic status of this order is more or less similar to that of other large orders. Being the largest group of insects in Sri Lanka (also the world) there are more to study than what we already know. Some recent work on Sri Lankan Coleoptera include; Bonadona, 1986 (Anthicidae); Chujo, 1975 (Erotylidae and Languridae); Hammond, 1972 (Staphylinidae: Oxytelini); Kaszab, 1980 (Tenebrionidae); Lobl, 1971 (Scaphidiidae); Medvedev, 1989 (Chrysomelidae); Ohira, 1973 (Elateridae); Therond, 1971 (Histeridae); Ullrich, 1975 (Staphylinidae: Tachyporinae); Wewalka, 1973 (Dytiscidae); Wiesner, 1975 (Cicindelidae); Wittmer, 1956, 1973 (Drilidae, Cantharidae, Prionoceridae). The Coccinellidae of Sri Lanka is being studied at Horticulture Research and Development Institute, Gannoruwa under a CARP funded project with the objective of preparing an identification guide for this important group.

Insect Taxonomy in Sri Lanka - Constraints

Most taxonomists who have studied Sri Lankan insects in the past were not Sri Lankans and this continues to be the case. If there were more local scientists working in this field our knowledge of Sri Lankan insects would have been much better by now. However, there are a few noteworthy local taxonomists who have contributed to increase the knowledge of Sri Lankan insects since Sri Lanka gained independence in 1948. Karunaratne, Fernando (C.H.), Amerasinghe, and Wijesekara have contributed by describing new species from Sri Lanka and compiling the taxonomic knowledge of several groups. W. Fernando also described many new insect species from Sri Lanka but his types are lost and most descriptions cannot be used to recognize the species. When one contemplates the present status of insect taxonomy in Sri Lanka one can identify three major impediments, though they are not exclusive of each other. First and foremost among the impediments is the lack of passionate amateur entomologists. It may be due to cultural taboo in the country that leads most people to teach children to avoid or let alone the animals they find in their environment. The second impediment is the lack of well-curated insect collections in the country. The national insect collection is not housed adequately nor well curated. The status of a few existing smaller collections is the same. In addition, these collections are virtually inaccessible even to local researchers as they are simply kept locked up. The third impediment is the lack of well-organized education in systematic entomology. There is no satisfactory training in modern systematic biology available even at university level, where the subject should be taught in conjunction with insect ecology, evolutionary biology, genetics, molecular biology and biological illustrations. Lack of comprehensive literature collection is the fourth impediment. Local libraries do not subscribe to any modern taxonomic journals. There is a fairly good collection of old literature but no one seems to take notice of the availability or need to preserve what is available. It is ironic that sometimes it is easier to find a locally published item in a library outside the country!

That is briefly my knowledge of the status of insect taxonomy in Sri Lanka. I will let readers to draw their own conclusions from this short review.

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Current Status and Future Directions in Bee Taxonomy in Sri Lanka

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Abstract

Bees (Hymenoptera:Apoidea) are the most important pollinators of flowering plants resulting in fruit and seed production. Bees are unique among all other pollinators due to the presence of special pollen carrying hairs on their body. The very first record of taxonomic work on bees of Sri Lanka dates back to 1897 and was later followed by the Smithsonian Surveys in the late 1970's. A recently conducted field study in 29 collection sites distributed among 13 districts of Sri Lanka led to the identification of 148 species of bees in 38 genera and 4 families. Among them are 5 genera and 15 species of bees previously not recorded from Sri Lanka and a bee species new to Science. Of the so far known bees, twenty one species are considered to be endemic to Sri Lanka. Based on field collections made in 29 sites, the highest number of bee species was recorded from the Low Country Dry Zone. Of the different habitats from which the bees were collected agricultural habitats documented the highest diversity of bees. Floral hosts on which bees were collected consisted of 167 species in 115 genera distributed in 44 plant families. Weeds and wild flowers were the most preferred floral hosts of bees being visited by 129 bee species, followed by vegetable crops and trees. Many gaps in our knowledge of bees were evident during our study. The need to conduct year round surveys especially in the Dry and Arid Zones of the country has been highlighted. Priority should be given to the revision of taxa in the light of new findings. Collaboration with experts on different taxa in the region is essential for this purpose. Proper management and protection of bee nesting sites and their foraging plants would lead to the conservation of bees.

Key words: *Bees, Taxonomy, Diversity, Floral hosts, Affinities*

Introduction

Bees (Hymenoptera: Apoidea: Apiformes) are the most important pollinators of flowering plants resulting in fruit and seed production. The specialized hairs on different parts of the body enable bees to carry pollen thus making them different from all other hymenopterans. Bees are an ancient group of insects that originated about 120 million years ago (Roubik, 1992). The present distribution of bees depends on their ability to reach suitable areas under their own power (Michener, 2000). The highest bee diversity has been recorded from warm temperate, desert regions of the world.

The world bee fauna comprises 16,325 species in 425 genera and 7 families (Michener 2000). From both temperate and tropical India about 2,500 species of bees have been recorded (Gupta, 2003). From Sri Lanka, 148 species of bees in 38 genera and 4 families have been recorded (Karunaratne, Edirisinghe and Pauly, 2005). The floral hosts of the documented bees comprise 167 species in 115 genera and 44 plant families (Karunaratne, 2004).

Taxonomic History

The published work on bees of Sri Lanka dates back to the British Colonial Period when Dalla Torre (1896) listed 17 species of bees from Sri Lanka. Bingham (1897) recorded and described 42 species of bees from Sri Lanka. Through a survey of published literature on bees of Sri Lanka, Wijesekara (2001) compiled an annotated list of bees of Sri Lanka documenting 132 bee species in 25 genera and 4 families. In addition to the latter two noteworthy publications on bees several others have described numerous species of bees from Sri Lanka. Among them are Sakagami and Ebmer (1987), Schwarz (1990), Sakagami (1978 and

1991), Sakagami, Ebmer and Tadauchi (1996 and 1998), Snelling (1980) and Baker (1996). The landmark publication on the bees of the world by Michener (2000) includes 29 genera and several subgenera of bees that have been documented form Sri Lanka. The Smithsonian Sri Lanka Insect Survey has resulted in the identification of several bee species. Duplicate specimens of bees identified through this survey have been deposited in two locations in Sri Lanka. The insect collection at the National Museums, Colombo holds about 58 species and about 42 species are held in the Invertebrate Systematics and Diversity Facility (ISDF) of the Department of Zoology, University of Peradeniya.

Following the work of Bingham (1897) and the Smithsonian Survey, recently local scientists undertook taxonomic studies on bees, their floral hosts and nesting. The recent study (Karunaratne, Edirisinghe and Pauly, 2005) documented 148 species of bees that are deposited in the ISDF of the Department of Zoology, University of Peradeniya.

Diversity of Bees

The world bee fauna according to Michener (2000) is classified under seven families of which only four families are known to occur in Sri Lanka (Appendix 1). The four families are Apidae (with 9 genera and 58 species), Colletidae (with one genus and two species), Halictidae (with 19 genera and 53 species) and Megachilidae (with 9 genera and 35 species). Apidae and Halictidae are the most specious families of bees in Sri Lanka while the two genera Lasioglossum and Megachile include the most number of species.

The recent study conducted in Sri Lanka documented 5 genera and 15 species of bees previously not recorded and a species new to science. Karunaratne, Edirisinghe and Pauly, (2005) provides an updated list of bees with new records. The so far recorded bees numbering 148 species are listed in Appendix 1.

Affinities of the Bee Fauna

Of the 38 bee genera recorded from Sri Lanka 10 genera are cosmopolitan in distribution according to Michener (2000). These include the well-known bee genera such as *Apis, Ceratina, Lasioglossum, Megachile,* and *Xylocopa.* The remaining bee genera are shared with one or more zoogeographic regions of the world while one genus is confined to the Oriental Region. Our bee fauna has close affinities with the Ethiopian Region where 34 of our genera (89%) are shared with this region. Eighteen genera (47%) are shared with the Palearctic Region and another 18 genera with the Australian Region.

With reference to the bees of the Indian subcontinent (Gupta 2003), 18 of our bee species have been recorded from other countries of the subcontinent other than India. About 30 species of our bees have also been recorded from neighbouring India. It is noteworthy that of them, seven species are confined to Sri Lanka and India.

Floral Hosts of Bees

Floral relationships of bees of Sri Lanka have not been recorded previously except for the four well known species of honeybees (Punchihewa, 1994) and *Euaspis edentata* (Gupta, 2003). The recent field study by Karunaratne (2004) documented 167 species of plants as floral hosts of bees. Pollen carriage by these flower-visiting bees was also documented.

The documented floral hosts of bees consist of 167 species of plants in 115 genera and 44 families. Of the different plant families, Fabaceae included the most number of bee floral hosts (23 species). Majority (51%) of the floral hosts of bees were indigenous plants. Naturalized exotic floral species (44%) were equally attractive to bees. Wild flowers were the most frequented floral hosts of bees followed by vegetable crops. Flowers of 6 plant species attracted unusually large number of bee species. Of them, *Hyptis suaveolens,* a naturalized exotic weed is highly attractive to bees from which 60 species of bees were recorded.

Nesting Ecology

Bees are diverse in their nesting habits. Honeybees make hives in which they store honey and pollen for their young. All other bees are termed pollen bees as they store only pollen to feed their young. Pollen bees have diverse nesting habits. Majority are ground nesters. Others nest in plant stems, in wood and in crevices.

Krombein and Norden (2001) were the first to record nesting in pollen bees in Sri Lanka during the Smithsonian Surveys. Three species of trap nesting bees, *Anthidiellum butarsis*, *A. krombeini* (Megachilidae) and *Hylaeus sedens* (Collectidae) have been reported. Recent field study identified 16 species of trap nesting bees in the families Apidae (5 species) and Megachilidae (8 species). Thirteen species of ground nesting bees were also recorded. Nesting in three species of wood boring carpenter bees of the Genus *Xylocopa* were also documented.

Gaps in Bee Taxonomy

The major constrains in bee taxonomy in Sri Lanka is the lack of regional bee specialists. Revision of known taxa is an essential task. Recent upgrading of the subfamily Nomiinae in Sri Lanka (Karunaratne, Edirisinghe and Pauly, 2005) resulted in 11 genera of bees that were previously under 3 genera. This highlights the need for revision of our bee taxa by experts of the regional fauna. Lack of an expert identified reference bee collection in the country is a major impediment to taxonomy.

Conservation

Being the most efficient pollinators of most of our flowering plants including certain crops, conservation priorities and proper management plans should focus on bees. Conserving the floral hosts that provide food for bees and their nesting sites is a priority. Rational and planned application of insecticides and weedicides that would affect the bees the least should be followed. Measures such as application of insecticides prior to flowering and at a time of the day when bees are less active on flowers (late evenings) would minimize their exposure to such chemicals.

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Appendix 1: List of Bees recorded from Sri Lanka.

FAMILY – COLLETIDAE

SUBFAMILY - HYLAEINAE

Hylaeus krombeini Snelling, 1980
Hylaeus sedens Snelling, 1980

FAMILY - HALICTIDAE

SUBFAMILY - HALICTINAE

Halictus (Seladonia) lucidipennis Smith, 1853
Homalictus singhalensis (Blüthgen, 1926)
Homalictus paradnanus (Strand, 1914)
Lasioglossum (*Ctenonomia*) *amblypygus* (Strand, 1913)
Lasioglossum (Ctenonomia) cire (Cameron, 1897)
Lasioglossum (*Ctenonomia*) *clarum* (Nurse, 1902)
Lasioglossum (*Ctenonomia*) *semisculptum* (Cockerell, 1911)
Lasioglossum (*Ctenonomia*) *vagans* (Smith, 1857)
Lasioglossum (Evylaeus) carinifrons (Cameron, 1904)
Lasioglossum (Nesohalictus) halictoides (Smith, 1859)
Lasioglossum (Nesohalictus) serenum (Cameron, 1897)
Lasioglossum (Sudila) alphenum (Cameron, 1897)
Lasioglossum (Sudila) aulacophorum (Strand, 1913)
Lasioglossum (Sudila) bidendatum (Cameron, 1898)
Lasioglossum (Sudila) kandiense (Cockerell, 1913)
Pachyhalictus bedanus *(Blüthgen, 1926)*
Pachyhalictus kalutarae (Cockerell, 1911)
Pachyhalictus sigiriellus (Cockerell, 1911)
Pachyhalictus vinctus (Walker, 1860)
Sphecodes biroi Friese, 1909
Sphecodes crassicornis Smith, 1875
Sphecodes decorus (Cameron, 1897)

SUBFAMILY - NOMIINAE

Austronomia notiomorpha Hirashima, 1978
Austronomia krombeini Hirashima, 1978
Austronomia sp. 1
Austronomia sp. 2
Curvinomia formosa (Smith, 1858)
Curvinomia iridiscens (Smith, 1857)
Hoplonomia westwoodi (Gribodo, 1894)
Leuconomia sp.
Lipotriches basipicta (Wickwar, 1908)
Lipotriches bombayensis (Cameron, 1908)
Lipotriches comberi (Cockerell, 1911)
Lipotriches sp nr. comperta (Cockerell, 1912)
Lipotriches exagens (Walker, 1860)
Lipotriches fervida (Smith, 1875)

Lipotriches fulvinerva (Cameron, 1907)
Lipotriches sp. *
Lipotriches pulchriventris (Cameron, 1897)
Macronomia rustica (Westwood, 1875)
Maynenomia sp. 1
Maynenomia sp. 2
Nomia crassipes Fabricius 1798
*Nomia nasicana** Cockerell, 1911
Nomia sp.
Pachynomia sp.
Pseudapis oxybeloides (Smith, 1875)
Steganomus nodicornis Smith 1875
Ceylalictus appendiculata (Cameron, 1903)
Ceylalictus horni (Strand, 1913)
Ceylalictus cereus (Nurse, 1901)
Ceylalictus taprobanae (Cameron, 1897)
Systropha tropicalis Cockerell, 1911

FAMILY – MEGACHILIDAE

Anthidiellum butarsis Griswold, 2001
Anthidiellum krombeini Griswold, 2001
Anthidiellum ramakrishnae (Cockerell, 1919)
Exanthidium rotundiventre Pasteels, 1987
Euaspis edentata Baker, 1995
Pachyanthidium sp. 1
Pseudoanthidium sp. 1
Lithurgus atratus Smith, 1854
Coelioxys angulata Smith, 1870
Coelioxys apicata Smith, 1854
Coelioxys capitata Smith, 1854
Coelioxys confusus Smith, 1875
Coelioxys fenestrata Smith, 1873
Coelioxys fuscipennis Smith, 1854
Coelioxys minutus Smith, 1879
Coelioxys nitidoscutellaris Pasteels, 1987
Coelioxys taiwanensis Cockerell, 1911
Megachile albolineata Cameron, 1897
Megachile amputata Smith, 1858
Megachile ardens Smith, 1879
Megachile ceylonica Bingham, 1896
Megachile conjuncta Smith, 1853
Megachile disjuncta Fabricius, 1781
Megachile hera Bingham, 1897
Megachile kandyca Friese, 1918
Megachile lanata Fabricius, 1793
Megachile mystacea Fabricius, 1775
Megachile nana Bingham, 1897

Megachile nigricans Cameron, 1898
Megachile reepeni Friese, 1918
Megachile relata Smith, 1879
Megachile umbripennis Smith, 1853
Megachile vestita Smith, 1853
Megachile vigilans Smith, 1878
Heriades binghami Cameron, 1897

FAMILY - APIDAE

Amegilla (Amegilla) confusa Smith, 1854
Amegilla (*Amegilla*) *quadrifasciata* de Villers, 1789
Amegilla (*Glossamegilla) violacea* Lepeletier, 1841
Amegilla (Micramegilla) mucorea (Klug, 1845)
Amegilla (*Zebramegilla*) *fallax* Smith, 1879
Amegilla (*Zebramegilla) subcoerulea* Lepeletier, 1841
Amegilla (*Zonamegilla) cingulata* Fabricius, 1775
Amegilla (Zonamegilla) cingulifera Cockerell, 1910
Amegilla (Zonamegilla) comberi Cockerell, 1911
Amegilla (Zonamegilla) niveocincta (Smith, 1854)
Amegilla (Zonamegilla) perasserta Rayment, 1947
Amegilla (Zonamegilla) puttalama Strand, 1913
Amegilla (*Zonamegilla) subinsularis* (Strand)
Amegilla (Zonamegilla) zonata Linnaeus, 1758
Amegilla sp.
Braunsapis cupulifera Vachal, 1894
Braunsapis flaviventris Reyes, 1991
Braunsapis mixta Smith, 1852
Braunsapis picitarsis Cameron, 1902
Ceratina (Ceratinidia) hieroglyphica Smith, 1854
Ceratina (Pithitis) binghami Cockerell, 1910
Ceratina (Pithitis) smaragdula Fabricius, 1787
Ceratina (*Simoceratina*) *tanganyicensis* Strand, 1911
Ceratina (Xanthoceratina) beata Cameron, 1897
Ceratina (Xanthoceratina) picta Smith, 1854
Nomada adusta Smith, 1875
Nomada antennata Meade-Waldo, 1913
Nomada bicellularis Schwarz, 1990
Nomada ceylonica Cameron, 1897
Nomada lusca Smith, 1875
Nomada priscilla Nurse, 1902
Nomada wickwari Meade-Waldo, 1913
Tetralonia commixtana Strand, 1913
Tetralonia taprobanicola Strand, 1913
Tetralonia fumida Cockerell, 1911
Thyreus ceylonicus Friese, 1905
Thyreus histrio Fabricius, 1775
Thyreus insignis Meyer, 1912

Thyreus ramosellus Cockerell, 1919
Thyreus surniculus Lieftinck, 1959
Thyreus takaonis Cockerell, 1911
Xylocopa aestuans Lepeletier, 1841
Xylocopa amethystina Fabricius, 1793
Xylocopa auripennis Lepeletier, 1841
Xylocopa bryorum Fabricius, 1775
Xylocopa coerulea Fabricius, 1804
Xylocopa dejeanii Lepeletier, 1841
Xylocopa fenestrata Fabricius, 1798
Xylocopa nasalis Westwood, 1842
Xylocopa nigrocaerulea *Smith, 1874*
Xylocopa ruficornis Fabricius, 1804
Xylocopa tenuiscapa Westwood, 1840
Xylocopa tranquibarica Fabricius, 1804
Apis cerana Fabricius, 1793
Apis dorsata Fabricius, 1793
Apis florea Fabricius, 1787
Trigona iridipennis Smith, 1854
Trigona sp.

(148 bee species in 38 genera)

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* Genus and species have been upgraded and published in Karunaratne *et. al.* (2005).

The Fauna of Sri Lanka (2006): 20-34

Current Status of Taxonomy, Research and Conservation of Dragonfly Fauna (Insecta: Odonata) of Sri Lanka

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Abstract

Altogether 116 described odonate species are known from Sri Lanka. The level of endemism is high – 53 taxa or 45.7 % are confined to the island. The families Chlorocyphidae, Euphaeidae, Protoneuridae, Platystictidae, Gomphidae and Corduliidae consist of almost exclusively endemic taxa. Additionally, four new endemic species are currently being described, bringing the actual number of dragonfly taxa to a total of 120 and the number of endemic representatives to a total of 57 taxa or 47.5 %. The odonate fauna of Sri Lanka is still insufficiently known. The knowledge on distribution, biology and taxonomy of adults and especially larval forms is very poor. Destruction of primary and secondary rainforests, destruction of forest corridors along streams, pollution and other pressures on streams and rivers in the southwestern and central parts of Sri Lanka are the major threats to the exceptionally rich endemic dragonfly fauna. More than 80% of the species confined to Sri Lanka are classified as endangered. Altogether 20 highly threatened endemic dragonfly species from Sri Lanka are currently proposed for inclusion on the new IUCN Global Red List of Threatened Animals. The paper elaborates on future research priorities, with recommendations for the conservation of odonate fauna in Sri Lanka.

Key words: *Odonata, Dragonflies, Sri Lanka, Taxonomy, Research, Conservation, Endangered species*

Short Outline of Dragonfly Biology

With the exception of the sea, extremely cold north and south parts of the Earth, completely dry deserts or high mountains, there is virtually no dragonfly-free place on the planet. They are predatory insects with incomplete metamorphosis, which spend most of their lives hidden from human eyes as larvae in the water. Adult winged insects can be met along rivers, streams, paddy fields, marshes, pools and lakes almost year round. Dragonflies are very interesting and diverse insects, which instantly attract our attention with their amazing flight skills and beautiful colours. They represent an independent insect order (lat. Odonata) with almost 6000 described species, of which around 120 are known to occur in Sri Lanka.

The dragonflies of Sri Lanka can be divided in two suborders – damselflies (lat. Zygoptera) and dragonflies (lat. Anisoptera), but the broadly applied term "dragonflies" applies to both suborders. Damselflies (Zygoptera) are generally small and delicate insects with hammer-shaped head on which the compound eyes are well separated, match-like slender abdomen and essentially equally shaped narrow wings, which at rest are folded over abdomen or are slightly spread. Dragonflies (Anisoptera) are generally larger and more robustly built insects, in which large compound eyes cover almost entire head. Their hind wings are always expanded at the base, the venation of fore and hind wings differs substantially and at rest the wings are broadly opened.

Incomplete metamorphosis – the life cycle consisting of egg and several larval instars followed by the adult phase – is characteristic of dragonflies. After several moults the larva becomes proportionally larger and its swollen wing pads declare it is ready to emerge. It climbs out of water and the adult emerges from unbearably tight larval casing, remarkably quickly expands its soft wings and flies away before even developing brighter colours. Before becoming sexually mature, adults indulge in feeding and their attractive colouration develops only after several days. During the pre-reproductive period and while feeding, the adults are encountered often far from their breeding places. At breeding places, which are usually near water, they mate and lay eggs.

Ecological Significance of Dragonflies

Although dragonflies are generally considered of little economic significance, both larvae and adults are predators near the top of food chains in their ecosystems. Some species feed chiefly on mosquitoes and their larvae. Thus, in some regions, their potential in pest control in paddy fields is substantial. The latter aspect has been well documented in a paddy field ecosystem in Sri Lanka (Bambaradeniya *et* al., 2004). Fonseka (2000) and Orr (2003) provide additional relevant information on dragonfly biology and ecology.

Dragonflies are often addressed as the “guardians of the watershed”. In nature conservation efforts they appear at two levels – as the subject of conservation concern in the case of endangered species and as indicators of wetland habitat quality. In different stages of their lives dragonflies occur both in terrestrial and freshwater habitats and are sensitive for disturbances in both. While the habitat selection of adult insects strongly depends on vegetation structure, their larvae develop in water and are critical in regard to water quality and aquatic habitat structure. Therefore, along with birds and amphibians, dragonflies can serve as one of the key bioindicator groups, whose high species diversity clearly mirrors favourable conservation state of wider wetland ecosystem.

An Overview of Past Dragonfly Research in Sri Lanka

The odonatological research in Sri Lanka has a very long history. The very first contribution to the knowledge of the island’s dragonflies was made by E. de Selys - Longchamps and H. A. Hagen in the middle of the 19th century. Although their work has been continued by several recognized odonatologists, e. g. B. W. F. Kirby, F. F. Laidlaw, F. C. Fraser, M. A. Lieftnick and D. St. Quentin, in the last years it became very clear that our knowledge of the dragonfly fauna of Sri Lanka is still very incomplete.

Famous dragonfly manuals published by F. C. Fraser in his series The Fauna of British India including Ceylon and Burma: Odonata: Vol. I-III (1933-1936), are still very relevant for the odonatological research in Sri Lanka. However, it is noteworthy that Sri Lanka is one of the few Asian countries, for which a book on its dragonfly fauna is available - titled “Dragonflies of Sri Lanka” (Fonseka, 2000). It represents the first overview of many different odonatological aspects, ranging from the history of odonatological research, compilation of the known species descriptions, determination keys for adults and larvae, summary of distributional records, notes on ecology etc. Despite some deficiencies and gaps it represents an important milestone in odonatological research in Sri Lanka and will surely stimulate further research.

For the past ten years I have studied the Sri Lankan dragonfly fauna, which made the main subject of my graduation thesis titled “An attempt of the analysis of the dragonfly fauna of Sri Lanka (Insecta: Odonata)” (Bedjaniè, 1998). In this work I gathered all published information on each dragonfly taxon, and combined with the results of my fieldwork in January and February 1995, I compiled a synopsis of the odonate fauna of Sri Lanka. Thus, an analysis of the present knowledge of the dragonfly fauna of Sri Lanka as well as a preliminary analysis of adult dragonfly phenology was presented. My research into the dragonfly fauna of Sri Lanka has continued since, with additional fieldwork in October - November 2001 and in April-May 2003, and with a number of publications (Bedjanič, 1999; 2000; 2001; 2002a; Bedjanič & Šalamun, 2002). In the special issue of International Journal of Odonatology, which has brought the first ever overview of dragonfly threat status and conservation priorities in different regions of the world also the status of dragonfly fauna of Sri Lanka has been discussed. Comprehensive article with the title Odonata fauna of Sri Lanka: research state and threat status (Bedjanič, 2004) covers different aspects of odonatology in Sri Lanka in detail.

Status of Taxonomy and Research on Sri Lankan Dragonfly Fauna

According to the present knowledge altogether 116 described dragonfly species from 12 families occur in Sri Lanka. Currently, four new endemic species are in the process of description, thus bringing the number of dragonfly taxa to a total of 120 (Appendix 1). The odonate fauna of Sri Lanka is similar to that of South India, but 53 species (45.7 %) are unique to the island. Four undescribed species bring the number of likely endemic representatives to a total of 57 (47.5 %). Endemism is very high or almost exclusive in the families Chlorocyphidae, Euphaeidae, Protoneuridae, Platystictidae, Gomphidae and Corduliidae (Fig. 1). More than half of all endemic species are probably not closely related to the species occurring in India. Some species, viz. *Sinhalestes orientalis, Cyclogomphus gynostylus, Microgomphus wijaya* and *Anisogomphus solitaris* seem to be taxonomically isolated.

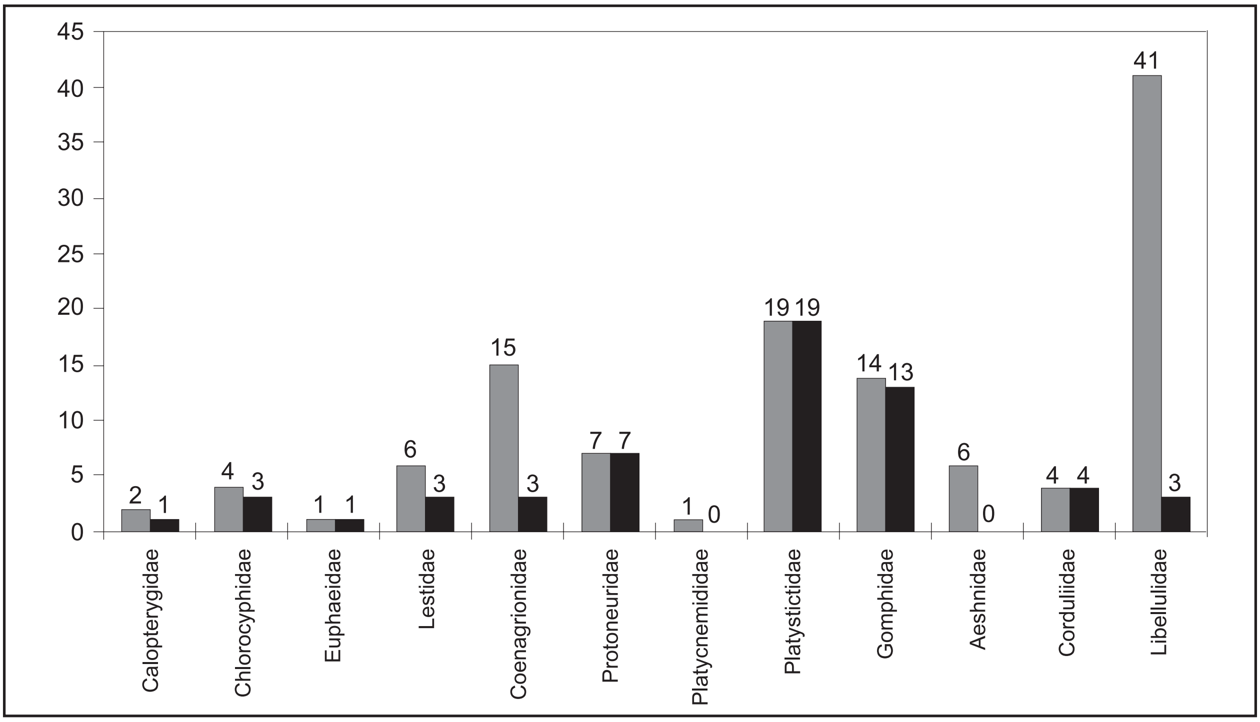

Figure 1: Endemism of dragonfly fauna of Sri Lanka. Total number of dragonfly taxa (grey columns) and number of endemic dragonfly taxa (black columns), sorted by families.

To gain a better overview of the present knowledge of the dragonfly fauna of Sri Lanka all published data for all species and subspecies were analysed in order to evaluate their research state. Also some of the author's unpublished data were included (Table 1). The analysis clearly shows that at present we know very little about dragonflies of Sri Lanka. Most species in given categories are confined to Sri Lanka and this fact definitely has also "global" importance from the biodiversity conservation point of view.

Category I: The species group known from one sex consists of only endemic taxa. Females are mostly undescribed. The reason is that females are rarely seen at waters, their behaviour is less known, and they are difficult to determine.

Category II: About one quarter of the species in Sri Lanka has been found on only a few localities and the records are from a limited number of specimens. This category also consists of exclusively endemic taxa. This information clearly indicates a poor faunistical research state of dragonfly fauna of Sri Lanka and in some cases should not be interpreted as actual species rareness.

Category III: The group of species with unknown larval stages or larval skin, contains no less than 75 species and subspecies or more than 60 % of the odonate fauna of Sri Lanka. This information is important because records of larvae and exuviae clearly indicate the development of the species in a particular habitat. For the research of ecological requirements of individual species, which forms a basis for the effective species conservation measures, the correct determination of larvae or exuviae is of crucial importance.

Category IV: Some species, e.g. *Sinhalestes orientalis, Heliogomphus ceylonicus* and *Heliogomphus nietneri*, have not been found for more than 120 years since their original descriptions. All species in this category appear rare and endangered or even extinct. They deserve special attention in the future.

Table 1: Research state of dragonfly fauna of Sri Lanka. In each category the number of taxa and their proportion to all taxa known for Sri Lanka is given. All species, except those with an asterisk, are endemic to the island. Species for which the material is present in the author's collection and awaits further treatment are underlined.

CATEGORY	SPECIES LIST
I. SPECIES WITH AN UNKNOWN SEX: 14 taxa; 11,7 %	*Mortonagrion ceylonicum*, *Archibasis* sp. nov., *Drepanosticta fraseri*, *D. sinhalensis*, *D. starmuehlneri*, *D. submontana*, *Drepanosticta* sp. nov. A, *Drepanosticta* sp. nov. B, *Disparoneura ramajana*, *Elattoneura caesia*, *Anisogomphus solitaris*, *Heliogomphus ceylonicus*, *H. nietneri*, *Macrogomphus annulatus keiseri*, *Gomphidia pearsoni*, *Macromia flinti*, *M. zeylanica*, *Macromidia* sp. nov.
II. SPECIES KNOWN FROM LESS THAN FIVE LOCALITIES: 29 taxa; 24,2 %	*Sinhalestes orientalis*, *Mortonagrion ceylonicum*, *Archibasis* sp. nov., *Drepanosticta adami*, *D. austeni*, *D. brincki*, *D. digna*, *D. fraseri*, *D. hilaris*, *D. montana*, *D. sinhalensis*, *D. starmuehlneri*, *D. submontana*, *D. subtropica*, *D. walli*, *Drepanosticta* sp. nov. A, *Drepanosticta* sp. nov. B, *Disparoneura ramajana*, *Elattoneura. leucostigma*, *Anisogomphus solitaris*, *Heliogomphus ceylonicus*, *H. nietneri*, *H. lyratus*, *Macrogomphus lankanensis*, *M. annulatus keiseri*, *Megalogomphus ceylonicus*, *Macromia flinti*, *Macromidia* sp. nov., *Hylaeothemis fruhstorferi*
III. SPECIES STILL LACKING DESCRIPTION OF LARVAL STAGES OR EXUVIA: 75 taxa; 62,5 %	*Libellago adami*, *L. finalis*, *L. greeni*, *L. lineata indica*, *Lestes praemorsus decipiens**, *L. elatus**, *L. malabaricus**, *Sinhalestes orientalis*, *Indolestes divisus*, *I. g. gracilis*, *Mortonagrion ceylonicum*, *Onychargia atrocyana**, *Paracercion malayanum**, *Enallagma parvum**, *Aciagrion occidentale**, *Ceriagrion cerinorubellum**, *Pseudagrion malabaricum**, *P. rubriceps ceylonicum*, *Archibasis* sp. nov., *Drepanosticta adami*, *D. austeni*, *D. brincki*, *D. digna*, *D. fraseri*, *D. hilaris*, *D. lankanensis*, *D. montana*, *D. nietneri*, *D. sinhalensis*, *D. starmuehlneri*, *D. submontana*, *D. subtropica*, *D. tropica*, *D. walli*, *Drepanosticta* sp. nov. A, *Drepanosticta* sp. nov. B, *Platysticta apicalis*, *P. maculata*, *Disparoneura ramajana*, *Elattoneura bigemmata*, *E. caesia*, *E. centralis*, *E. leucostigma*, *E. tenax*, *Prodasineura sita*, *Anax indicus**, *Anaciaeschna donaldi**, *Gynacantha dravida**, *Cyclogomphus gynostylus*, *Heliogomphus ceylonicus*, *H. lyratus*, *H. nietneri*, *H. walli*, *M. annulatus keiseri*, *Macrogomphus lankanensis*, *Gomphidia pearsoni*, *Macromia flinti*, *Macromidia* sp. nov., *Hylaeothemis fruhstorferi* , *Tetrathemis yerburii*, *Cratilla lineata calverti**, *Lathrecista a. asiatica**, *Orthetrum chrysis**, *O. glaucum**, *O. luzonicum**, *O. t. triangulare**, *Indothemis carnatica**, *I. limbata sita**, *Trithemis pallidinervis**, *Onychothemis tonkinensis ceylanica**, *Palpopleura s. sexmaculata**, *Rhyothemis triangularis**, *Aethriamanta b. brevipennis**, *Hydrobasileus croceus**, *Macrodiplax cora**
IV. SPECIES NOT FOUND FOR MORE THAN 50 YEARS: 11 taxa; 9,2 %	*Sinhalestes orientalis*, *Drepanosticta adami*, *D. austeni*, *D. hilaris*, *D. montana*, *D. submontana*, *Elattoneura leucostigma*, *Heliogomphus ceylonicus*, *H. nietneri*, *H. lyratus*, *Macrogomphus lankanensis*

Additional comment: There are many additional species, whose occurrence in Sri Lanka is very poorly known but are not rare elsewhere. The following species could be included in this category: *Lestes malabaricus, Agriocnemis f. femina, Paracercion malayanum, Anax indicus, Hemianax ephippiger, Gynacantha dravida, Indothemis carnatica, Indothemis limbata sita, Onychothemis tonkinensis ceylanica, Palpopleura s. sexmaculata, Rhyothemis triangularis, Aethriamanta b. brevipennis* and *Zyxomma petiolatum*.

From the above analysis of the present knowledge of the dragonfly fauna of Sri Lanka the following important conclusions can be made:

- The dragonfly fauna of Sri Lanka is insufficiently known. The fact, that almost 65% or 78 species and subspecies are included in at least one category is self-explaining.
- Special attention should be devoted to projects dealing with taxonomy of larval forms and adults in direct connection with rigorous faunistic mapping.
- In whole South and South-east Asia more attention should be devoted to the description of larval forms and exuviae. To the present not a single Zygopteran larval form of mostly endemic Sri Lankan representatives of the families Chlorocyphidae, Lestidae, Platystictidae and Protoneuridae has been described.

Threat Status of the Dragonfly Fauna of Sri Lanka

It is obvious that at present we know very little about dragonflies of Sri Lanka. Relevant published information on the biology and ecology of endemic representatives is virtually nonexistent, while our knowledge on the taxonomy and distribution is patchy.

Not a single dragonfly species from Sri Lanka is included in the global 2003 IUCN Red List of Threatened Species (IUCN, 2003). So far only one species, *Sinhalestes orientalis has* been placed on the "prestigious" world list of dragonfly taxa to which special attention should be devoted in the following years (Moore et al., 1997). Unfortunately there are many additional ones which would deserve such status and should be declared as priority species for future investigations. This is imperative since endemic dragonfly fauna of Sri Lanka is severely threatened and some very interesting taxa are at the brink of extinction.

The main reason for this is rapid destruction of primary rainforest, which has approached a catastrophe in the last decades. In the middle of 20th century more than 50% of Sri Lanka was covered with forest but only thirty years later the percentage has fallen to around 20%. Impoundment, extraction for irrigation, over-use of pesticides and careless pollution of rivers and streams, together with other pressures on flowing waters, have brought most endemic species near to extinction. Factors as high population growth followed by urbanisation and acute shortage of land (Sri Lanka has nearly 19 million inhabitants and population density over 300 people per sq. km!), mining, soil erosion and environment pollution result in additional habitat loss and affect fauna and flora both directly and indirectly.

It may look surprising but around 14% of the island is within different forms of protected areas, ranging from biosphere reserves and national parks, nature reserves, forest reserves, wildlife sanctuaries etc. Unfortunately, there is a complete lack of systematically gathered information on dragonfly fauna of existing protected areas in Sri Lanka and not a single professional study on this topic has ever been made. In this situation we can only guess to which extent the existing protected areas really ensure the long-term conservation of dragonfly fauna. Despite the fact that the proportion of protected areas in Sri Lanka is relatively high they are mainly located in the dry zone lowlands because of the historically strong attachment of official nature conservation towards elephants, leopards and other large animals. Our data indicates that only a small proportion of endemic dragonfly taxa inhabit dry zone forests with lowland rivers and numerous water tanks.

The speculation that some endemic species may already be extinct and that many small and isolated dragonfly populations are probably on the brink of disappearance is unfortunately very close to reality. In addition, many protected areas are too small for long term survival of endangered species or degraded to a considerable extent. Even more problematic is the exclusion of several patches of rainforests with exceptionally rich fauna and flora from the current protected area network.

Only recently the nature protection agencies and institutions in Sri Lanka started to recognise dragonflies as an important part of island's biodiversity. Not a single dragonfly species is mentioned in the official "Fauna and Flora Protection Ordinance". On the other hand, in the publication named "The 1999 List of Threatened Fauna and Flora of Sri Lanka" (IUCN Sri Lanka, 2000), altogether 50 dragonfly species are listed as threatened (TR), 20 dragonfly species as highly threatened (HT) and 4 dragonfly species as data deficient (DD). More or less the same data are presented also in "A Comparison of the Conservation and Legal Status of the Fauna and Flora of Sri Lanka" (IUCN Sri Lanka, 2003). Unfortunately, the only basis for the mentioned evaluation of the dragonfly species' threat status has been the book Dragonflies of Sri Lanka (Fonseka, 2000), which is not the best source for such task, especially for the non-odonatologist. Despite numerous deficiencies in listing and ranking of single dragonfly taxa the general message was stressed quite correctly – dragonfly fauna of Sri Lanka with its numerous endemic representatives is very endangered.

Bedjanič (2004) assessed the threat status of the Sri Lanka dragonfly fauna. The list of endangered dragonfly species of Sri Lanka comprises 47 exclusively endemic taxa, among them also 4 recently discovered, yet undescribed species. This means that more than 80% of endemic dragonfly taxa are threatened. Almost all endemic representatives of the families Protoneuridae, Platystictidae, Gomphidae and Corduliidae are listed as endangered.

In the framework of IUCN SSC Odonata Specialist Group, Bedjanič (2005a) published a report titled Globally Endangered Dragonflies of Sri Lanka. Threat and conservation status of 20 most endangered endemic dragonfly species, viz. *Sinhalestes orientalis*, *Drepanosticta adami*, *D. austeni*, *D. hilaris*, *D. montana*, *D. submontana*, *Elattoneura leucostigma*, *E. caesia*, *Disparoneura ramajana*, *Anisogomphus solitaris*, *Cyclogomphus gynostylus*, *Gomphidia pearsoni*, *Heliogomphus ceylonicus*, *H. lyratus*, *H. nietneri*, *Macrogomphus lankanensis*, *Microgomphus wijaya*, *Macromia flinti*, *Tetrathemis yerburii* and *Hylaeothemis f. fruhstorferi* was assessed and they were proposed for inclusion on the new IUCN Global Red List of Threatened Animals.

It should be stressed that this list is very incomplete. Surely some additional endemic species as well as some undescribed taxa are highly endangered and are at the brink of extinction. Globally, all endangered dragonfly species of Sri Lanka can be marked as range restricted species. Their known occurence is limited almost exclusively to a few isolated localities in the wet and intermediate zones of Sri Lanka. These facts are alarming and definitely have global importance from the biodiversity conservation point of view.

Conservation Priorities and Recommendations

Effective nature conservation measures in declared protected areas as well as establishment of new protected areas in the wet zone is of utmost importance and probably the only way to ensure the long-term preservation of rich endemic fauna and flora of Sri Lanka, including dragonflies. Since natural vegetation and habitats are already so disturbed and fragmented the focus should be set on taking an effective action to stop further encroachment on the wet zone rainforests and establishment of smaller protected areas and corridors between them. Only such a "network" could ensure long-term preservation of endemic fauna and flora.

Basic information on biology and distribution of endemic dragonfly species is still very poor. It is therefore impossible at this point to suggest "single-species-oriented" conservation measures. In order to improve our knowledge on the dragonfly fauna of Sri Lanka special attention should be devoted to projects dealing with taxonomy of larval forms and adults, in connection with serious faunistic mapping and research on the biology of selected dragonfly species. Only in this way we will be able to effectively assess their conservation status, suggest appropriate conservation measures for the key species as well as recognise and promote the importance of dragonfly fauna of Sri Lanka for biodiversity conservation.

General guidelines for protection of rich endemic dragonfly fauna of Sri Lanka include the following:

- Establishment of network of new small protected areas and corridors in the wet zone.
- Conservation of forest corridors along streams and rivulets outside protected areas in the wet zone.
- Effective execution of appropriate nature conservation measures in partially degraded existing protected areas.

Fortunately very high diversity of fauna and flora, especially the number of taxa confined to the island, has already been recognised and there are good reasons to name Sri Lanka as one of the “hot-spots” of South and South-east Asia (Mittermeier et al., 2000). In addition, Sri Lankan Moist Forests (Ecoregion 21) and South-western Sri Lanka Rivers and Streams (Ecoregion 172) are included in the prestigious WWF’s Global 200 list of the Earth’s most biologically outstanding habitats.

Research Priorities and Recommendations

Dragonfly fauna of Sri Lanka is very interesting but insufficiently known. Knowledge on distribution, biology and taxonomy is very poor - especially regarding larval forms. Due to the habitat destruction (mainly primary tropical rainforest) the dragonfly fauna of Sri Lanka is also very endangered – some very interesting or/and endemic taxa are threatened with extinction or are probably already extinct.

According to the above facts the main dragonfly research priorities are as follows:

- Special attention in the future should be devoted to taxonomy of larval forms and adults. Expert taxonomic knowledge should be focused especially on description of larval forms and exuviae. In adult dragonfly taxonomy a revision of exclusively endemic family Platystictidae with remarkable species radiation is urgently needed.
- Serious faunistic mapping should cover the whole island. In order to get an overview of conservation status of less widespread and highly endangered endemic species, the research should be focused on protected areas and other still preserved areas without nature conservation status. Especially reserves and sanctuaries in the wet and intermediate zone will surely bring many new dragonfly taxa to light, not to mention the crucial nature conservation overview, namely, to which extent the existing protected areas really ensure the long-term preservation of extremely interesting endemic dragonfly fauna.
- Research of biology and ecology of most endangered species should be carried out in order to evaluate their remaining population size and options of long term survival.
- All existing odonatological data (museum collections, literature, unpublished field observation) should be gathered in the odonatological database called “Distributional Atlas of the dragonflies of Sri Lanka”, which will enable an overview of present knowledge for each species and generate outputs such as distribution maps, seasonal phenology and altitudinal distribution charts etc.
- An expert should produce a photographic field guide for the dragonfly fauna of the island with a comprehensive, clear and reliable determination key for adult dragonflies as soon as possible.

To carry out the suggested measures successfully, some basic conditions have to be fulfilled on local and international level. Above all, mutual cooperation with appropriate nature conservation institutions and experts in Sri Lanka should be built and joint projects should be prepared. A small team of local scientist or students should be trained in dragonfly research. With appropriate taxonomic and field knowledge on biology of dragonflies it would be possible for them to carry out the necessary field work in different seasons at selected localities year around or to explore many different parts of the island in the same season.

For serious scientific faunistic work, which is inevitably connected to capturing of dragonflies and building a scientifically managed museum collection, a legal permission has to be issued by the appropriate nature conservation authority. However, a mechanism should be developed, which would ensure easier obtaining of necessary permits for field work on one hand and on the other hand would control the field work in terms of collecting and submitting the results. IUCN Species Survival Commission – Odonata Specialists Group could act as an important mediator in issuing recommendation based on references of the researcher and could also play an important role in the exchange and evaluation of results.

Finally, the necessary funds for additional odonatological fieldwork and research should be assured at the state or international level.

Current Odonatological Activities and Future Perspectives

In last years the interest on the dragonfly fauna of Sri Lanka has considerably grown. Herewith the book Dragonflies of Sri Lanka (Fonseka, 2000) greatly fulfilled its basic purpose. In addition, some popular articles on dragonflies, such as the one written for unfortunately discontinued nature conservation magazine Sri Lanka Nature (Silva Wijeyeratne, 2001), definitely helped to stimulate this aspect. Based on the cooperation of the author with local naturalists and sponsored by the leading Sri Lankan ecotouristic company Jetwing, a small photographic guide to the dragonflies of Sri Lanka has been published in last two years (de Silva Wijeyeratne et al., 2003; reprint 2004). It comprises 88 photographs of 64 dragonfly species, including many interesting endemic representatives. Dragonfly photographs and short species descriptions will also form a part of the new popular Field Guide to Birds, Butterflies and Dragonflies of Sri Lanka, which is scheduled to be hopefully published in 2005 in Sinhala and English language. In the frame of activities of ecotouristic company Jetwing, also a special Dragonfly Research Project is being developed, details of which can be found on the Internet (www.jetwingeco.com).

As already mentioned the author is involved in the studies of the dragonfly fauna of Sri Lanka since his first field trip to the island in 1995. Up to now a comprehensive graduation thesis (Bedjanič, 1998), as well as some faunistic and taxonomic articles were published on the topic (Bedjanič, 1999; 2000; 2001; 2002a; Bedjanič & Šalamun, 2002). Three years ago, a small booklet Dragonflies of Sri Lanka in Colour has been privately published as a draft of future photographic manual to the dragonfly fauna of the island (Bedjanič, 2002b). After January and February 1995 the serious faunistic work in the frame of the PhD project was continued in October-November 2001 and in April-May 2003. In absence of official permits the fieldwork has unfortunately mainly been limited to the non-protected areas, but nevertheless gave very good results. More than 50 localities in different parts of the island were visited and more than 70 species were recorded both in 2001 and 2003. Among the recorded species there are some very interesting and even new taxa as well as many hereto unknown larval forms. Currently, two new species (genus *Archibasis* and *Macromidia*, which were previously not known to be present on the island) are in the process of describing from material collected in 2001 and at least two new species (genus *Drepanosticta*) are present in the material gathered in April and May 2003. All of them are endemic, and the percentage of the species confined to the island is slowly nearing 50%, a fact that is of immense conservation importance on a global scale. In addition, larval stages of more than dozen mostly endemic species are now known and await description. This will enable additional field work methods and open better possibilities for detecting the species with unusual behaviour and/or out of optimal season. In this way, the knowledge on distribution, larval biology and habitat requirements of selected species is expected to be greatly improved.

In the beginning of 2005 the work on the odonatological database called “Distributional Atlas of the dragonflies of Sri Lanka” finally started. Considerable proportion of all existing odonatological data (all published literature, unpublished author’s data, data from some museum collections) is already imported and currently there are about 3500 faunistic records of different quality in the database. Further important step includes geolocating of all dragonfly localities what will enable future GIS analysis. In this way it should soon be possible to generate basic outputs such as distribution maps, seasonal phenology and altitudinal distribution charts etc. Also the distribution map of all dragonfly localities in Sri Lanka will be elaborated in order to point out the white spots and very limited distribution of many endemic species.

Hopefully, the nature conservation authorities in Sri Lanka will show some interest and support towards planned dragonfly research projects in the future. Of course, the most important thing would be exchange of experience and knowledge as well as logistic support in the field, not to mention help in obtaining necessary permits. On the other hand, funds for covering of travel and material costs will have to be organized. With the proper advice, knowledge support or contacts with possible donors, the IUCN SSC, IUCN Sri Lanka and National Science Foundation of Sri Lanka could play an important role in this respect.

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Appendix 1: Species List of the Dragonflies of Sri Lanka

According to the present knowledge altogether 116 described dragonfly species from 12 families occur in Sri Lanka. Currently, four new endemic species are in the process of description (numbered and indicated as "sp. nov.", not printed bold), thus bringing the number of dragonfly taxa to a total of 120. Altogether 57 taxa are endemic and are marked with (*).

Additional 7 species (marked with §, not printed bold) are included in the present species list without a number: *Aciagrion hisopa* (Selys, 1876), *Hemicordulia asiatica* Selys 1878, *Neurothemis fluctuans* (Fabricius, 1793), *Trithemis kirbyi kirbyi* Selys, 1891, *Rhyothemis obsolescens* Kirby, 1889 and *Rhyothemis phyllis phyllis* (Sulzer, 1776). Their occurrence on Sri Lanka is doubtful and not well documented or the record is based on determination error. One of them, viz. *Trithemis kirbyi kirbyi* is listed in FONSEKA (2000), who gives 117 species and subspecies for the island.

System and nomenclature mainly follow the Catalogue of the family-group, genus-group and species-group names of the Odonata of the world (BRIDGES, 1994).

ORDER ODONATA

SUB-ORDER ZYGOPTERA

Family Calopterygidae

1.) *Neurobasis chinensis chinensis* (Linnaeus, 1758)
***2.) *Vestalis apicalis nigrescens* Fraser, 1929**

Family Chlorocyphidae

***3.) *Libellago adami* Fraser, 1939**
***4.) *Libellago finalis* (Hagen, 1869)**
***5.) *Libellago greeni* (Laidlaw, 1924)**
6.) *Libellago lineata indica* (Fraser, 1928)

Family Euphaeidae

***7.) *Euphaea splendens* Hagen, 1853**

Family Lestidae

8.) *Lestes elatus* Hagen, 1862
9.) *Lestes malabaricus* Fraser, 1929
10.) *Lestes praemorsus decipiens* Kirby, 1894
***11.) *Sinhalestes orientalis* (Hagen, 1862)**
***12.) *Indolestes divisus* (Hagen, 1862)**
***13.) *Indolestes gracilis gracilis* (Hagen, 1862)**

Family Coenagrionidae

14.) *Agriocnemis femina femina* (Brauer, 1868)
15.) *Agriocnemis pygmaea* (Rambur, 1842)
***16.) *Mortonagrion ceylonicum* Lieftinck, 1971**
17.) *Onychargia atrocyana* Selys, 1865
18.) *Paracercion malayanum* (Selys, 1876)
§ *Aciagrion hisopa* (Selys, 1876)
19.) *Aciagrion occidentale* Laidlaw, 1919
20.) *Enallagma parvum* Selys, 1876

21.) *Ischnura aurora aurora* (Brauer, 1865)
22.) *Ischnura senegalensis* (Rambur, 1842)
23.) *Ceriagrion cerinorubellum* (Brauer, 1865)
24.) *Ceriagrion coromandelianum* (Fabricius, 1798)
25.) *Pseudagrion malabaricum* Fraser, 1924
26.) *Pseudagrion microcephalum* (Rambur, 1842)
***27.) *Pseudagrion rubriceps ceylonicum* (Kirby, 1891)**
*28.) *Archibasis* sp. nov.

FAMILY PLATYCNEMIDIDAE

29.) *Copera marginipes* (Rambur, 1842)

FAMILY PLATYSTICTIDAE

***30.) *Drepanosticta adami* (Fraser, 1933)**
***31.) *Drepanosticta austeni* Lieftinck, 1940**
***32.) *Drepanosticta brincki* Lieftinck, 1971**
***33.) *Drepanosticta digna* (Selys, 1860)**
***34.) *Drepanosticta fraseri* Lieftinck, 1955**
***35.) *Drepanosticta hilaris* (Hagen, 1860)**
***36.) *Drepanosticta lankanensis* (Fraser, 1931)**
***37.) *Drepanosticta montana* (Hagen, 1860)**
***38.) *Drepanosticta nietneri* (Fraser, 1931)**
***39.) *Drepanosticta sinhalensis* Lieftinck, 1971**
***40.) *Drepanosticta starmuehlneri* St. Quentin, 1972**
***41.) *Drepanosticta submontana* (Fraser, 1933)**
***42.) *Drepanosticta subtropica* (Fraser, 1933)**
***43.) *Drepanosticta tropica* (Hagen, 1860)**
***44.) *Drepanosticta walli* (Fraser, 1931)**
*45.) *Drepanosticta* sp. nov. A
*46.) *Drepanosticta* sp. nov. B
***47.) *Platysticta apicalis* Kirby, 1894**
***48.) *Platysticta maculata* Hagen, 1860**

FAMILY PROTONEURIDAE

***49.) *Disparoneura ramajana* Lieftinck, 1971**
***50.) *Elattoneura bigemmata* Lieftinck, 1971**
***51.) *Elattoneura caesia* (Hagen, 1860)**
***52.) *Elattoneura centralis* (Hagen, 1860)**
***53.) *Elattoneura leucostigma* (Fraser, 1933)**
***54.) *Elattoneura tenax* (Hagen, 1860)**
***55.) *Prodasineura sita* (Kirby, 1894)**

SUB-ORDER ANISOPTERA

FAMILY AESHNIDAE

56.) *Anaciaeschna donaldi* Fraser, 1922
57.) *Anax guttatus* (Burmeister, 1839)
58.) *Anax immaculifrons* Rambur, 1842

59.) *Anax indicus* Lieftinck, 1942
60.) *Hemianax ephippiger* (Burmeister, 1839)
61.) *Gynacantha dravida* Lieftinck, 1960

Family Gomphidae

***62.) *Anisogomphus solitaris* Lieftinck, 1971**
***63.) *Burmagomphus pyramidalis sinuatus* Fraser, 1933**
***64.) *Cyclogomphus gynostylus* Fraser, 1926**
***65.) *Heliogomphus ceylonicus* (Selys, 1878)**
***66.) *Heliogomphus lyratus* Fraser, 1933**
***67.) *Heliogomphus nietneri* (Selys, 1878)**
***68.) *Heliogomphus walli* Fraser, 1925**
***69.) *Macrogomphus annulatus keiseri* Lieftinck, 1955**
***70.) *Macrogomphus lankanensis* Fraser, 1933**
***71.) *Microgomphus wijaya* Lieftinck, 1940**
***72.) *Paragomphus henryi* (Laidlaw, 1928)**
***73.) *Megalogomphus ceylonicus* (Laidlaw, 1922)**
***74.) *Gomphidia pearsoni* Fraser, 1933**
75.) *Ictinogomphus rapax* (Rambur, 1842)

Family Corduliidae

***76.) *Epophthalmia vittata cyanocephala* Hagen, 1867**
***77.) *Macromia flinti* Lieftinck, 1977**
***78.) *Macromia zeylanica* Fraser, 1927**
*79.) *Macromidia* sp. nov.
§ *Hemicordulia asiatica* Selys, 1878

Family Libellulidae

***80.) *Hylaeothemis fruhstorferi fruhstorferi*(Karsch, 1889)**
***81.) *Tetrathemis yerburii* Kirby, 1894**
82.) *Brachydiplax sobrina* (Rambur, 1842)
83.) *Cratilla lineata calverti* Förster, 1903
84.) *Lathrecista asiatica asiatica* (Fabricius, 1798)
85.) *Orthetrum chrysis* (Selys, 1891)
86.) *Orthetrum glaucum* (Brauer, 1865)
87.) *Orthetrum luzonicum* (Brauer, 1868)
88.) *Orthetrum pruinosum neglectum* (Rambur, 1842)
89.) *Orthetrum sabina sabina* (Drury, 1773)
90.) *Orthetrum triangulare triangulare* (Selys, 1878)
91.) *Potamarcha congener* (Rambur, 1842)
92.) *Acisoma panorpoides panorpoides* Rambur, 1842
93.) *Brachythemis contaminata* (Fabricius, 1793)
94.) *Bradinopyga geminata* (Rambur, 1842)
95.) *Crocothemis servilia servilia* (Drury, 1770)
96.) *Diplacodes nebulosa* (Fabricius, 1793)
97.) *Diplacodes trivialis* (Rambur, 1842)
98.) *Indothemis carnatica* (Fabricius, 1798)

99.) ***Indothemis limbata sita*** **Campion, 1923**
§ *Neurothemis fluctuans* (Fabricius, 1793)
100.) ***Neurothemis intermedia intermedia*** **(Rambur, 1842)**
101.) ***Neurothemis tullia*** **(Drury, 1773)**
102.) ***Rhodothemis rufa*** **(Rambur, 1842)**
103.) ***Sympetrum fonscolombii*** **(Selys, 1840)**
104.) ***Trithemis aurora*** **(Burmeister, 1839)**
105.) ***Trithemis festiva*** **(Rambur, 1842)**
§ *Trithemis kirbyi kirbyi* Selys, 1891
106.) ***Trithemis pallidinervis*** **(Kirby, 1889)**
107.) ***Onychothemis tonkinensis ceylanica*** **Ris, 1912**
108.) ***Palpopleura sexmaculata sexmaculata*** **(Fabricius, 1787)**
§ *Rhyothemis obsolescens* Kirby, 1889
§ *Rhyothemis phyllis phyllis* (Sulzer, 1776)
109.) ***Rhyothemis triangularis*** **Kirby, 1889**
110.) ***Rhyothemis variegata variegata*** **(Linnaeus, 1763)**
111.) ***Hydrobasileus croceus*** **(Brauer, 1867)**
112.) ***Pantala flavescens*** **(Fabricius, 1798)**
113.) ***Tramea basilaris burmeisteri*** **Kirby, 1889**
114.) ***Tramea limbata*** **(Desjardins, 1832)**
115.) ***Tholymis tillarga*** **(Fabricius, 1798)**
116.) ***Zyxomma petiolatum*** **Rambur, 1842**
117.) ***Aethriamanta brevipennis brevipennis*** **(Rambur, 1842)**
118.) ***Macrodiplax cora*** **(Kaup, 1867)**
119.) ***Urothemis signata signata*** **(Rambur, 1842)**
120.)** ***Zygonyx iris ceylonicum **(Kirby, 1905)**

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Current Status of Aphid Taxonomy in Sri Lanka

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Abstract

Aphids (Homoptera: Aphididae) are a group of minute insects (with winged and wingless adults) that live on plants. They are plant sap feeders and thereby act as vectors of viral diseases of plants. Hence, aphids are of much economic importance. Presently, the known aphid fauna of Sri Lanka consists of 84 species in 46 genera and 6 subfamilies. Two species of aphids are considered to be endemic to Sri Lanka, while 74 of our aphid species are shared with India. The aphids that are found particularly on upcountry vegetables are cosmopolitan in distribution. Distribution of aphids in Sri Lanka is associated more with the distribution of their host plants than the geography of the country. Field studies indicate that aphids are more abundant in the Mid Country Wet Zone. Majority of the aphid species are polyphagous, inhabiting a variety of unrelated host plants. Aphids have been recorded from 300 species of plants belonging to 71 families.

To fill the gaps in aphid taxonomic research it is necessary to make extensive field collection covering parts of the country where previous collections have not been made. Furthermore, the balance of the flowering plants including crops need to be examined for aphids. Specially, host specific or oligopahgous aphid species on crops need to be identified. Since aphids are considered as potential pests and viral vectors, their management becomes more important than conservation.

Key words: *Aphids, Taxonomy, Affinities, Host plants, Distribution*

Introduction

Aphids (Homoptera:Aphididae) are one of the most harmful insect groups as plant sap feeders, plant gall formers and vectors of viral diseases of plants. They occur both in the tropics and the temperate regions of the world. The greatest distribution of aphids is in the temperate region. The world aphid fauna comprises over 4,000 species in 493 genera and 9 subfamilies (Blackman et al., 1982). In India, where both tropical and temperate climates prevail a rich aphid fauna is present nearing 1,000 species in 214 genera and 9 subfamilies (Blackman and Eastop, 1984; Gosh and Agarawala, 1982). Presently, 82 species of aphids in 46 genera and 6 subfamilies have been recorded from Sri Lanka (Wijerathna and Edirisinghe, 1999). The aphids documented from Sri Lanka have been recorded from 300 species of plants belonging to 21 families. Eighteen species of aphids have been documented from vegetable crops and over 20 species from weeds. Among the aphid species are several potential vectors of plant viruses. Aphids have been proven to be the vector of viral diseases in several local crops (Abeygunawardena and Perera, 1964; Jeyanadarajah and Liyanage, 1994).

Systematics

The early records of aphids of Sri Lanka date back to the British Period (Westwood, 1890; Scoutenden, 1905; van der Goot, 1918) during which several aphid species collected on water traps have been described. Therefore, the aphid species recorded are without host records. Thereafter, Judenko and Eastop (1963), Caver (1965) and Blackman and Eastop (1984) reported several aphid species from Sri Lanka with their host records. The most comprehensive study so far conducted of aphids is by Wijerathna (1997). In this study aphids were collected from 26 sites located in 7 agroecological regions within the Wet, Intermediate and Dry Zones of the country. The collection sites came within 17 Administrative Districts of Sri Lanka. A total of 47 species of aphids in 28 genera and 5 subfamilies were collected during this study. Over 1,000 plant species were examined for aphids and of them, aphids were present on 300 plant species in 71 plant families.

The list of aphids so far recorded from Sri Lanka is given in Table 1. Aphids of the Family Aphididae is represented in Sri Lanka by 6 subfamilies. Within each subfamily are several tribes. Subfamily Aphidinae includes 2 tribes; Aphidini and Macrosiphini. Each of the remaining subfamilies includes only a single tribe in Sri Lanka. In the tribe Aphinidi, 7 genera are included of which the Genus *Aphis* is represented by the largest number of species. The Tribe Macrosiphini includes the largest number of genera (22). Each of these genera is represented by 1-3 species. Subfamily Drephanociphinae includes two tribes with a single Genus in each. Subfamily Pemphiginae has a single tribe represented by 5 genera. A comprehensive list of the taxonomy of the currently known aphid species from Sri Lanka is provided in Wijerathna and Edirisnghe, 1999.

Table 1: Aphid taxa recorded from Sri Lanka

Subfamily	**Tribe**	**Genus**	**No. of species**
Aphidinae	Aphidini	*Aphis*	6
		Hylopterus	1
		Hysteroneura	1
		Melanaphis	1
		Rhopalosiphum	3
		Schizaphis	4
		Toxoptera	3
	Macrosiphini	*Acyrthosiphon*	3
		Akkaia	1
		Aulacorthum	2
		Brachycaudus	1
		Chaetosiphon	1
		Dysaphis	1
		Ipuka	1
		Liaphis	1
		Macrosiphoniella	2
		Macrosiphum	2
		Matsumuraja	1 *
		Micromyzus	3
		Myzuz	6
		Neotoxoptera	1
		Pentalonia	1
		Phorodon	1
		Rhodobium	1
		Rhopalosiphoninus	1
		Sinomegoura	1
		Sitobion	8
		Uroleucon	1
		Vesiculaphis	1
Drepanosiphinae		*Tinocallis*	1
	Phyllaphidini	*Phyllaphidini*	1

Greenidenae	Sebaphidini	*Schoutedenia*	1
	Greenideni	*Greenidea*	2
		Greenideoida	1
Hormaphidinae	Ceratophidini	*Astegopteryx*	3
		Cerataphis	1
		Ceratoglyphina	1
		Ceratovacuna	1
		Pseudoregma	1
Lachninae		*Lachnus*	1
		Pyrolachnus	1
Pemphiginae		*Ceratopemphigus*	1 *
		Eriosoma	1
		Geoica	1
		Kaltenbachiella	2
		Tetraneura	2

* Species Endemic to Sri Lanka

The type specimens of aphids of Sri Lanka have been deposited in museums outside Sri Lanka. Type specimens of 40 species of aphids (in 22 genera) are held in the Natural History Museum (NHM), London. Several expert-identified (mostly by taxonomists at the NHM) aphid specimens are held in local Institutions. In the Agriculture Department, the HORDI museum holds a number of specimens collected and identified by the British. In the University of Peradeniya, Department of Zoology holds specimens of 34 aphid species collected during a field survey (Wijerathna, 1997) whose identity been confirmed by the Commonwealth Institute of Entomology, London.

Identification of aphids (collected into 70% alcohol) is based on slide mounted specimens. The identification key prepared by Martin (1983) for tropical aphids includes most of the common aphids of Sri Lanka and is a useful illustrated guide.

Affinities of the aphid fauna

A quarter of the world aphid fauna has been described from India. Therefore, it is not surprising that most of our aphids are shared with India. Of the 84 known species of aphids of Sri Lanka (Appendix 1), 74 species are shared with India (Gosh, 1971). Few other species are shared with Central Asia, East Africa and Mauritius. The aphid, *Sitobion wickstroemiae* recorded from the shrub *Wickstroemia indica* (Family Thymelaeceae) also occurs in South Africa and Mauritiu. The shrub, *Wickstroemia indica* has been introduced to Sri Lanka from East Africa and it has since become a weed in and around Kandy. Majority of the aphids on vegetable crops are cosmopolitan in distribution (Wijerathna and Edirisinghe, 1997).

Endemism in aphids of Sri Lanka cannot be ascertained accurately as the aphids of the Indian subcontinent are not fully known. According to Ghosh (1971A) 10 aphid species are endemic to Sri Lanka. However, 8 of these species have been subsequently reported from other countries in the Indian subcontinent, thus making only two aphid species endemic to Sri Lanka. The two species are *Matsumaraja capitophoroides* H.R.Lo. and *Ceratopemphigus zehntneri* Schouteden (Schouteden, 1905; Judenko and Eastop, 1963).

The aphid fauna of India is well known through the work of several authors among whom Ghosh (1971A, 1971B, 1974 & 1990) has made a significant contribution. From Pakistan, 15 species of vegetable infesting aphids have been recorded by Nasir and Yousuf (1995).

Host Plants of Aphids

During a field survey nearly one third of our flowering plants were examined for aphids. The 300 plant species in 71 families that harboured the 84 species of aphids recorded for Sri Lanka are included in Wijerathna and Edirisinghe (1999). The host plants of aphids were grouped into14 categories based on the economic use or taxonomic status of the plant. Most aphid species was found on non - graminaceous weeds followed by vegetable crops and fruit trees. Endemic plants that were examined for aphids harboured a few species of very common aphids.

The number of flowering plant species endemic to Sri Lanka is 879 (Bandaranayake and Sultanbawa, 1991) which is very high compared to India. Yet, Sri Lanka is poor in endemic aphid species. About half of the aphid species (443) recorded from India is endemic to that country (Ghosh, 1990). In Sri Lanka most of the endemic plant species are found in very stable mixed forests where plant diversity is very high forming several canopy layers. Furthermore, most endemic plant species are trees and not herbaceous plants on which aphids continuously feed.

Of the two species of aphids considered to be endemic to Sri Lanka, the plant host of *Matsumaraja capitophoroides* is recorded as *Brunfelsia uniflora* Pohl.D. (F.Solanaceae) (Judenko and Eastop, 1963). The other endemic aphid species, *Ceratopemphigus zehntneri* has been recorded from water traps and hence is without a host record. Majority of the aphids recorded are polyphagous, living on several unrelated plants. The aphids on vegetables in particular are polyphagous except for the two species that occur on carrots. Few other species of aphids are host specific. The host specific aphids known from Sri Lanka are, *Macrosiphoniella psedoartemesiae* on *Artemesia vuigaris* (F.Compositae) *Greenideoida ceyloniae* on *Mesua ferra* (F.Guttiferae) and *Sitobion wickstroemiae* on *Wickstroemia indica* (F. Thymelaeceae)

Distribution

Distribution of aphids (based to collection sites) is associated more with the distribution of their host plants than any other factor. Mid country Wet Zone had the highest diversity of aphid species than any other agro-ecological region of the country. In terms of habitats, areas cultivated with vegetables and weedy areas harboured the most number of aphids. In primary forests such as the Sinharaja and Delwala, only the forest edge and boundaries bearing common weeds harboured aphids.

Economically Important Aphids

Of the different plant categories on which aphids were collected, vegetables formed a very important group. Although, aphids were recorded from 55 crops only about 20 vegetable species can be considered as extensively cultivated and commonly consumed. These include both up country and low country vegetables. A total of 18 species of aphids infested vegetable plants. Among these vegetables beans, carrot, cauliflower, chilly, lettuce and tomato harboured the most number of aphids.

Of the aphids recorded from Sri Lanka about 30 species are potential viral vectors, known world over (Blackman and Eastop, 1984). Work of Thevasagayam and Canagasinghum (1961), Abeygunawardena and Perera (1964), Peries (1985) and Jayanandaraja and Liyanage (1994) have confirmed the role of aphids as viral vectors of vegetable crops of Sri Lanka.

In conclusion the aphid species recorded from Sri Lanka is relatively small (84 species) in comparison to most other countries in the Indian subcontinent. Considering the high diversity of our flowering plants, the paucity of the aphid fauna cannot be explained. It is more so when the aphids endemic to Sri Lanka (2 species) are considered. Although Sri Lanka has a rich endemic flora, none of them harboured any endemic aphids. Aphids have limitations in distribution, as only the alates produced under high population density are able to take to flight. Natural barriers may limit their dispersal by air. Extensive field studies encompassing the entire country and the balance of the flowering plants and ferns would shed further light on our aphid fauna.

Acknowledgements

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Appendix 1. List of Aphids Recorded from Sri Lanka

FAMILY –APHIDIDAE

SUBFAMILY- APHIDINAE

TRIBE-APHIDINI

Aphis craccivora (Koch, 1854)
Aphis fabae solanella (Theobald, 1914)
Aphis gossypii (Glover, 1877)
Aphis nasturtii (Kaltenbach, 1843)
Aphis nerii (Boyer de Fonscolombe, 1841)
Aphis spiraecola (Patch, 1914)
Hylopterus pruni (Geoffroy, 1762)
Hysteroneura setariae (Thomas)
Melanaphis sacchari (Zehntner)
Rhopalossiphum maidis (Fitch, 1859)
Rhopalossiphum padi L., 1758
Rhopalossiphum rufiabdominali (Sasaki)
Schizaphis cyperi (Passerini, 1874)
Schizaphis graminum (Rondoni, 1852)
Schizaphis hypersiphonata Basu, 1970
Schizaphis minuta (van der Goot)
Toxoptera aurantii (Boyer de Fonsocolombe, 1841)
Toxoptera citricidus (Kirkaldy)
Toxoptera odinae (van der Goot)

TRIBE-MACROSIPHINI

Acyrthosiphon gossypii (Mordvilko, 1914)
Acrythosiphon kondoi (Shinji, 1938)
Acrythosiphon pisum (Harris, 1776)
Akkaia taiwana Tak.
Aulacorthum circumflexus (Buckton, 1876)
Aulacorthum solani (Kaltenbach, 1843)
Brachycaudus helichrysi (Kaltenbach, 1843)
Chaetosiphon tetrarhodum (Walker, 1849)
Dysaphis crataegi (Kaltenbach, 1843)
Ipuka dispersum (van der Goot)
Lipaphis erysimi (Kaltenbach)
Macrosiphoniella sanborni (Gillette, 1908)
Macrosiphoniella pseudoartemisiae (Shinji, 1933)
Macrosiphum euphorbiae (Thomas)
Macrosiphum rosae (Linnaeus, 1758)
Matsumuraja capitophoroides (Hille Ris Lambers)
Micromyzus judenkoi (Carver)
Micromyzus kalimpongensis (Basu, 1967)
Micromyzus nigrum (van der Goot, 1918)
Myzus ascalonicus (Doncaster, 1946)
Myzus boehmeriae (Takahashi, 1933)

Myzus cerasi (Fabricius, 1775)
Myzus obtusirostris (David)
Myzus ornatus (Laing, 1932)
Myzus persicae (Sulzer, 1776)
Neotoxoptera oliveri (Essig, 1935)
Pentalonia nigronervosa (Coquerel, 1859)
Phorodon humuli (Schrank, 1801)
Rhodobium porosum (Sanderson, 1900)
Rhopalosiphoninus latysiphon (Davidson, 1912)
Sinomegoura citricola (van der Goot, 1917)
Sitobion avenae (Fabricius, 1775)
Sitobion lambersi (David)
Sitobion leelamaniae (David)
Sitobion miscanthi (Takahashi, 1921)
Sitobion pauliani (Ram)
Sitobion phyllanthi Takahashi
Sitobion wikstroemiae (Marmet)
Sitobion sp. (Unidentified)
Uroleucon minutum (van der Goot)
Vesiculaphis caricis (Fullaway, 1910)

SUBFAMILY-DREPANOSIPHINAE
Tinocallis kahawaluokalani (Kitkaldy, 1907)

TRIBE-PHYLLAPHIDINI
Shivaphis celti (Das, 1918)

SUBFAMILY- GREENIDINAE
TRIBE - SEBAEPHIDINI
Schoutedenia lutea L., 1917

TRIBE- GREENIDENI
Greenidea artocarpi (Westwood, 1890)
Greenidea formosana Takahashi, 1916
Greenideoida ceyloniae van der Goot, 1918

SUBFAMILY-HORMAPHIDINAE
TRIBE-CERATOPHIDINI
Astegopteryx bambusae (Buckton, 1893)
Astegopteryx insularis (van der Goot, 1917)
Astegopteryx minuta (van der Goot, 1917)
Cerataphis variabilis (Hille Ris, 1934)
Ceratoglyphina bambusae (van der Goot, 1917)
Ceratovacuna lanigera (Zehntner, 1897)
Pseudoregma bambusicola (Takahashi, 1893)

SUBFAMILY-LACHNINAE

Lachnus greeni (van der Goot)
Pyrolachnus pyri (Buckton, 1899)

SUBFAMILY-PEMPHIGINAE (ERIOSOMATINAE)

TRIBE- ERIOSOMATINI

***Ceratopemphigus zehntneri* Schouteden, 1905**
Eriosoma lanigerum (Hausmann, 1802)
Geoica lucifuga (Zehntner, 1898)
Kaltenbachiella elsholtriae (Shinji, 1936)
Kaltenbachiella japonica (Matsumura, 1917)
Tetraneura nigriabdominalis (Sasaki, 1899)
Tetraneura yezoensis (Matsumura, 1917)

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Current Taxonomic Status of Ants (Hymenoptera: Formicidae) in Sri Lanka

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Abstract

The paper highlights the status of research on ants of Sri Lanka, based on published information and ongoing research of the author. A total of 181 ant species in 61 genera have been recorded from Sri Lanka, which includes the endemic and relict monotypic genus *Aneuretus.* Majority of the ant species recorded from Sri Lanka belong to the subfamily Myrmicinae. The Genus *Camponotus* (Formicinae) includes the highest number of ant species recorded so far in the island.

Key words: *Ants, Species, Distribution, Research*

An overview of past research on ants of Sri Lanka

Ants are a very common group of insects in most terrestrial habitats in Sri Lanka. Their habitats vary from highly disturbed urbanized areas to undisturbed forests. They inhabit buildings and outdoors, their microhabitats extend into soil (even up to a depth of 20 cm) decaying wood, plants, trees, litter, termite nests etc. Bingham (1903) was one of the very first to publish a list and descriptions of ant species recorded from Sri Lanka. This publication provides identification keys to the species. The past five decades has seen several publications on taxonomic work on ants in Sri Lanka (Bolton and Belshaw, 1987; Dorow and Kohout, 1995; Jayasooriya and Traniello, 1985; Wilson, 1964; Wilson et al., 1956). A revival of taxonomic work on ants of Sri Lanka in recent times began with the work initiated by the author in 2000. A preliminary taxonomic study of the ants collected from the premises of the Kelaniya University (Gampaha District) was carried out (Dias and Chaminda, 2000; Dias et al., 2001) and this work was later extended to areas in the Districts of Gampaha, Colombo, Ratnapura and Galle (Dias and Chaminda, 2001; Chaminda and Dias, 2001).

The subfamilies, genera and species of ants identified during these studies are listed in the Tables 1 and 2. The absence of a given subfamily, genus or species in a given district does not indicate that the particular taxa are actually absent in the area as ants were not collected from each and every site in a district. Field and laboratory methods for the study of ants and a list of ants held in the Reference Insect collection of the Department of National Museums, Colombo is given in Dias (2002a, 2002b).

Ant Diversity and their distribution in Sri Lanka

According to the currently accepted classification of ants by Bolton (1994), ants belonging to ten subfamilies have been recorded from Sri Lanka (Table 1). The provisional checklist of ants documented from Sri Lanka given in Appendix 1 is based on Bolton (1995), specimens deposited at the National Museums, Colombo and recent field studies by the author. Certain generic and species names appearing in this list are different from those of Dias (2002) due to the updating of taxonomic names according to Bolton (1995). Fifty six genera of ants have been recorded from Sri Lanka by Bolton (1995). Our studies added five more genera namely *Aphaenogaster* Mayr, *Cardiocondyla* Emery, *Ochetellus, Prenolepis* Mayr and *Protanilla* Taylor to the ant fauna of the country. Although the genus *Leptanilla* (subfamily Leptanillinae) has not been recorded from the recent field study, it is recorded by Bolton (1995) as being present in Sri Lanka.

Currently, a total of 181 ant species in 61 genera have been recorded from Sri Lanka (Table 1 and Appendix 1) and includes the endemic and relict monotypic genus *Aneuretus.* Majority of the ant species recorded from Sri Lanka belong to the subfamily Myrmicinae (75 spp,), followed by Formicinae (49 spp.) and Ponerinae (30 spp.). The Genus *Camponotus* (Formicinae) includes the highest number of ant species (22) recorded so far.

Table 1: A summary of the taxonomic diversity of ants of Sri Lanka, based on information gathered up to 2004.

Subfamily	**Genera**	**Species**
Aenictinae	01	05
Aneuretinae	01	01
Cerapachyinae	01	05
Dolichoderinae	04	09
Dorylinae	01	01
Formicinae	12	49
Myrmicinae	24	75
Ponerinae	13	30
Pseudomyrmecinae	01	04
Leptanillinae	02	02
Total	61	181

Worker ants belonging to 58 species in 39 genera and ten subfamilies collected from the Districts of Gampaha, Colombo, Ratnapura and Galle were identified (Table 2). Ant subfamilies that were common to the four districts were Dolichoderinae, Formicinae, Myrmicinae, Pseudomyrmecinae and Ponerinae. Among the dolichoderines, *Tapinoma* and *Technomyrmex* were common in all the four districts. The formicines *Anoplolepis gracilipes, Camponotus, Paratrechina* and *Oecophylla smaragdina* and the myrmicines, *Crematogaster, Pheidologeton, Monomorium, Pheidole, Meranoplus bicolor, Lophomyrmex* and *Solenopsis* were common in all four districts. The Pseudomyrmecine, *Tetraponera* and the ponerines, *Diacamma, Odontomachus* and *Hypoponera* were also common in the four districts. *Pachycondyla* was found in all three districts except Colombo district. The sole living representative of the Subfamily Aneuretinae, *Aneuretus simoni* was found only in the Ratnapura District and the cerapachyine, *Cerapachys* was collected from Maimbula forest (Gampaha District) only. Worker ants belonging to the genus *Aenictus* was collected from Gampaha, Ratnapura and Galle districts. So far, *Polyrhachis rastellata* was recorded only from Colombo District and a single specimen of *Strumigenys* was collected from Galle District. Several unidentified species belonging to six genera *(Crematogaster, Cerapachys, Myrmicaria, Anochetus, Leptogenys, Myrmoteras* and *Cataulacus)* were collected from the forest reserves.

The field surveys enabled the identification of micro-habitats preferred by certain ant species. *Aenictus* and most ponerines were found in the leaf litter, while *Aneuretus simoni* inhabited the leaf litter and associated soil. Species of the genera *Tetraponera* and *Crematogaster* occurred in vegetation. *Monomorium* was generally found indoors. *Dorylus* and *Lophomyrmex* were found both indoors and outdoors, indicating that they are generalists. *Protanilla* occurred in soil.

Recent research (Dias and Chaminda, 2001; Perera, 2003; Perera and Dias, 2003; Perera and Dias, 2004 collection) showed that the single living representative species (*Aneuretus simoni* – Plate 1) of the Subfamily Aneuretinae recorded only from Sri Lanka (Bolton, 1995) inhabits the city - reservoir associated forest ("Pompekelle") in Ratnapura. Its density in a selected region of this forest was 7 m^{-2}. This species has been found in the Gilimale forest too. It is listed as globally threatened (IUCN, 2004).

Table 2: Ants recorded from University of Kelaniya premises, areas in Gampaha, Colombo, Ratnapura and Galle Districts

Species	**Kelaniya**	**Gampaha**	**Colombo**	**R'pura**	**Galle**
Aenictinae					
Aenictus sp.		X			X
Aneuretinae					
Aneuretus simoni				X	
Cerapachyinae					
Cerapachys sp.		X			
Dolichoderinae					
Tapinoma melanocephalum	X		X	X	
Tapinoma indicum				X	X
Technomyrmex bicolor	X				
Technomyrmex elatior	X				
Tapinoma sp.	X	X		X	X
Technomyrmex sp.	X		X	X	X
Dolichoderus sp.	X	X		X	
Dorylinae					
Dorylus orientalis		X			
Dorylus sp.					X
Formicinae					
Anoplolepis gracilipes	X	X		X	
Oecophylla smaragdina	X	X	X	X	X
Paratrechina longicornis	X	X	X	X	
Camponotus sp.	X	X	X	X	X
Paratrechina sp.	X	X	X	X	X
Polyrhachis sp.	X	X		X	
Prenolepis sp	X		X		
Polyrachis rastellata			X		
Lepisiota sp.				X	
Myrmoteras sp.				X	
Acropyga sp.					X
Myrmicinae					
Pheidologeton diversus	X			X	
Monomorium destructor	X				
Monomarium floricola	X		X		
Meranoplus bicolor	X	X	X	X	X
Pheidole spathifera	X				
Solenopsis geminata	X	X	X	X	X
Lophomyrmex quadrispinosus	X	X	X		
Lophomyrmex spp.	X			X	X
Crematogaster spp.	X	X			

Pheidole spp.	X	X	X		X
Pheidologeton spp.	X	X	X		X
Tetramorium sp.		X	X	X	
Monomarium spp.			X	X	X
Crematogaster Sp.1				X	X
Crematogaster Sp.2				X	
Crematogaster Sp.3				X	
Crematogaster Sp.4				X	
Crematogaster Sp.5				X	
Crematogaster Sp.6				X	
Cataulacus sp.				X	
Strumigenys sp.					X
Leptanillinae					
Protanilla sp.				X	
Pseudomyrmecinae					
Tetraponera rufonigra	X		X	X	X
Tetraponera spp.		X			
Tetraponera allaborans				X	
Ponerinae					
Odontomachhus simillimus	X	X			
Diacomma ceylonense	X	X			
Diacomma rugosum	X	X			X
Diacamma spp.	X		X	X	X
Odontomachus spp.	X		X	X	X
Hypoponera sp.	X	X	X	X	X
Leptogenys spp.	X	X			
Pachycondyla sp.	X	X		X	X
Platythyrea sp.		X			
Anochetus sp.				X	X
Total Species	**33**	**26**	**20**	**35**	**24**

Issues pertaining to taxonomy and research on ants

Like most other tropical countries, Sri Lanka has a rich ant fauna that remains undiscovered due to lack of taxonomic research by local scientists. Setting up a good reference collection of ants collected island wide is an essential task, since the collection at the National Museum is very old, incomplete and not properly curated.

Although a colony of ants consist of queen/s, males, major workers and minor workers, taxonomic keys of ants, generally, are based on the morphology of minor workers. However, identification to the species level requires the collection of both minor and major workers for some ant genera such as *Pheidole*. Ant genera of subfamily Leptanillinae have been identified on the basis of male morphology (Ogata et al., 1995) and it appears that workers are rare in this subfamily (Three workers of *Protanilla* were present in our recent collection).

The two publications, Bolton (1994) and Bolton (1995) provide the most recent classification and taxonomic keys for the subfamilies and genera of ants recorded from the world. About 9200 species of ants have been recorded from the world according to Bolton (1995) but this number has been increased to 11,100 by 2002. However, lack of a good reference collection of ants and unavailability of publications that provide species descriptions are two major problems for the identification of ants collected from Sri Lanka.

In the past, very few research has been carried out to collect, identify and record ants of Sri Lanka. Bingham (1903) is the only publication which carries species descriptions of ants based on sporadic collections. The system of classification used in this publication is outdated. Dias and Chaminda (2000, 2001) and Dias (2002, 2003) provide accounts on ants of Sri Lanka and a reference collection of ants is held in the Department of Zoology, University of Kelaniya.

The inadequacy of research that focuses on forest ants of Sri Lanka (except for Perera 2003, Perera and Dias, 2003) with only a few sporadic publications by foreign researchers is a major barrier for the development of myrmecology in Sri Lanka. The current research (funded by the National Science Foundation of Sri Lanka) in progress at the Department of Zoology, University of Kelaniya to study ant communities in the city reservoir associated forests in Ratnapura, Gilimale and Sinharaja would reveal most of the wet zone ants. In addition, steps should be taken to extend ant surveys to other districts in the Wet zone and also to the Dry zone of Sri Lanka.

Research priorities and recommendations

- Initiate taxonomic research on ants in the other districts of Sri Lanka, with emphasis on forest-dwelling ants.
- Initiate detailed studies on the single living representative species of the subfamily Aneuretinae (A. simoni) in the Ratnapura District. One of its current localities includes the highly disturbed "Pompekelle" forest, it would be worthwhile to document how it survives in such disturbed areas.
- Develop a well-maintained reference collection of ants at the Dept. of National Museums, Colombo.
- Maintain active links with the Network for the study of Asian ants (ANeT), an association comprising Asian myrmecologists who work towards the development of myrmecology in Asia (Website:http://www.geocities.com/anet_malaysia). New research findings of the members of this association are published through ANeT Newsletter printed at the Kagoshima University in Japan.

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Appendix 1: A provisional checklist of subfamilies, genera and species of ants recorded from Sri Lanka (10 subfamilies, 61 genera and 180 species)

AENICTINAE

***Aenictus* Shuckard**
Aenictus fergusoni Walker
Aenictus porizonoides Walker
Aenictus biroi Forel
Aenictus pachycercus (Dalla Torre)
Aenictus ceylonicus (Dalla Torre)

ANEURETINAE

Aneuretus Emery
Aneuretus simoni Emery (Endemic)

CERAPACHYINAE

***Cerapachys* Smith**
Cerapachys coecus (Emery)
Cerapachys fossulatus Forel
Cerapachys fragosus (Emery)
Cerapachys luteoviger Brown
Cerapachys typhlus (Emery)

DOLICHODERINAE

***Dolichoderus* Lund**
Dolichoderus taprobanae (Mayr)
***Ochetellus* Shattuck**
Ochetellus glaber Shattuck
***Tapinoma* Foerster**
Tapinoma melanocephallum (Santschi)
Tapinoma indicum Forel
***Technomyrmex* Mayr**
Technomyrmex albipes Emery
Technomyrmex bicolor Emery
Technomyrmex detorquens (Donisthorpe)
Technomyrmex elatior Bingham
Technomyrmex albipes (Emery)

DORYLINAE

Dorylus Fabricius
Dorylus orientalis Fabricius

FORMICINAE

***Acropyga* Roger**
Acropyga acutiventris Roger
***Anoplolepis* Santschi**
Anoplolepis gracilipes (Jerdon)
***Camponotus* Mayr**
Camponotus irritans (Roger)
Camponotus albipes Emery
Camponotus auriculatus Mayr
Camponotus mitis (Roger)
Camponotus barbatus Roger
Camponotus fletcheri Donisthorpe
Camponotus greeni Forel
Camponotus sericeus Mayr
Camponotus indeflexus (Donisthorpe)
Camponotus variegatus Mayr
Camponotus mendax Bingham
Camponotus maculatus (Mayr)
Camponotus isabellae Forel
Camponotus latebrosus (Donisthorpe)
Camponotus ominosus Forel
Camponotus rufoglaucus Forel
Camponotus reticulatus Roger
Camponotus sesquipedalis Roger
Camponotus simoni Emery
Camponotus thraso Bingham
Camponotus varians Roger
Camponotus wedda Forel
***Lepisiota* Santschi**
Lepisiota capensis Mayr
***Myrmoteras* Forel**
M. binghami Forel
Myrmoteras ceylonica Gregg

***Oecophylla* Smith**
Oecophylla smaragdina Fabricius
***Paratrechina* Motschoulsky**
Paratrechina longicornis Latrielle
Paratrechina taylori (Bolton)
Paratrechina yerburyi (Bolton)
***Plagiolepis* Mayr**
Plagiolepis pisssina Roger
Polyrhachis Smith
Polyrhachis rastellata Smith F.
Polyrhachis (Hemioptica) bugnioni Forel
Polyrhachis (*Hemioptica*) *scissa* (Roger, 1862)
Polyrhachis (campomyrma) exercita

Donisthorpe
Polyrhachis (Myrma) horni Emery
Polyrhachis (Myrma) illaudata Donisthorpe
Polyrhachis (Myrmhopla) jerdonii Emery
Polyrhachis (Myrma) nigra Emery
Polyrhachis (Myrmhopla) tibialis var. *pectita* Santschi
Polyrhachis (Myrma) punctillata Emery
Polyrhachis (Myrmhopla) rupicapra Emery
Polyrhachis (Myrmhopla) sophocles Emery
Polyrhachis (Myrmothrinax) thrinax Forel
Polyrhachis (Myrmhopla) xanthippe Emery
Polyrhachis (Myrma) yerburyi Emery
***Prenolepis* Mayr**
***Pseudolasius* Emery**
Pseudolasius isabellae Forel
***Acanthomyrmex* Emery**
Acanthomyrmex luciolae Emery

MYRMICINAE

***Anillomyrma* Emery**
Anillomyrma decamera Ettershank
***Aphaenogaster* Mayr**
Aphaenogaster becarii Emery
***Calyptomyrmex* Baroni Urbani**
Calyptomyrmex singalensis Baroni Urbani
Calyptomyrmex tamil Baroni Urbani
Calyptomyrmex vedda Baroni Urbani
***Cardiocondyla* Emery**
Cardiocondyla nuda Forel
***Cataulacus* Emery**
Cataulacus simoni Emery
Cataulacus taprobanae Smith F.
***Crematogaster* Lund**
Crematogaster dohrni Mayr
Crematogaster anthracina Smith
Crematogaster apicalis (Emery)
Crematogaster biroi (Emery)
Crematogaster brunnescens (Emery)
Crematogaster haputalensis (Emery)
Crematogaster pellens (Donisthorpe)
Crematogaster ransonneti Emery
Crematogaster rogeri Emery
Crematogaster rogenhoferi Mayr
***Dilobocondyla* Santschi**
Dilobocondyla didita (Donisthorpe)

***Lophomyrmex* Emery**
Lophomyrmex quadrispinosus (Jerdon)

***Metapone* Forel**
Metapone greeni Forel
Metapone johni Karavaiev

***Meranoplus* Smith F.**
Meranoplus bicolor (Smith F.)
***Monomorium* Mayr**
Monomorium destructor (Jerdon)
Monomorium floricola (Jerdon)
Monomorium pharaonis (L.)
Monomorium latinode Mayr
Monomorium consternens (Donisthorpe)
Monomorium subopacum (Mayr)
Monomorium rogeri (Ettershank)
Monomorium criniceps (Emery)
Monomorium taprobanae (Bolton)
***Monomorium mayri* Forel**

***Myrmicaria* Saunders**
Myrmicaria brunnea Saunders

***Oligomyrmex* Ettershank**
Oligomyrmex bruni Forel
Oligomyrmex butteli (Ettershank)
Oligomyrmex deponens (Donisthorpe)
Oligomyrmex aprobanae Forel

***Paedalgus* Forel**
Paedalgus escherichi Forel.
***Paratopula* Wheeler**
Paratopula ceylonica (Wheeler)
***Pheidole* Westwood**
Pheidole barreleti Forel
Pheidole ceylonica Motchoulsky
Pheidole diffidens Walker
Pheidole gracilipes (Emery)
Pheidole horni Emery
Pheidole latinoda (Roger)
Pheidole malinsii Forel
Pheidole megacephala (Roger)
Pheidole nietneri Emery
Pheidole noda Smith
Pheidole parva Mayr

Pheidole pronotalis Forel
Pheidole rugosa Smith F.
Pheidole spathifera Emery
Pheidole sulcaticeps Roger
Pheidole templaria Forel

***Pheidologeton* Mayr**
Pheidologeton diversus (Jerdon)
Pheidologeton pygmaeus Emery
Pheidologeton ceylonensis Forel
***Rophalomastix* Forel**
Rophalomastix escherichi Forel
***Recurvidris* (Bolton)**
Recurvidris pickburni (Bolton)
***Solenopsis* Westwood**
Solenopsis geminata Mayr
Solenopsis nitens Bingham
***Stereomyrmex* Emery**
Stereomyrmex horni Emery (Endemic)
***Strumigenys* F. Smith**
Strumigenys godeffroyi Brown
Strumigenys lyroessa (Roger)
***Tetramorium* Mayr**
Tetramorium bicarinatum (Mayr)
Tetramorium curvispinosum Mayr
Tetramorium tortuosum Roger
Tetramorium simillimum (Mayr)
Tetramorium pilosum Emery
Tetramorium pacificum Mayr
Tetramorium transversarium Roger
Tetramorium yerburyi Bingham
Vollenhovia Mayr
Vollenhovia escherichi Forel

PONERINAE

***Anochetus* Mayr**
Anochetus consultans (Brown)
Anochetus longifossatus Mayr
Anochetus madaraszi Mayr
Anochetus nietneri (Mayr)
Anochetus yerburyi Forel

***Centromyrmex* Mayr**
Centromyrmex feae (Emery)
***Cryptopone* Emery**
Cryptopone testacea Emery
***Diacamma* Mayr**
Diacamma rugosum Mayr
Diacamma ceylonense Emery
D. didita (Donisthorpe)
***Gnamptogenys* Brown**
Gnamptogenys coxalis (Brown)
***Harpegnathos* Jerdon**
Harpegnathos saltator Jerdon
***Hypoponera* Santschi**
Hypoponera ceylonensis (Taylor)
Hypoponera confinis Wilson & Taylor
Hypoponera taprobanae Bolton
***Leptogenys* Roger**
Leptogenys ocellifera Emery
Leptogenys exudans (Donisthorpe)
Leptogenys falcigera Roger
Leptogenys hysterica Forel
Leptogenys. meritans (Donisthorpe)
Leptogenys. pruinosa Forel
Leptogenys. diminuta (Emery)
Leptogenys. yerburyi Forel
Leptogenys peuqueti (Andre)
***Myopopone* Roger**
Myopopone castanea (Roger)
***Myopias* Roger**
Myopias amblyops Roger
***Odontomachus* Latreille**
Odontomachus simillimus Fred Smith
***Pachycondyla* Smith F.**
Pachycondyla luteipes Brown
***Platythyrea* Roger**
Platythyrea parallela (Donisthorpe)
Platythyrea clypeata Forel

PSEUDOMYRMECINAE

***Tetraponera* Smith F.**
Tetraponera rufonigra (Smith F.)
Tetraponera allaborans
Tetraponera nigra var. *insularis* (Bolton)
T. petiolata (Bingham)

LEPTANILLINAE

Leptanilla Emery
Leptanilla besucheti Baroni Urbani
Protanilla Taylor

Species Richness, Distribution and Conservation Status of Butterflies in Sri Lanka

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Abstract

Although butterflies are a group of charismatic insects, only a few researchers have studied them in Sri Lanka. The total butterfly species in Sri Lanka described to date includes 243 species, classified under five families. This includes 20 species that are endemic to the island. Their distribution in Sri Lanka is governed by climate, topography and vegetation types. In general, a higher species richness of butterflies occurs in the foothill areas. Several species of butterflies exhibit mass migrations, usually from the Dry and Arid zones towards the Intermediate and Wet Zones. The paper discusses the current conservation status of butterflies, and recommends actions to enhance their conservation.

Key words: *Butterflies, Species, Distribution, Conservation*

Historical background

The butterflies of Sri Lanka have been studied in detail by only a handful of researchers, starting from the work of Fedric Moore (1880). This was followed by the pioneering studies of Ormiston (1924), Woodhouse and Henry (1942), and Woodhouse (1950), based on extensive field observations. More recently, d'Abrera (1998) made a publication based mainly on a study of local butterfly specimens in the Natural History Museum in Britain, supplemented by some field observations carried out in the island.

Apart from the above works, several researchers have studied and published on the status of specific butterfly families (Bambaradeniya and Ranawana, 1996), butterflies occurring in specific localities (Samarasinghe et al., 1996; van der Poorten, 1996; Dening, 1992; Goonatilake and Goonatilake, 2000; Chamikara and Sumanaratne, 1998: Perera and Perera 2001; Samarawickrama and Rajapaksha, 2003), life cycle and natural history of species (Kolambaarachchi, 2001; Munidasa K.G.H. 1995; Nanayakkara, 1999; Chamikara, 1998; Samarasinghe et al., 1998), and migration of species (Perera, 2001, 2002; Senaratne, 1997; Williams and Senaratne, 1998). A paper published by Gaonkar (1996) highlights the butterflies of the Western Ghats region in India, including Sri Lanka.

Current taxonomic status

Based on phylogenetic analysis of butterflies in the world, Ackery et al (1999) revised the classification of butterflies, and grouped them under three super families; Hedyloidea, Hesperoidea and Papilionoidea. According to the classification of Ackery et. al (1999), the butterflies of Sri Lanka belong to the latter two super families, representing five families. The total butterfly species in Sri Lanka described to date includes 243 species (d'Abrera, 1998) (Appendix 1), classified under Papilionoidea (Family Papilionidae – 15 species; Pieridae – 27 species; Nymphalidae – 69 species; Lycaenidae – 86 species) and Hesperoidea (Family Hesperridae – 46 species). The total includes 20 endemic species (Papilionidae – 2; Nymphalidae – 8; Lycaenidae – 8; Hesperridae – 2). However, ongoing taxonomical work on the group may result in an increase in the number of endemic species (Gaonkar, in prep.).

Distribution of butterfly species

The major factors that govern the distribution of butterfly species in the island include climate, topography and vegetation types. Most butterfly species in Sri Lanka are distributed island-wide, with differences in their relative abundance related to bioclimatic zones. Some species occur in more than one bioclimatic/floristic zone, while certain others are restricted in their distribution, as highlighted in Table 1. In general, a higher species richness of butterflies occurs in the foothill areas. The populations of butterflies in the Dry and Arid Zones reach peak levels soon after the monsoons. Their populations in the Wet Zone are also seasonal but not so pronounced, being generally stable throughout the year, with slight reductions during high rainfall periods.

Table 1: Butterfly species with restricted distribution patterns

Bio-climatic Zone	**Habitats/ Vegetation types**	**Species**
Lowland Wet Zone	Tropical Rain Forests	*Jamides coruscans , Mycalesis rama, Hasora badra, "Papilio helenus"*
Montane Wet Zone	Montane and Lower Montane Forests	*Parantica taprobana, Vanessa indica, Lethe daretis, Udara lanka*
	Wet Patana Grassland	*Baracus vittatus*
Lowland Dry and Intermediate Zone	Dry Zone Forests (Evergreen/ Deciduous) and scrubland	*Pathysa nomius, Charaxes solon, Amblypodia anita*
	Grasslands	*Zizula hylax, Freyeria trochilus,Azanus jesous*
	Savanna and Dry & Intermediate Patana	*Symphaedra nais, Ypthima singala*
Arid Zone (North)	Scrubland, mangrove and other coastal vegetation	*Colotis danai, Colotis fausta, Azanus ubaldus, Tarucus nara, Spindasis lunulifera, Tajuria jehana*
Arid Zone (South)	Scrubland, mangrove and other coastal vegetation	*Ixias marianne, Gomalia elma, Colotis amata, Belenois aurota, Tarucus callinara*
Wet coastal zone	Mangrove and coastal scrub Home Gardens and secondary vegetation	*Euploea phaenareta, Ideopsis similes, Curetis thetis,Zesius chrysomallus*

Several species of butterflies exhibit mass migrations, soon after the north-eastern monsoon rains. Woodhouse (1950) has listed 70 butterfly species that exhibit migratory behaviour. Most common species that take part in mass migrations include members of the Pieridae (Pioneer, Mottled Emmigrant, Lemon Emmigrant, Lesser Albatross). They usually migrate from the Dry and Arid zones towards the Intermediate and Wet Zones.

Butterflies that occur in forest and scrubland vegetation types also exhibit vertical stratification, as highlighted in Table 2.

Table 2: Vertical stratification of butterfly species according to forest types

Vegetation Type	**Strata 1**	**Strata 2**	**Strata 3**	**Strata 4**
Lowland Tropical Rain Forest	Canopy (30-40m) *Pachliopta jophon, Vindula erota*	Sub-canopy *Papilio helenus, Idea iasonia, Kallima philarchus*	Understorey *Mycalesis rama, Jamides coruscans Cheritra freja*	Ground *Nissanga patina, Melantis leda*
Lowland Dryand Intermediate Zone Forest	Canopy (25m) *Papilio crino, Pachliopta hector, Hebomoia glaucippe*	Understorey *Neptis jumbah, Euploea core*	Ground *Ypthima ceylonica Leptosia nina*	-

Dry and Arid Zone Scrubland	Tall scrub (3m) *Cotopsila pyranthe, Ixias marianne, Belenois aurota*	Ground layer *Leptosia nina*	-	-

Conservation status, constraints and threats to butterflies

Among the total butterfly species in Sri Lanka, 76 are nationally threatened (IUCN Sri Lanka, 2000), while one species (the endemic Ceylon Rose – *Atrophaneura jophon*) is listed as globally threatened, under the critically endangered category (IUCN, 2003). The status of 40 species could not be analyzed due to lack of data on their occurrence and distribution. The natural history of more than 50% of the butterflies in the island is still unknown. The major threats to butterflies in Sri Lanka include destruction and degradation of habitats, air pollution, over-use of pesticides, over-exploitation for commercial trade and natural factors such as prolonged drought and over-predation by opportunistic predators in managed landscapes.

A majority of the endemic species in Sri Lanka are restricted to natural forests in the Wet Zone, and their populations have been negatively affected by clearance and fragmentation of these forests. Similarly, a decrease in the mass migrating pierids is clearly evident during the past decade, and this may be attributed to clearance of scrubland vegetation in the Dry and Arid Zone, for human settlements and other development activities. Similarly, the Common Banded Peacock *(Papilio crino)* has declined in many parts of the Dry Zone, with the felling of its primary food plant - Satin wood *(Chloroxylon sweitenia)*. The mass migratory species are also subjected to large scale mortality due to road accidents, when they move between forest/scrubland patches fragmented by road networks.

Many species of butterflies visit and/or breed in agricultural landscapes. For instance, Bambaradeniya (2004) documented 53 species of butterflies from a single rice field ecosystem in Bathalagoda. The agricultural ecosystems such as rice fields in Sri Lanka are subjected to over-use of pesticides and weedicides, and this could lead to negative impacts on butterflies that use many herbaceous food plants (weeds) growing in such landscapes.

Over-collection of butterflies such as the Papilionids for ornamental trade is a growing concern, as indicated by the detections of the Customs Department over the past decade.Among the butterflies subjected to commercial trade in Sri Lanka, two species (Ceylon Rose – *Pachliopta jophon,* Ceylon Birdwing – *Troides darsius*) are included in the CITES appendices.

Prolonged periods of drought experienced in different parts of the island during the past decade may have also affected butterflies populations in such area, due to scarcity of food resources, and harsh conditions. The butterflies that have adapted to survive in managed landscapes such as home gardens are negatively affected by opportunistic predatory animals such as Ants, Mynahs, Bulbuls and Drongos, which feed on eggs, caterpillars, pupae and adult butterflies.

There are several species that have become commoner during the past two decades, due to the expansion of larval host plants in modified landscapes. For instance, the population of the Blue Mormon *(Papilio polymnestor)* has expanded, due to the increase in the availability of its larval food plants, belonging to the Family Rutaceae (Lime, Lemon, Orange etc.). Among the pierids, the Lemon Emigrant *(Catopsilia pomona)* has increased in numbers, due to the use of *Cassia fistula* in avenue plantations. Similarly, the populations of the Common Grass Yellow *(Eurema hecabe)* and the Three-spot Grass Yellow *(Eurema blanda)* have also increased, due to the planting of *Sesbania grandiflora* in home gardens, and the spread of *Cassia tora* in degraded areas, which are preferred larval food plants of these butterflies. Among the danaids, the Single-banded Crow *(Euploea core)* has also increased in numbers, due to the use of *Nerium oleander* as a home garden hedge plant. Among the lycaenids, the population of the Lesser Grass Blue *(Zizina otis)* has also grown, due the expansion of grasses in disturbed areas.

Current conservation actions

At present, a revival of interest on butterflies of Sri Lanka and their conservation is evident. IUCN is in the process of compiling data on butterflies, to evaluate their conservation status, using the global Redlist criteria and categories. IUCN has also initiated a joint programme with Dr. Michael van der Poorten, who possesses a wealth of knowledge and experience on the butterflies in Sri Lanka, to promote research and awareness on butterflies in the island. A pioneering website (www.srilankaninsects.net) initiated by Dr. van der Poorten provides useful information on the butterflies of Sri Lanka, including the distribution and life histories of several species. A proposal has already been prepared for a comprehensive field study on the abundance, distribution, and life histories of butterflies in Sri Lanka. Several awareness creation workshops were also organized during the recent past. Several individuals (mostly foreigners) involved in illegal collections have been caught and filed legal action by the Department of Wildlife Conservation and the Customs Department over the past decade. It is interesting to note that some of the private sector corporates have begun to use butterflies to promote eco-tourism, and produced pictorial awareness material (Wijeyeratne, 2004).

Recommendations for conservation of butterflies in Sri Lanka

The following recommendations are made to promote research and other activities to conserve the butterflies in Sri Lanka.

- Conduct an island-wide survey on the distribution,and flight seasons, with particular emphasis on the once that were categorized as data deficient in the IUCN analysis conducted in 1999. This should lay the foundation for long-term monitoring of prioritized populations in selected localities in the island. Identify butterfly hotspots, and promote restoration of degraded areas with suitable larval host plants.
- Conduct comparative molecular biological studies to verify the taxonomic status of the endemic species, sub-species, races in Sri Lanka (proposed by Woodhouse, 1950 and d'Abrera, 1998) with those of the Indian mainland.
- Special studies should be initiated by academic institutions, focusing on the following aspects:
  - Impact of habitat degradation / forest fragmentation on local and meta populations
  - Impact of industrial/agro-chemicals.
  - Impacts of invasive alien plant species.
  - Studies on life histories and ecology of butterflies
  - Indigenous nectaring sources and larval food plants
  - Adaptations of species to changing habitats.
  - Seasonal migration, morphological variations and other behavioural patterns.
- The repository at the national museum needs to be upgraded, in order to facilitate future research on the taxonomy of butterflies in Sri Lanka.
- Establish butterfly friendly habitats in non-forested areas. This should be done with the cooperation of the private sector organizations, schools, NGOs, temples and government agencies.
  - Establish relevant larval food plants and adult nectaring plants in home gardens, urban parks, and agricultural landscapes

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Appendix 1: Checklist of Butterflies in Sri Lanka

Family	Species	Common Name
PAPILIONIDAE	*Troides darsius* [E]	Common Birdwing/ Ceylon Birdwing
	Pachliopta hector	Crimson Rose
	Pachliopta jophon [E]	Ceylon Rose
	Pachliopta aristolochiae	Common Rose
	Papilio crino	Banded Peacock
	Papilio demoleus	Lime Butterfly
	Papilio helenus	Red Helen
	Papilio polytes	Common Mormon
	Papilio polymnestor	Blue Mormon
	Chilasa clytia	Mime
	Graphium sarpedon	Blue Bottle
	Graphium doson	Common Jay
	Graphium agamemnon	Green Jay/ Tailed Jay
	Pathysa nomius	Spot Swordtail
	Pathysa antiphates	Five bar Swordtail
PIERIDAE	*Leptosia nina*	Psyche
	Delias eucharis	Jezebel
	Prioneris sita	Painted Saw-tooth
	Belenois aurota	Pioneer
	Cepora nerissa	Common Gull
	Cepora nadina	Lesser Gull
	Appias indra	Plain Puffin
	Appias libythea	Striped Albatross
	Appias lyncida	Chocolate Albatross
	Appias albina	Common Albatross
	Appias paulina	Lesser Albatross
	Ixias marianne	White Orange Tip
	Ixias pyrene	Yellow Orange Tip
	Hebomoia glaucippe	Great Orange Tip/ Giant Orange Tip
	Catopsilia pyranthe	Mottled Emigrant/ African Emigrant
	Catopsilia pomona	Lemon Emigrant
	Pareronia ceylanica	Blue Wanderer/ Dark Wanderer
	Colotis amata	Small Salmon Arab
	Colotis fausta	Large Salmon Arab
	Colotis danae	Crimson Tip
	Colotis aurora	Plain Orange Tip
	Colotis etrida	Little Orange Tip
	Eurema brigitta	Small Grass Yellow
	Eurema laeta	Spotless Grass Yellow
	Eurema hecabe	Common Grass Yellow

	Eurema blanda	Three-spot Grass Yellow
	Eurema andersoni	One-spot Grass Yellow
NYMPHALIDAE	*Idea iasonia*	Tree Nymph
	Ideopsis similis	Blue Glassy Tiger
	Tirumala limniace	Blue Tiger
	Tirumala septentrionis	Dark Blue Tiger
	Parantica aglea	Glassy Tiger
	Parantica taprobana	Ceylon Tiger
	Danaus chrysippus	Plain Tiger
	Danaus genutia	Common Tiger
	Euploea core	Common crow
	Euploea sylvester	Double- banded Crow
	Euploea phaenareta	King Crow
	Euploea klugii	Brown King Crow
	Ariadne ariadne	Angled Castor
	Ariadne merione	Common Castor
	Byblia ilithyia	Joker
	Cupha erymanthis	Rustic
	Phalanta phalantha	Leopard
	Phalanta alcippe	Small Leopard
	Vindula erota	Cruiser
	Cirrochroa thais	Tamil Yeoman/ Yeoman
	Cethosia nietneri	Ceylon Lace Wing
	Argynnis hyperbius	Indian Fritillary
	Vanessa indica	Indian Red Admiral
	Vanessa cardui	Painted Lady
	Kaniska canace	Blue Admiral
	Junonia lemonias	Lemon Pansy
	Junonia orithya	Blue Pansy
	Junonia hierta	Yellow Pansy
	Junonia atlites	Grey Pansy
	Junonia iphita	Chocolate Soldier
	Junonia almana	Peacock Pansy
	Hypolimnas bolina	Great Eggfly
	Hypolimnas misippus	Danaid Eggfly
	Doleschallia bisaltide	Autumn Leaf
	Kallima philarchus [E]	Blue Oakleaf
	Pantoporia hordonia	Common Lasker
	Neptis hylas	Common Sailor
	Neptis jumbah	Chestnut-streaked Sailor
	Moduza procris	Commander
	Parthenos sylvia	Clipper

	Symphaedra nais	Baronet
	Dophla evelina	Red spot Duke
	Euthalia lubentina	Gaudy Baron
	Euthalia aconthea	Baron
	Rohana parisatis	Black Prince
	Polyura athamas	Nawab
	Charaxes solon	Black Rajah
	Charaxes psaphon	Tawny Rajah
	Libythea celtis	Beak
	Libythea myrrha	Club Beak
	Acraea violae	Tawny Costor
	Discophora lepida	Southern Duffer
	Melanitis leda	Common Evening Brown
	Melanitis phedima	Dark Evening Brown
	Lethe drypetis	Tamil Treebrown
	Lethe daretis [E]	Ceylon Treebrown
	Lethe dynaste [E]	Ceylon Forester
	Lethe rohria	Common Treebrown
	Orsotriaena medus	Nigger
	Mycalesis visala	Tamil Bush Brown
	Mycalesis mineus	Dark-brand Bushbrown
	Mycalesis perseus	Common Bushbrown
	Mycalesis rama[E]	Cingalese Bushbrown
	Nissanga patnia	Gladeye Bushbrown
	Ypthima ceylonica	White Four-ring
	Ypthima singala [E]	Jewel Four-ring
	Elymnias hypermnestra	Common Palmfly
	Elymnias singala [E]	Ceylon Palmfly
LYCAENIDAE	*Spalgis epeus*	Apefly
	Curetis thetis	Indian Sunbeam
	Arhopala abseus	Aberrant Bushblue
	Arhopala amantes	Large Oakblue
	Arhopala ormistoni[E]	Ormiston's Oakblue
	Arhopala bazaloides	Tamil Oakblue
	Arhopala pseudocentaurus	Centaur Oakblue
	Surendra vivarna	Common Acacia Blue
	Zesius chrysomallus	Redspot
	Amblypodia anita	Purple Leafblue
	Iraota timoleon	Silverstreak Blue
	Catapaecilma major	Common Tinsel
	Loxura atymnus	Yamfly
	Rathinda amor	Monkey-puzzle

	Horaga onyx	Blue Onyx
	Horaga albimaculata	Brown Onyx
	Cheritra freja	Common Imperial
	Spindasis lohita	Long -banded Silverline
	Spindasis vulcanus	Common Silverline
	Spindasis schistacea	Plumbeous Silverline
	Spindasis ictis	Ceylon Silverline
	Spindasis lunulifera	Scarce Shot Silverline
	Spindasis nubilus [E]	Clouded Silverline
	Tajuria cippus	Peacock Royal
	Tajuria jehana	Plains Blue Royal
	Tajuria arida [E]	Ceylon Indigo Royal
	Pratapa deva	White Royal
	Hypolycaena nilgirica	Nilgiri Tit
	Bindahara phocides	Plane
	Virachola perse	Large Guava Blue
	Virachola isocrates	Common Guava Blue
	Rapala iarbus	Indian Red Flash
	Rapala manea	Slate Flash
	Rapala varuna	Indigo Flash
	Rapala lankana	Malabar Flash
	Deudorix epijarbas	Cornelian
	Anthene lycaenina	Pointed Ciliate Blue
	Petrelaea dana	Dingy Lineblue
	Nacaduba pactolus	Large 4-Lineblue
	Nacaduba hermus	Pale 4-lineblue
	Nacaduba ollyetti [E]	Woodhouse's 4-Lineblue
	Nacaduba berenice	Rounded 6-Lineblue
	Nacaduba sinhala [E]	Pale Ceylon 6-Lineblue
	Nacaduba kurava	Transparent 6-Lineblue
	Nacaduba beroe	Opaque 6-Lineblue
	Nacaduba calauria	Dark Ceylon 6-Lineblue
	Prosotas nora	Common Lineblue
	Prosotas dubiosa	Tailless Lineblue
	Prosotas noreia [E]	White-tipped Lineblue
	Ionolyce helicon	Pointed Lineblue
	Jamides bochus	Dark Cerulean
	Jamides coruscans [E]	Ceylon Cerulean
	Jamides lacteata	Milky Cerulean
	Jamides alecto	Metallic Cerulean
	Jamides celeno	Common Cerulean
	Catochrysops panormus	Silver Forget-me-not

	Catochrysops strabo	Forger-me-not
	Lampides boeticus	Pea Blue
	Syntarucus plinius	Zebra Blue
	Castalius rosimon	Common Pierrot
	Discolampa ethion	Banded Blue Pierrot
	Caleta decidia	Angled Pierrot
	Tarucus nara	Striped Pierrot
	Tarucus callinara	Butler's Spotted Pierrot
	Freyeria trochilus	Grass Jewel
	Zizeeria karsandra	Dark Grass Blue
	Zizina otis	Lesser Grass Blue
	Zizula hylax	Tiny Grass Blue
	Talicada nyseus	Red pierrot
	Everes lacturnus	Indian Cupid
	Azanus ubaldus	Bright Babul Blue
	Azanus jesous	African Babul Blue
	Actyolepis lilacea	Hampson's Hedge Blue
	Actyolepis puspa	Common Hedge Blue
	Celastrina lavendularis	Plain Hedge Blue
	Udara singalensis	Singalese Hedge Blue
	Udara akasa	White Hedge Blue
	Udara lanka [E]	Ceylon Hedge Blue
	Neopithicops zalmora	Quaker
	Megisba malaya	Malayan
	Euchrysops cnejus	Gram Blue
	Chilades pandava	Plains Cupid
	Chilades lajus	Lime Blue
	Chilades parrhasius	Small Cupid
	Abisara echerius	Plum Judy
HESPERIIDAE	*Bibasis oedipodea*	Branded Orange Awlet
	Bibasis sena	Orange-tail Awl
	Badamia exclamationis	Brown Awl
	Choaspes benjaminii	Indian Awl king
	Gangara thyrsis	Gaint Redeye
	Gangara lebadea	Banded Redeye
	Hasora chromus	Common Banded Awl
	Hasora taminatus	White-banded Awl
	Hasora badra	Ceylon Awl
	Celaenorrhinus spilothyrus	Black flat
	Coladenia indranii	Tricolour Pied Flat
	Sarangesa dasahara	Common Small Flat
	Tapena thwaitesi	Black Angle

	Tagiades japetus	Ceylon Snow Flat
	Tagiades litigiosa	Water Snow Flat
	Caprona ransonnettii	Golden Angle
	Caprona alida	Ceylon Golden Angle
	Gomalia elma	African Marbled Skipper
	Baracus vittatus	Hedge Hopper
	Ampittia dioscorides	Bush Hopper
	Halpe decorata [E]	Decorated Ace
	Halpe egena [E]	Rare Ace
	Halpe ceylonica	Ceylon Ace
	Suastus gremius	Indian Palm Bob
	Suastus minuta	Ceylon Palm Bob
	Iambrix salsala	Chestnut Bob
	Udaspes folus	Grass Demon
	Notocrypta paralysos	Common banded Demon
	Notocrypta curvifascia	Restricted Demon
	Hyarotis adrastus	Tree Flitter
	Matapa aria	Common Red eye
	Spalia galba	Indian Skipper
	Tractrocera maevius	Common Grass Dart
	Oriens goloides	Common Dartlet
	Potanthus pallida	Indian Dart
	Potanthus pseudomaesa	Common Dart
	Potanthus confuscius	Tropic Dart
	Telicota colon	Pale Palmdart
	Telicota ancilla	Dark Palmdart
	Baoris penicillata	Paintbrush swift
	Borbo cinnara	Wallace’s Swift
	Pelopidas agna	Little Branded Swift
	Pelopidas mathias	Small Branded Swift
	Pelopidas thrax	Large Branded Swift
	Pelopidas conjuncta	Conjoined Swift
	Cattoris kumara	Blanck Swift
	Cattoris philippina	Philippine Swift
	Panara bada	Smallest Swift

(E – Endemic species)

Taxonomic Status of Ticks in Sri Lanka

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Abstract

Twenty-seven species of Ixodid ticks (hard ticks) belonging to nine genera have been reported to date from Sri Lanka. Of the nine genera, genus *Haemaphysalis* is the best represented genus in Sri Lanka with 11 species of ticks recorded to date. These tick species have been recorded feeding on a range of wild and domesticated vertebrate hosts in the country.

The geographic distribution of these tick species on the island is less well understood, except in the case of species parasiting domestic pets and livestock. A recent study carried out on the distribution of cattle ticks in Sri Lanka recorded eight species of ticks. Of these, *Boophilus* sp., *Haemaphysalis bispinosa, Haemaphysalis intermedia* and *Rhipicepahlus haemaphysaloides* showed a wide distribution in the country, from montane to dry zones. *Hyalomma marginatum, Hyalomma brevipunctata Amblyomma integrum* and *Haemaphysalis spinigera* were found to be more prevalent in the low country dry zone.

The *Boophilus* sp. found in Sri Lanka (hitherto identified as *B. annulatus* s.l.) is here considered to be an undescribed species. The immature stages (larva and nymph) of *Amblyomma* sp., *Hyalomma* spp. and *Rhipicephalus* spp. have been found to attack humans extensively and have been reported to cause severe intra-aural (within ear canal) conditions in humans in some areas of Sri Lanka.

Key words: *Ticks, Research, Parasites, Taxonomy*

Introduction

Ticks are obligate blood sucking external parasites of mammals, birds and reptiles found in almost every region of the world. They are primarily parasites of wild animals and only 10% of the species feed on domestic animals (Lane and Crosskey, 1993). Many ticks feed opportunistically on humans; some species feed more avidly than others on human hosts. Ticks have biologically complex interactions with micro-organisms and with their vertebrate hosts, on whom they depend for blood meals and survival (Wilson, 2002). Therefore, they transmit a wide variety of pathogens (bacteria, rickettsiae, protozoa and viruses) that surpasses any other group of blood sucking arthropods. They rank second only to the mosquitoes as vectors of life-threatening, debilitating diseases. Apart from being vectors, they also cause severe damage to the host through their bite.

Ticks belong to the suborder Ixodida, of the Order Parasitiformes (class Arachnida; subclass: Acari), a taxon that also includes mites (Sonenshine, 1991, Goddard, 1989). About 850 tick species belonging to two major tick families are known to occur in the world. The Family Ixodidae includes ticks that are commonly called 'hard ticks' because they possess a hard sclerotized dorsal scutum. The group includes more than 650 species belonging to thirteen genera. The Family Argasidae includes 'soft ticks', and contains 150 species belonging to five genera (Sonenshine, 1991). There is a third Family, the Nuttaliellidae, which is monophyletic and share characters of both Argasidae and ixodidae, in addition to having many derived features. The only species found in Family Nuttaliellidae is *Nuttalliella namaqua* Bedford 1931 collected in localities in Namibia, Republic of South Africa, and Tanzania from nests of rock swallows and hyraxes, and is of minor veterinary and medical importance (Sonenshine, 1991).

The studies conducted on the taxonomy and ecology of ticks in Sri Lanka are scanty. The most comprehensive study on hard ticks in Sri Lanka was conducted by Seneviratne (1965). This study reported 26 species of ticks belonging to nine genera. This study was conducted on the samples collected by the various persons in different parts of the country on wild and domesticated animals. Weilgama (1974) conducted another study on taxonomy of the cattle tick *Boophilus annulatus* (sensu lato) in Sri Lanka. Halim et al (1983) recorded tick species on goats in the dry zone of the country. Other citations are short reports or brief mentions of tick species in works focused on disease aspects (e.g., Balasuriya et al., 1995; Dilrukshi and Amerasinghe (1999 a,b); Weilgama, 1982; Weilgama et al., 1986a, 1986b, 1989a, 1989b). The most recent and comprehensive eco-taxonomic study was by Dilrukshi (2004) on cattle ticks.

The Ixodid Tick Fauna of Sri Lanka

Twenty-seven species of ixodid ticks belonging to nine genera have been reported to date from Sri Lanka (Seneviratne, 1965). These genera are as follows: *Amblyomma* Koch, 1844; *Aponomma* Neumann, 1899; *Boophilus* Curtice, 1891; *Dermacentor* Koch, 1844; *Haemaphysalis* Koch, 1844; *Hyalomma* Koch, 1884; *Ixodes* Latreille, 1795; *Rhipicephalus* Koch, 1844; and *Nosomma* Schulze, 1919. In the paragraphs below, information on hosts and distribution from available literature are summarized. It is to be notes that most are derived from fragmentary records accumulated over the years and collated in works such as Seneviratne (1965) and others. Understandably, the bulk of information relates to ticks parasiting domestic pets and livestock. We have, at present, a very poor understanding of the geographic distribution and host relations of ticks parasiting wild animals in the country.

In the genus *Amblyomma*, three species are recorded to occur in Sri Lanka to date. They are *A. integrum* Karsch, 1879, *A. clypeolatum* Neumann, 1899, and *A. testudinarum* Koch 1844. They have been reported commonly on wild animals. Adult *A. clypeolatum* have been reported on the star tortoise (*Testudo elegans* Schoepff), wild boar (*Sus scrofa cristatus* Wagner) and water buffalo (*Bubalus bubalis bubalis* Linnaéus), while *A. integrum* has been found on a variety of animals such as sloth bear (*Melursus ursinus* Shaw), water buffalo, Sambar (*Cervus unicolor unicolor*), domestic pig (*Sus scrofa domesticus*), horse (*Equus caballus*), cattle (*Bos* spp), and elephant (*Elephas maximus zeylanicus*). Immature stages have been reported on humans, the domestic cat (*Felis catus*), and mouse deer (*Moschiola meminna*). Immature stages of *A. integrum were* the major intra-aural tick species in human patients in a recent study in the Sabaragamuwa Province (Dilrukshi et al., 2004). *Amblyomma testudinarum* has been collected on wild boar *(Sus scrofa cristatus)* and water buffalo (Senadhira, 1969).

Three species (and one variety) belonging to genus *Aponomma* are reported in Sri Lanka namely, *A. gervaisi Lucas*, 1847; *A. gervaisi* var lucasi Warburton, 1910; *A. javanense* Supino, 1897 and *A. trimaculatum* Lucas, 1878 (Seneviratne, 1965). Ticks of this Genus have been found usually on reptiles and, rarely, on wild boar (Senadhira, 1969).

The status of the species of Genus *Boophilus* in Sri Lanka is presently rather unclear. Seneviratne (1965) listed both *B. microplus* and *B. annulatus* characters in *Boophilus* sp. in Sri Lanka. Later, Weilgama (1974) found that the Sri Lankan "*B. annulatus*" differed from the typical form, listed it as *B. annulatus* (sensu lato). Dilrukshi (2004) provides a detailed analysis of the complex of character traits seen in the Sri Lankan species and does not consider the species to be closely allied to *B. annulatus*. Taxonomic material pertaining to the Sri Lanka *Boophilus* is currently under study at the Institute of Arthropodology and Parasitology, USA, and the consensus of opinion is that this is a distinct and as yet undescribed species (personal communication from L. Durden, Institute of Arthropodology and Parasitology (IAP), Georgia, Southern University, USA). *Boophilus* generally feed on mammalian hosts and have been recorded on the domestic dog (*Canis famialiris*), leopard *(Panthera pardus kotiya*), spotted deer (*Cervus axis ceylonensis*), Sambar (*Cervus unicolor*) , buffalo, goat (*Capra hircus*), sheep (*Ovis* sp.), cattle and horse (Seneviratne 1965, Balasuriya et al 1997, Dilrukshi and Amerasinghe 1999 a&b, Dilrukshi and Amerasinghe, 2000). They have been recorded on humans (Seneviratne, 1967, Dilrukshi et al, 2004). This species was the most abundant cattle tick found in Sri Lanka (Dilrukshi, 2004).

The genus *Dermacento*r *Koch*, 1844 is represented by only one species *D. auratus* in Sri Lanka on wild pig, Sambar and sloth bear. Edussuriya and Weilgama (2003) reported immature stages of this species infesting human ear canals at the Central Province location of Kandy.

The Genus *Nosomma* too, is represented by one species, *N. monstrosum* Nuttall and Warburton 1908 on wild pig, and wild and domesticated water buffalo (Seneviratne 1965). The genus *Ixodes*, is represented by two species, *Ixodes petauristae* Warburton, 1938 and *Ixodes ceylonensis* Kohls, 1950 (Kohls, 1950). The ticks of this genus are poorly represented on large mammals and seem to occur more on small mammals such as mongoose (*Herpestes fuscus*), rat (e.g. *Rattus rattus kandiyanus*), and birds such as the Ceylon bush lark (*Mirafra affinis ceylonensis*) in Sri Lanka.

The Genus *Rhipicephalus* Koch, 1844 is represented by two species, *R. haemaphysaloides* Supino, 1897 and R. sanguineus Latreille, 1806. These two species have a wide distribution in the country. *Rhipicephalus haemaphysaloides* is found on animals such as domestic dog, cattle, domesticated water buffalo, sheep, goat, horse, chicken (*Gallus domesticus*), and on wild animals such as black-naped hare (*Lepus nigricollis sinhala*) and wild boar; immature forms occur on humans (Senadhira, 1969; Halim et al., 1983, Dilrukshi 2004, Dilrukshi et al., 2004). The species *R. sanguineus* is found more on domestic stock such as the cat, domesticated water buffalo, sheep, cattle, dog, chicken and also on hare. The larva and nymph occurs on humans (Seneviratne, 1965; Senadhira, 1969, Dilrukshi et al., 2004).

In the Genus *Hyalomma*, Seneviratne (1965) recorded one species *Hy. marginatum isaaci* Sharif, 1928 on cattle, domesticated water buffalo, goat, sheep horse, leopard, and wild water buffalo. The larva occurs on mongoose (*Herpestes flavidens*), hare and mouse deer in Sri Lanka. More recently Weilgama et al. (1989) reported the presence of another species *Hy. brevipunctata* Sharif, 1928 on domestic water buffaloes in Sri Lanka. Dilrukshi and Amerasinghe 1999 reported the presence of *Hy. brevipunctata* on neat cattle in Sri Lanka in the areas of low country dry zone , low country wet zone and mid county regions in the island. Dilrukshi et al. (2004) reported the occurrence of nymphs of *Hy. marginatum* and *Hy. brevipunctata* in the ear canal of humans in Ratnapura district. This is one of the common species found to attack humans in association with jungle or areas with a high density of vegetation.

Of the nine genera, Genus *Haemaphysalis* is the best represented genus in Sri Lanka with 11 species of ticks recorded to date. They are as follows 1. *H. aculeata* Lavarra, 1905; 2. *H. bispinosa* Neumann, 1897; 3. *H. cuspidata* Warburton, 1910; 4. *H. cornigera* var anamala Warburton; 1913, 5. *H. hystricis* Supino, 1897; 6. *H. intermedia* Warburton and Nuttal 1909; 7. *H. kyasanursensis* Trapido, Hoogstraal and Rajagopalan, 1964; 8. *H. leachi* var indica Warburton, 1910; 9. *H. minuta* Kohls, 1950; 10. *H. spinigera* Neumann, 1897; 11. *H. turturis* Nuttall and Warburton 1915. The ticks of this genus are found on a wide variety of animals such as wild mammals, livestock, birds, and immature forms sometimes on humans (Seneviratne 1965, Senadhira, 1969).

The most widespread species of this Genus are *H. bispinosa* and *H. intermedia* which are found on cattle, domesticated buffaloes, sheep, goat, dog, chicken, leopard, Ceylon jackal (*Canis lanka* Wroughton), sloth bear, hare, mouse deer, and Ceylon jungle fowl (*Gallus lafayetti* Lesson). Apart from these hosts, *H. intermedia* also has been found on wild boar and spotted deer, and immature stages found on the forest wagtail (*Dendronanthus indicus* Gemlin), a migrant bird from India (Senevirathene, 1965, Halim et al., 1983 and Halim 1984). The *H. bispinosa* and *H. intermedia* are common cattle ticks found in all parts of the country (Dilrukshi, 2004). Recent morphometric analyises done on the *H. bispinosa* populations found in the low country dry, low country wet, mid country, and montane wet zones showed three distinct sub populations of this taxon. This is an indication of the probable presence of a subspecies or species complex within the taxon identified as "*H. bispinosa*" on the island – an aspect that needs further investigation. The species *H. spinigera* has been recorded on cattle, leopard and sloth bear, and immature stages recovered from the forest wagtail (Seneviratne, 1965). *H. spinigera* was only found in the cattle of low country dry zone (Dilrukshi, 2004). *Haemaphysalis cornigera* has been collected only from sambar at Elahara in the North Central Province. *Heamaphysalis aculeata* has been recorded on mouse deer, leopard and mongoose, and is known to attack humans. The species *H. cuspidata* is another species found on domestic goat, and also has been recorded on wild animals such as leopard, Ceylon civet cat (*Viverricula indica mayori*), mongoose, polecat (*Paradoxurus hermaphroditus hermaphroditus*) and mouse deer. This species appears to be restricted to Sri Lanka (Seneviratne, 1965). *Haemaphysalis* *hystricis* has been found only on wild mammals such as the sloth bear wild boar, and birds such as the common Ceylon mynah (*Acridotheres tristis melanosternus*). *Haemaphysalis kyasanursensis* has been recorded on the Indian crested porcupine (*Hystrix indica*), and *H. leachi* var indica has been recorded on goat, Ceylon civet cat and Grey flying squirrel (*Petaurista philipensis lanka*) and nymphs collected on forest wagtails. *Haemaphysalis minuta* has been recorded on chicken, Ceylon civet cat, and Ceylon jungle fowl. *Haemaphysalis turturis* has been recorded on leopard, civet cat, spotted deer, wild boar, Sambar, Ceylon small civet (*Viverricula indica mayori*), spotted dove (*Streptopelia chinensis ceylonensis*) and black crow (*Corvus macrorhynchos culminatus*) (Seneviratne, 1965).

The checklist of the ticks found in Sri Lanka presented here is based on the studies of Seneviratne (1965), Weilgama et al. (1989), Dilrukshi et al. (1999 a&b) and Dilrukshi (2004).

Issues and gaps related to tick research

There have been many studies relating to livestock-related tick-borne disease aspects in Sri Lanka (see review in Dilrukshi 2004). However, a paucity of published literature in the fields of tick taxonomy and ecology show that these areas have been somewhat neglected during the past 25 years. There are no comprehensive taxonomic keys or descriptions of the tick fauna of the island. Intra-species morphological variability in relation to geographic, climatological, and/or other factors within their distributional range on the island is poorly known except for the *Boophilus annulatus* (sensu lato) of Weilgama (1974) and the cattle ticks investigated by Dilrukshi (2004). Information on ecology, too, seems to have been more a by-product of studies focused on disease aspects of tick infestations, rather than ecologically focused investigations. The most recent work is that of Dilrukshi, (2004), who carried out a taxonomic and ecological study of ticks parasitizing cattle in four zones climatological within Sri Lanka in order to determine the distribution of ticks species, the tick parasite burden borne by cattle in different localities, and the distribution of different species on the body of the host. Dilrukshi et al, (2004) conducted a limited investigation on human infestations of ticks, based on hospital records and surgically removed tick specimens. An attempt also was made by author to investigate the molecular basis of the intra-species morphological variation seen in tick populations.

Future research priorities

It is felt that apart from the tick species presently known there can be more unknown species present in Sri Lanka. Therefore more comprehensive island wide surveys on ticks in different hosts in Sri Lanka should be carried out to investigate the current status of ticks in the country. Additionally, systematically collected information is necessary on distributional, ecological, and pathogen relations of ticks that parasitize both domestic and wild animals, as well as those that appear to be exclusive wild animal feeders. This is an important priority in an era when, increasingly, human population expansion at the expense of wild areas creates conditions where zoonotic infections are tranisiting from their natural cycles, impinging on humans, and causing human disease.

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Systematics and Conservation of Spiders in Sri Lanka: Current Status and Future Prospects

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Abstract

In this review we examine recent advances in our understanding of the systematic status of Sri Lankan spider fauna, which currently consist of 501 known species. In general they are very poorly known. The endemic spider fauna are confined to the natural forests of the south-west and the central highland region and are related to that of Western Ghats in India. Detailed collection based study is needed before further conclusions could be drawn.

Key words: *Spiders, Taxonomy*

Introduction

Sri Lanka with a forest cover of approximately 23% of total land area, is known to be of great conservation importance, highlighted by the presence of a rich endemic fauna and flora. The island is classified as one of the 25 global biodiversity 'hot spots' with an extraordinary level of endemism, and with an imminent threat of habitat loss. The tropical rainforests in the south-west of Sri Lanka has been reduced to a great extent during the past five decades, and at present the near-primary forest cover accounts for less than 5% of the land area of the biodiversity-rich Wet Zone of the island. The existing forest patches of the wet zone are in a severely fragmented state.

Spiders are one of the most diverse arthropod groups, and an important component in terrestrial ecosystems. They are valuable indicators of endemism, and for early warning of ecological change. They are capable of responding more rapidly to changes in the environment than long-living vertebrates and plants. Many spiders in Sri Lanka could be used as focal species in the complex process of deciding which habitats afford conservation priority. The above salient aspects related to spiders and ongoing rapid habitat destruction, make the collection and study of Sri Lankan spider fauna most important. In this review we will highlight the current status of spider taxonomy using a set of families currently under revision. We discuss previous work on the group, current state of knowledge, problems encountered and suggest future directions. Although, our focus is on spiders, the interpretations presented should prove useful for other arthropod taxa as well.

Taxonomy of spiders in Sri Lanka

In general spiders in Sri Lanka are very poorly known. Scientific documentation of spiders in Sri Lanka began with the work of Pickard-Cambridge (1869). The last comprehensive study was conducted more than a century ago by Pocock (1900). A few foreign researchers worked on a few spider families in Sri Lanka there after (Brignoli, 1972, 1975; van Helsdingen, 1985). Involvement of local researchers in spider taxonomy in Sri Lanka began with the works of Wijesinghe (1983, 1987) who conducted a preliminary survey and a review on the group. He stated that a little over 400 species of spiders are known from Sri Lanka, with an estimation of the actual total number to be close to 1000. The 1990s onwards has been a period of renowned interest on spider taxonomy in Sri Lanka, with several new species being described (Benjamin, 1999, 2000, 2001; Benjamin and Jocque, 2000; Wijesinghe, 1997, 1999a, 1999b). Bambaradeniya (2001) documented seven spider taxa (two species and five genera occurring in the oriental region) that are new records to Sri Lanka, from a rice field ecosystem at Bathalagoda. Recently, Huber and Benjamin (2005) described a new genus *(Wanniyala)* of pholcid spiders from the island.

Based on a review of these recent advances on spiders, it could be stated that the Sri Lankan spider fauna consists of about 501 known species, under 45 families (Appendix 1). However, the actual number might be even exceeding 4000 species. Among the total species described so far, the Mygalomorphs (commonly referred to as ‘tarantulas’ or ‘bird-eating spiders’) consist of 21 species, under five families. They are dominated by the Family Theraphosidae, which is represented by 10 species currently described from the island (Smith and Kirk, 2002). The balance consist of Araneomorphs, which are dominated by the jumping spiders (Family Salticidae – 104 species).

In general even the described taxa are very poorly known. Many species and even new genera await discovery and description. The taxonomical identity of most known species is uncertain as these were described without modern taxonomical standards and/or were based on juvenile specimens. Further, field work, mainly in the south western and central highlands and detailed systematic studies will be needed to provide a more complete picture of the spider fauna of Sri Lanka.

Distribution

The spiders of Sri Lanka are distributed throughout the island, from the high mountains to the coast, occurring in natural and managed environments. Preliminary results suggest that the endemic spider fauna are confined to the intact natural forests in the south-west and the central highland region. In some cases there appears to be sister species in lowland rainforest, central highlands and the forest of the knuckles conservation area. Preliminary results suggest that Sri Lankan endemic spider fauna are more related to that of Western Ghats in India. This biogeographic pattern is in accordance to that of what is known for other faunal groups.

For example, the primitive jumping spider Genus *Onomustus* Simon. 1900, is represented by *O. nigricauda* in the Sinharaja forest reserve, by *O. quinquenotatus* (Agra-bopath forest reserve) and *Onomustus* sp A (from Hakgala) in the central highlands and by *Onomustus* sp B from Knuckels conservation area. In the case of *Oxytate subvirens* (Strand, 1907), which is not an endemic, it is found in disturbed habitats and is widely distributed. On the other hand *Oxytate taprobane* Benjamin, 2001 is endemic to the central highlands. The two Sri Lankan *Oxytate* species are certainly closely related, but their taxonomic affinities to other species in Oriental region is unclear due to the limited information available. Although the type species of *Oxytate* was re described, a generic revision still remains to be done. Thus, most species of the genus are only known from their original descriptions. Thus, even the non-endemic spider fauna of Sri Lanka is in need of study.

Research in progress

Currently the spiders of the families Thomisidae, Tetragnathidae, Saticidae, Pholcidae and Zodariidae are being revised. Some Genera of the spider Families Tetrablemmidae (Lehtinen, 1981), Stenochilidae (Lehtinen, 1982), Ochyroceratidae (Brignoli, 1972, 1975), Hersiliidae (Baehr & Baehr, 1993), Nesticidae (Lehtinen & Saaristo, 1980), Linyphiidae (Helsdingen, 1985) and Lycosidae (Lehtinen & Hippa, 1979) have been revised. Benjamin (2004) has conducted a taxonomic revision for the jumping spider subfamily Ballinae (Araneae, Salticidae). A survey of the pholcid spiders of the island has been undertaken (Huber & Benjamin, 2005). A study on the occurrence and distribution of Theraphosids in the south-western part of Sri Lanka is currently under progress. However, as only a few habitats have been sampled in these studies, many more new species should be expected.

Conservation

So far Arachnida and other invertebrates have hardly been considered for conservation in Sri Lanka, neither for biodiversity assessment nor for conservation research. The reasons for this are multifold: Sri

Lanka's conservation program is based on large vertebrates, of high aesthetic value. The other reasons include the unmanageable number of species involved, non-availability of sufficient taxonomical information and a dearth of trained personnel to work on the group. The drawbacks are that decisions have been based on a very small fraction of the total biodiversity. Not much work has been done on the ecology or biology of the Sri Lankan spider fauna. This absence of faunistic information could also hamper attempts to interpret the faunal composition of the Indian subcontinent as well as understanding biogeography patterns.

For a detailed assessment of the spider fauna a good systematic collection of material representing all ecological regions within the island is needed. To date no such collection is available. Collections housed in major museums seem to be random collections not suitable for a detailed study.

The descriptions of most of the known species are around 100 or more years old, no illustrations were provided, making identification difficult. Furthermore, the exact localities are unknown, in some cases only the main cities like Colombo, Galle or Kandy is given, making positive identification extremely difficult.

It may be necessary to examine museum material, most of which are in Europe or the USA. These voucher specimens are difficult to obtain from Sri Lanka. Moreover, in some cases it is necessary to examine types of Indian species, as related species of a Genus currently known only from India may occur in Sri Lanka. For example the Genus *Colaxes* Simon, 1900 (Salticidae) was only known by a single species, *Colaxes nitidiventris*, from Trichinopoly, India. During recent field work two new species, *Colaxes wanlessi* Benjamin, 2004 (from Hakgala, Hakgala forest and Agra-bopath forest) and *Colaxes horton,* Benjamin, 2004 (from Horton Plains) both in the central highland were discovered. In another case, the Genus *Suffasia* was established in 1893, for two species from southern India. The type species, *S. tigrina* (Simon, 1893) from Kodaikanal, Tamil Nadu, and an undescribed species from the same locality. During recent field work in Sri Lanka two undescribed species were collected. The first one, *Suffasia mahasumana* Benjmain and Jocqué, 2000 (from the Knuckles Range) and the second species, *Suffasia attidiya* Benjamin and Jocqué, 2000 (from the Bellanwila-Attidiya sanctuary and the Kalugala, Labugama Forest Reserve). Thus, if we are to avoid the creation of new synonyms the simultaneous study of Indian types may be necessary.

In some cases the types may be lost. The type of *Oxytate subvirens* (Strand, 1907) was deposited in the Staatlichees Museum für Naturkunde, Stuttgart, Germany. This collection was destroyed during the second-world war, and the description was based on female specimens, with no illustrations. There was no recent redescription of *O. subvirens* or any other *Oxytate* species from Sri Lanka. As closely related *Oxytate* species can be reliably identified only by male genital morphology the designation of a male neotype and redescription of the species based on both sexes become necessary.

Future directions

1. Establishing a reference collection of spiders.
2. Redescription of known taxa.
3. Study of their behaviour/life history.
4. Inclusion of spiders in conservation decision-making.
5. Training of taxonomists and para taxonomists in Sri Lanka.

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Appendix 1. Species richness of spiders under different families and genera in Sri Lanka

Family / Genera	Number of pecies
Mygalomorphs	
Idiopidae *Heligmomerus, Scalidognathus*	4
Dipluridae *Ischnothele*	1
Nemesiidae *Atmetochilus*	1
Barychelidae *Diplothele, Plagiobothrus, Sason, Sipalolasma*	5
Theraphosidae *Chilobrachys, Plesiophrictus, Poecilotheria*	10
Araneomorphs	
Scytodidae *Loxosceles, Scytodes*	3
Tetrablemmidae *Brignoliella, Pahanga, Shearella, Tetrablemma*	7
Pholcidae *Artema, Belisana, Crossopriza, Leptopholcus, Micropholcus, Modisimus, Pholcus, Psilochorus, Smeringopus, Spermophora, Wanniyala*	18
Ochyroceratidae *Merizocera, Simonocera*	7
Segestriidae *Ariadna*	12
Stenochilidae *Stenochilus*	1
Mimetidae *Mimetus, Phobetinus*	3
Oonopidae *Aprusia, Epectris, Gamasomorpha, Ischnothyreus, Opopaea, Orchestina, Xestaspis*	5
Eresidae *Stegodyphys*	1
Oecobiidae *Oecobius*	1
Hersiliidae *Hersilia, Tama*	5
Uloboridae *Hyptiotes, Miagrammopes, Uloborus, Zosis*	6
Nesticidae *Nesticella*	1
Theridiidae *Achaearanea, Anelosimus, Argyrodes, Cephalobares, Chrysso, Coleosoma, Coscinida, Dipoena, Enoplognatha, Episinus, Euryopis, Gnathonarium, Latrodectus, Molione,Phoroncidia, Steatoda, Theridion, Theridula, Thwaitesia*	42

Theridiosomatidae *Ogulnius, Theridiosoma*	2
Theridiosomatidae *Ogulnius, Theridiosoma*	2
Mysmenidae *Mysmenella, Phricotelus*	2
Linyphiidae *Atypena, Labullinyphia, Lepthyphantes, Meioneta, Metalepthyphantes, Microbathyphantes, Neriene, Obrimona, Lygarina, Nematogmus, Trematocephalus, Typhistes*	20
Tetragnathidae *Dyschiriognatha, Nephila, Tetragnatha*	28
Araneidae *Anepsion, Arachnura, Araneus, Argiope, Caerostris, Chorizopes, Clitaetrea, Cyclosa, Cyrtarachne, Cyrtophora, Gasteracantha, Gea, Glyptogona, Herennia, Homalopoltys, Mangora, Neogea, Neoscona, Nephilengys, Ordgarius, Poltys, Pronous,Ursa*	53
Hahniidae *Aviola, Hahnia*	5
Dictynidae *Atelolathys, Brigitta, Dictyna, Dictynomorpha, Rhion*	5
Agelenidae *Tegenaria*	2
Titanoecidae *Pandava*	1
Psechridae *Fecena, Psechrus*	2
Oxyopidae *Oxyopes, Peucetia*	7
Ctenidae *Ctenus*	2
Zoridae *Diallomus*	2
Lycosidae *Arctosa, Hippasa, Hogna, Ocyale, Pardosa, Zoica*	16
Pisauridae *Perenethis, Thalassius*	5
Miturgidae *Campostichomma, Devendra*	4
Liocranidae *Argistes, Paratus*	4
Clubionidae *Cheiracanthium, Corinna, Matidia, Medmassa, Simalio, Sphingius*	11
Corinnidae *Castianeira, Aetius, Coenoptychus, Copa (Koppe), Oedignatha, Orthobula, Sphecotypus, Trachelas, Utivarachna*	21

Zodariidae *Cryptothele, Storena. Suffasia*	6
Cryptothelidae *Cryptothele*	1
Selenopidae *Selenops*	1
Sparassidae *Heteropoda, Olios, Pandercetes, Spariolenus, Thelcticopis*	22
Philodromidae *Thanatus, Gephyrota, Tibellus*	2
Thomisidae *Amyciae, Ascurisoma, Boliscus, Borboropactus, Cymbacha, Diaea, Epidius, Holopelus, Lysiteles, Monaeses, Pagida, Peritraeus, Phrynarachne, Runcinia, Stiphropus, Tagulis, Talaus, Thomisus, Tmarus*	36
Salticidae *Asemonea, Ballus, Bianor, Brettus, Carrhotus, Chrysilla, Cocalus, Colaxes, Colopsus, Cosmophasis, Curubis, Cyrba, Epidelazia, Epocilla, Euphrys, Flacillula, Gangus, Gelotia, Harmochirus, Hasarius, Hispo, Hyllus, Icius, Irura, Maevia, Marengo, Menemerus, Modunda, Mymarachne, Onomastus, Padillothoraz, Panachraesta, Panysinus, Phaeecius,Phausina, Phintella, Phyaces, Plexippus, Plotius, Portia, Ptocasius, Rhene, Saitis, Sandalodes, Sigytes, Siler, Simaetha, Spartaeus, Stergusa, Telamonia, Thiania, Thyene, Uroballus*	106
Total	**501**

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Conservation of Sri Lankan Freshwater Crabs

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Abstract

A surge in research interest on Sri Lanka's freshwater crabs since the early 1990s has resulted in the discovery of several new crab species in the island, with 51 species being described to date. All Sri Lankan freshwater crab species recorded so far, along with 5 genera are endemic to the island. It is alarming to note that 37 of the 51 species are threatened with extinction, with 26 species being restricted to a single site. This paper discusses the threats in detail, and lists actions that need to be taken to safeguard these species from future extinction. Based on the findings it is apparent that conservation actions should involve not only more extensive research in to this field, but also legal and institutional reforms which will engage local communities in the *in- situ* conservation of freshwater crabs.

Key words: *Freshwater crabs, Conservation, Pollution, Invasive species*

Introduction

The exploration of Sri Lanka's freshwater crabs began 125 years ago with the description in 1880 of *Thelphusa* [now *Perbrinckia*] *enodis* and *Thelphusa [Ceylonthelphusa] rugosa* by the American zoologist, J. S. Kingsley. Following partial treatments by Rathbun (1904), Roux (1915) and Fernando (1960), the freshwater crab fauna of Sri Lanka was treated in a single revision for the first time only in 1970, by the German carcinologist R. Bott in his *Süßwasserkrabben von Ceylon.*

In the early 1990s, there was a surge in interest in Sri Lanka's freshwater crabs following a collaborative exploration and taxonomic treatment of this fauna by the National University of Singapore and the Wildlife Heritage Trust of Sri Lanka (Ng, 1994, 1995a, b; Bahir, 1998, 1999; Ng & Tay, 2001; Bahir & Ng, 2005; Bahir & Yeo, 2005). This was followed by an (on-going) island-wide survey of the freshwater carcinofauna commissioned by the National Science Foundation of Sri Lanka.

While only eight species in four genera were recognized as valid as at 1994, the fauna today stands at 51 species in seven genera, with every prospect of the species-count increasing as exploration continues. Based on the present state of knowledge of the peninsular Indian carcinofauna (Bossuyt et al., 2004; MMB & D. C. J. Yeo, in prep.), it appears that all Sri Lankan freshwater-crab species are endemic, as are the genera *Ceylonthelphusa, Perbrinckia, Mahatha, Clinothelphusa* and *Pastilla.* The lowland genera *Oziothelphusa* and *Spiralothelphusa,* however, are shared also with southern India.

All the Sri Lankan freshwater crabs belong to a single family, the Parathelphusidae (some species were assigned to the Sundathelphusidae by earlier workers, but this family has been synonymised with Parathelphusidae by recent authors). The restricted range of many species, together with extensive loss of habitat, cause concern for the security of this fauna into the future. Twenty-six of the 51 species presently recognized from Sri Lanka occur only at a single site each, rendering them extremely vulnerable to habitat loss, degradation and stochastic events. A conservation assessment leading to species under threat being identified and classified according to the IUCN's Red List criteria was made by Bahir et al. (2005), using quantitative data to calculate the probability/risk of extinction for each species at the global scale; the present report draws heavily on the content of this paper.

As a result of prioritising species for conservation action and gathering information on the distribution of and threats to each species through the Red List assessment process, it is now possible to proceed to the preparation of recovery plans for the conservation of threatened species.

Country Background

Sri Lanka (65,230 km^2) receives relatively low rainfall (< 2,000 mm yr^{-1}) except in the south-western 'wet zone' (~ 17,200 km^2), where precipitation ranges from ~ 2,000–5,000 mm yr^{-1}. Diversity, richness and endemism across all taxa are much higher in the wet (including the montane) zone than in the dry zone, the biota of which resemble those of southern India.

The wet zone, which accounts for only a quarter of Sri Lanka's territory, contains 88% of the flowering plants occurring in the island, and 95% of the island's angiosperm endemics (Dassanayake et al., 1980–2004). This pattern repeats also for other groups for which the results of recent surveys are available, such as amphibians (Meegaskumbura et al., 2002; Manamendra-Arachchi & Pethiyagoda, 2005) and land snails (Naggs & Raheem, 2000; Naggs et al., 2005). Not surprisingly, the same is true also of the freshwater crabs, in which 41 (80%) of the 51 known species are restricted to the wet zone. Yet, only 4.6% of the wet zone (800 km^2) now contains natural forest. This predicament is exacerbated by the fact that the wet zone contains 67% of the island's 19 million human population (Anon., 2003)—a density of 700km^{-2} — which is exceptional by the standards of all other global biodiversity hotspots (Cincotta et al., 2000).

Given the very poor representation of Sri Lankan freshwater crabs in old museum collections, there is no reliable historical baseline against which to judge trends in distributions or populations. As a result, it is unlikely that evidence of recent extinctions will be found, unlike has been the case for flowering plants (~ 130 species: see Dassanayake et al., 1980–2004); amphibians (19 species: Manamendra-Arachchi & Pethiyagoda, 2005; Stuart et al., 2004); and freshwater fish (2 species: Pethiyagoda, 1994). The conservation of the entire freshwater crab fauna, given its remarkable diversity, richness and endemism, is therefore a matter of the highest priority.

Sri Lanka's freshwater carcinofauna is undoubtedly rich in comparison with other similar, well-studied tropical Asian countries. For example, Peninsular Malaysia and Singapore, which together have a territory about twice the extent of Sri Lanka, have about the same number of freshwater crab species (Ng, 1988), while Taiwan (36,000 km^2) has 34 species (Ng et al., 2001).

Conservation

With 37 of 51 species threatened with global extinction, it is clear that conservation interventions are urgently necessary. The urgency is more so given that freshwater crabs are not targeted for exploitation in Sri Lanka. Unfortunately, several important conservation-relevant questions remain unanswered for lack of data. Are the crab species that are known from exceedingly small populations naturally rare or cryptic, or are they the vanishing remnants of a sudden decline? Have species been reduced to extremely small Extents of Occurrence because of habitat loss (or other impacts) or are their distributions naturally so severely restricted?

We propose that a precautionary approach be adopted in determining strategies for conserving this fauna: the present tentative conservation assessments should be accepted at face value, and recovery strategies devised accordingly, until data become available to support the conclusion that each threatened species is in fact secure.

Sri Lanka's aquatic habitats are threatened by invasive alien species (>90% of the freshwater-fish biomass comprises exotics: Pethiyagoda, 1994) and pollution, while its forests are threatened by encroachment and illegal produce extraction. The greater threats to the island's remaining wet zone habitats are perceived to be from indirect sources exacerbated by 'island effects' resulting from fragmentation — invasive species, encroachment, pesticide influx, edge effects, local climate change (Schaefer, 1998), rainwater acidification and increased erosion (and consequential silt load in flowing waters).

Pesticides are a serious concern given that these substances are freely and widely used in Sri Lanka. Regulation presently addresses only human safety issues, and not impacts on other non-target organisms or the environment in general (Anon., 1980). Given that 24 of Sri Lanka's 51 freshwater crab species are restricted to montane and sub-montane habitats, poor sloping-land management and unwise land-use change in the highlands continues to be a serious problem (Hewawasam et al., 2003). An estimated 292 MT ha^{-1} yr^{-1} of topsoil is lost to erosion from these lands, degrading habitats and increasing silt loads in streams and rivers (ADB, 2003).

A handful of freshwater-crab species have wide distributions and are clearly tolerant of land-use change, given that they persist in rice fields (e.g. *Oziothelphusa* spp.) and tea plantations (e.g. *Ceylonthelphusa rugosa* and *Ceylonthelphusa soror*). Even such species, however, could suffer catastrophic declines as a result of changes, for example, in land development, hydrology or pesticide-use regimes. It is noteworthy that the populations of two species of widely distributed freshwater fishes (*Labeo lankae* and *Macrognathus* aral) assessed in 1980 as "common" (Senanayake, 1980) crashed within a decade, without warning, for reasons still unknown— they are now presumed extinct (Pethiyagoda, 1994).

It is of immediate concern that 26 (51%) of the island's 51 crab species are known from Extents of Occurrence <100 km^2 (see Table 1). Studies in Brazil (Bierregaard et al., 2001; Ferraz et al., 2003) have shown that extreme rainforest fragmentation could lead to catastrophic declines and extinction of species in less than a decade. The long-term security of Sri Lanka's biodiversity will therefore depend on minimizing fragmentation impacts through effective land-use planning and restoration initiatives while maximizing habitat connectivity between forest sites. Such goals can be met only through a policy framework built on sound scientific data, implemented through sustained, long-term financing mechanisms. Planning on such a scale is not imminent in Sri Lanka, and in the mean time, it is best that conservation activities be aimed primarily at preserving the integrity of sites and habitats while at the same time closely monitoring key populations.

The only other Sri Lankan fauna that has been completely assessed for conservation status are the Amphibia (Stuart et al., 2004). These results show that 11, 28 and 5 of the 94 amphibian species recognized from the island at the time of the assessment were Critically Endangered, Endangered and Vulnerable, respectively (cf. 23, 8 and 6 for the crabs, respectively). A total of 19 species of amphibians are suspected to have become extinct in Sri Lanka, a result that is evidently not paralleled in the crabs. Nevertheless, the proportion of the Extinct and Threatened amphibian fauna (67%) is comparable to that of the crabs (73%).

Given that the conservation of freshwater crabs hinges almost entirely on preserving patches of natural forest large enough to maintain good water quality, it is of concern that water quality is deteriorating even in key natural habitats (Gunawardena et al., 1998). Many freshwater crabs are extremely sensitive to polluted or silted waters and will not survive when exposed to these factors. In Singapore for example, the small patch of primary forest of Bukit Timah Hill (~ 70 ha) has been sufficient to maintain a thriving population of the endemic potamid *Johora singaporensis* (see Ng, 1988; 1989; 1990a). The same is also true for *Parathelphusa reticulata*, which is known to occur in only a small remnant patch of peat-swamp forest patch of less than five hectares (Ng, 1989; 1990a, b). Decade-long monitoring of these populations demonstrates that crab species will persist even in small habitat fragments if these are managed well, though exposed to extirpation by stochastic events (Brook et al., 2003).

Recommended conservation actions

1. It is necessary that the national freshwater crab survey commissioned by the National Science Foundation be completed, leading to a gap analysis and the identification of key habitats for conservation attention.

2. Periodic monitoring of Critically Endangered species is necessary, especially so as to detect actions that could alter habitat, so that these could be treated before they impact on the population involved.
3. All pesticides approved for release in Sri Lanka should be assessed for impact on non-target organisms and the environment in general, and the labelling of such products should include information on environmental safeguards.
4. Legal and institutional reforms need to be made to engage local communities in the *in situ* conservation of point-endemic freshwater crabs.
5. The *ex situ* management of crabs is still in its infancy. It is necessary that capacity in *ex situ* management be built so that captive populations of Critically Endangered species could be maintained.

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Table 1: Checklist of the freshwater crabs of Sri Lanka (Parathelphusidae). Conservation status is derived using the IUCN (2001) Red List criteria. CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NT, Near Threatened; LC, Least Concern. Extent occurrence is estimated based on available habitat; Number of Locations is the number of discontiguous sites from which the species was recorded; Habitat Protection notes whether at least one population lies within a protected area and if so, the institution managing the protected area: FD = Forest Department, WD = Department of Wildlife Conservation.

Species	**Conservation Status**	**~ Ext. of Occurrence (km^2)**	**No. of sites**	**Habitat protection**
Ceylonthelphusa alpina	EN	10	2	Y FD
Ceylonthelphusa armata	EN	20	2	N
Ceylonthelphusa callista	CR	5	1	N
Ceylonthelphusa cavatrix	VU	10	3	Y FD
Ceylonthelphusa diva	CR	10	1	N
Ceylonthelphusa durrelli	CR	1	1	N
Ceylonthelphusa kandambyi	NT	1,750	5	Y FD
Ceylonthelphusa kotagama	CR	5	1	Y FD
Ceylonthelphusa nata	CR	5	1	N
Ceylonthelphusa orthos	CR	5	1	N
Ceylonthelphusa rugosa	LC	> 20,000	>10	Y FD/WD
Ceylonthelphusa savitriae	CR	5	1	N
Ceylonthelphusa sentosa	LC	5,000	>10	Y FD
Ceylonthelphusa sanguinea	CR	10	1	Y FD
Ceylonthelphusa soror	LC	5,600	>10	Y FD/WD
Ceylonthelphusa venusta	NT	250	3	Y FD
Clinothelphusa kakoota	CR	100	1	N
Mahatha adonis	NT	2,000	3	Y FD
Mahatha helaya	CR	5	1	N

Mahatha iora	CR	100	1	N
Mahatha lacuna	CR	5	1	N
Mahatha ornatipes	LC	5,000	>10	Y FD
Mahatha regina	CR	5	1	N
Oziothelphusa ceylonensis	NT	12,000	5	N
Oziothelphusa dakuna	EN	1,000	2	Y WD
Oziothelphusa gallicola	EN	100	2	N
Oziothelphusa hippocastanum	NT	> 20,000	3	Y WD
Oziothelphusa intuta	CR	10	1	N
Oziothelphusa kodagoda	CR	10	1	N
Oziothelphusa mineriyaensis	LC	2,500	2	Y WD
Oziothelphusa populosa	EN	2,000	2	N
Oziothelphusa ritigala	VU	900	1	Y WD
Oziothelphusa stricta	NT	10,000	5	Y WD
Pastilla ruhuna	EN	350	3	Y FD
Perbrinckia fenestra	VU	1	1	Y FD
Perbrinckia cracens	CR	10	1	N
Perbrinckia enodis	CR	10	1	Y WD
Perbrinckia fido	CR	10	1	N
Perbrinckia gabadagei	VU	10	1	Y WD
Perbrinckia glabra	VU	50	1	Y WD
Perbrinckia integra	NT	300	5	Y FD/WD
Perbrinckia morayensis	CR	100	1	Y WD
Perbrinckia nana	NT	1,750	5	Y FD
Perbrinckia punctata	CR	50	1	Y WD
Perbrinckia quadratus	CR	5	1	N
Perbrinckia rosae	CR	5	1	N
Perbrinckia scansor	LC	6,500	>10	Y FD
Perbrinckia scitula	CR	80	2	N
Perbrinckia uva	VU	120	3	Y FD
Spiralothelphusa fernandoi	EN	1,800	2	N
Spiralothelphusa parvula	EN	250	3	N

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Land Snails in Sri Lanka

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Abstract

Land snails in Sri Lanka form a highly diverse group. Of the 246 land snail species recorded from the island, 83% are endemic to the country. These include five endemic and relict land snail genera. Pulmonate land snails (Sub class Pulmonata) form the major group (64% of the total) of the land snail fauna in Sri Lanka, while prosobranch land snails (Sub class Prosobranchia) form the balance component (36%). About 18 exotic snail and slug species have been introduced to the country during the last century, mainly through the agricultural trade. The introduced pest snail and slug species have been concentrated in vegetable growing landscapes in the high altitude region. Pest species have not moved deep inside the natural forests. Most of island's land snail diversity is concentrated in lowland wet zone forests and wet montane forest regions of the country. Therefore, the conservation of these important forest regions is essential for the long-term survival of the islands' rich land snail fauna.

Key words: *Molluscs, Species richness, Endemicity, Distribution, Conservation*

Introduction to molluscs

Molluscs are among the most ancient of animals on earth today. They appear in the oldest Cambrian deposits, more than 500 million years BP (Kay, 1995). With an estimated 80,000 species worldwide, molluscs (snails and slugs) comprise the second most diverse animal phyla after arthropods (Solem, 1984; Emberton et al., 1997). They also form a most successful animal group living today (Kay, 1995). Majority of the molluscs are aquatic (marine and freshwater) while terrestrial species comprise of about 25% of the total number (Emberton et al., 1997).

Class Gastropods is the largest class of molluscs having over 75,000 living species. Gastropod molluscs are the most successful of all molluscan classes and thy have colonized a wide range of habitats including the oceans, freshwaters as well as the land. The class Gastropods is divided in to three major subclasses, namely Prosobranchia, Opisthobranchia and Pulmonata. Opisthobranchs are generally marine. Prosobranchs have robust calcareous shells, long thin tentacles with eyes at their bases and a circular plate, the operculum, fixed to the top of the shell, which closes the shell's aperture when the snail retracts. The sexes are separate. Land pulmonates are highly evolved for a terrestrial life than are Prosobranchs and their physiology and anatomy is more specialized for dealing with life on land. Some pulmonates possess shells as solid as those of prosobranchs but many do not. The shells often have little calcium carbonate and may be largely made from protein. The shell may be reduced in size to the extent that the snail can no longer retract into its shell as in *Eurychlamys.* In several independent pulmonate lineages such as slugs a shell is residual or completely absent. Most pulmonates have a lower pair of chemosensory and tactile tentacles and all possess a longer pair of upper tentacles with eyes located in the bulbous tips. They are hermophrodites with a combined genital orifice usually sites just behind the right tentacles (Barnes, 1982).

During recent years, molluscs along with other animals and plants are undergoing a rapid process of extinction largely due to human activities, and the present extinctions of species occur in time spans of less than ten years (Kay, 1995). Majority of the terrestrial molluscs are forest dwellers, which are sensitive to habitat disturbance. Therefore, the terrestrial molluscs are of regional and global concern, from the biodiversity conservation point of view (Emberton, 1995; Tattersfield et al., 2001). Molluscs have become important elements in the studies on mechanisms of evolution and examining the effects of ecology on evolutionary change (Crampton, 1932; Cain and Sheppard 1950; Cain and Currey, 1963; Cowie, 1992; Johnson et al., 1993). Their low vagility also makes them suitable as indicators for biogeographical studies of early tectonic events (Solem, 1981).

Land snail communities occur nearly world-wide, with sympatric species richness varying from one in sub Antarctic islands (Solem, 1984) to 97 indigenous species recorded from a patch of rainforest in southwestern Camaroon (de Winter and Gittenberger, 1998). According to Solem (1984) land snail communities with more than 30 species is extremely rare, especially in tropical rainforests, where "snails generally are neither diverse nor abundant". However, recent land snail surveys conducted in afromontane forests of Mount Kenya (Tattersfield et al., 2001) and Pukeamaru Ecological District in northeastern New Zealand (Barker and Mayhill, 1999) resulted in recording high species richness (68 species from Mount Kenya and 94 species from New Zealand), indicating that land snails are a poorly understood group in tropical forests (de Winter and Gittenberger, 1998). According to Lange and Mwinzi (2003), although the malacofauna is facing a conservation challenge, patterns of their biodiversity in many parts of the world are poorly understood.

Most of the ecological studies on land snails in the tropics are confined to African tropics (de Winter and Gittenberger, 1998; Emberton et al., 1997; Lange and Maes, 2001; Lange and Mwinzi 2003; Tattersfield, 1996; Tattersfield, 1998, Tattersfield, 2001). Similarly, land molluscs in the Madagascan rainforests have also been well studied (Emberton, 1995). Outside the tropical region more attention has been paid for the land molluscs in New Zealand, where there is a high species richness (Barker and Pauline, 1999; Emberton, 1995). A comparatively limited amount of work has been carried out on land molluscs in the South Asian region.

Studies on land snail fauna of Sri Lanka

Studies on land snails in Sri Lanka was initiated more than 100 years ago (Collet, 1897, 1898, 1900; Blanford and Godwin-Austen, 1908; Guade 1914, 1921). Although these works were mainly on the taxonomy and distribution of species, they still remain as the pioneering work on the land molluscs in Sri Lanka. After this initial period, work on land molluscs showed very slow progress until the 1980's (Ratnapala, 1984; Ratnapala and Arudpragasam, not dated; Breckenridge and Fallil, 1973). A revival of interest on ecological research on Sri Lankan land molluscs occurred in the late 1990's (Morden et al., 2003; Naggs et al., 2003; Raheem et al., 2000; Raheem and Butterworth, 1998). Commencement of the Darwin Initiative (UK) land snail diversity project in Sri Lanka (1999 – 2002) was mainly responsible for initiating the second phase of ecological research on Sri Lankan land molluscs.

Although there is a growing interest on ecological research on land molluscs in Sri Lanka little is known of the ranges of distribution and population sizes of a large proportion of the fauna. Basic distributional information is lacking for nearly 30% of snail taxa known from Sri Lanka. Many of the endemic species are known only from single localities and they have not been recorded since the publication of the last volume of the Fauna of British India series in 1921 (Raheem et. al., 2000).

Land snail surveys conducted in Sri Lanka during the recent past have focused on the distribution of land snails in the wet southeastern part of the county, where there is a high endemism of species (Naggs et al., 2003; Raheem, et al., 2000; Raheem and Butterworth, 1998). Natural forest of the other parts of the country has not been surveyed to the same extent and hence data on the distribution and diversity of land snails in those regions are not available. Naggs et al. (2003) stressed that land snails are ideal subjects for addressing high priority questions relating to rainforest biotas and have long been recognized as possessing a number of attributes that make them particularly suitable subjects for studies in evolutionary biology. Due to their low mobility land snails have become models for studying the effects of pesticides and influence of the activities of man in altering the environment. Therefore, information on the distribution and ecology of land snails is an important prerequisite for monitoring habitat quality. Some land snails are vectors of helminthic diseases of vertebrates in Sri Lanka (Ratnapala, 1984).

Species richness and endemicity of land snails

Species richness and endemicity is high among Sri Lankan land snails (Naggs et al., 2003). Approximately 246 species of land snails are known from Sri Lanka of which the majority (83%) are endemic to the country (Naggs and Raheem, 2000). Sub class Pulmonata is represented by 159 species in 23 families and subclass Prosobranchia is represented by 88 species in four families (Appendix 1). This indicates that the pulmonate group dominates land snails in Sri Lanka.

The families Ariophantidae (mainly *Cryptozona* and *Euplecta*) with 45 species and Glessulidae (22 species) are the largest pulmonate families found in the country. Cyclophoridae (48 species) is the largest Prosobranch family (Appendix 1)

Much of this endemism is concentrated in the wet, southwestern portion of the island (Raheem, 2000). A significant portion of Sri Lankan snail fauna consists of Gondwanan relicts, with origins dating back prior to the break up of the southern super-continent over 100 million years ago (Naggs et al., 2003). Despite its faunistic affinities with Indian mainland the Sri Lankan land mollusc fauna is the most distinct in the South Asian Region (Naggs et al., 2003). A total of five land snail genera, namely, *Ravana, Ratnadvipia, Acavus, Oligospira* and *Aulopoma* are endemic to Sri Lanka. Except for the latter Genus, the rest belongs to the pulmonate group. Fourteen species are included in these five genera. All the species belonging to these genera show discontinued distribution and are restricted to few specific habitats. Although some large and brilliantly coloured snails of the Genus *Acavus* has attracted attention from scientists, nature lovers and traditional medical practitioners (Hausdorf and Perera, 2000; Perera, 1991), ecological information on the species of other four genera are almost lacking.

Land-snail fauna in Sri Lanka bears evidence of the island's long association with the Indian subcontinent. Of the 60 land snail genera recorded from the island 13 *(Ruthvenia, Thysanota, Cryptozona, Euplecta, Mariaella, Eurychlamys, Corilla, Beddomea, Trachia, Leptopomodes, Micraulax, Tortulosa* and *Nicida)* are restricted to Sri Lanka and Peninsular India, primarily to Western Ghats; approximately 50% of the 247 species recorded from the island belong to genera endemic to southern India and Sri Lanka (Raheem et al., 2000)

About 18 exotic land snails and slug species, most of which are agricultural pests, have also been recorded from the country during recent studies (Naggs et al., 2003).

Land snail distribution

Recently concluded studies (Raheem et al., 2000; Ranawana, 2005) show that the lowland rainforest zone and the montane rainforest zone in Sri Lanka have distinctive snail faunas. The lowland rainforest fauna is composed of a widely distributed element and a localized or restricted-range component. Widely distributed lowland rainforest species include *Cryptozona chenui, Ratnadvipia irradians, Acavus phoenix, Corilla adamsi, Beddomea albizonatus* aggregate and *Leptopoma semiclausum* These taxa range across most or all of the forested area of the lowland wet zone: some species such as *Ratnadvipia irradians* occur in both forest and non forest habitats (Raheem et al., 2000).

Recent and on-going studies on land snails in Sri Lanka

Recently concluded Darwin Initiative Land Snail Diversity project: October 1999 – October 2002, was the most intensive study undertaken to evaluate the status of land snails in the country (excluding the Knuckles Region) during the last century. During this three-year study approximately 150 morphospecies were recorded, including 110 endemic species. At least 50 species (undescribed) are new to science, which include several unidentified genera and exotic species (Naggs et al., 2005). Systematic work on these new species is now being carried out at the Natural History Museum, London.

Forty-nine species of land snails have been recorded from Knuckles region alone during the same period. Of these, 37 species haven been positively identified in to species level while 12 species could not be identified to the species level. These included 36 species of pulmonates, while 15 were prosobranchs. Of the 49 species recorded 28 (57%) were endemics, including species representing three endemic genera. Of the 39 species recorded from the montane forests of Knuckles 22 were endemics, including three endemic genera. Sub montane forests supported 20 endemic species including four endemic genera. The intermediate zone forests of Knuckles harboured 19 endemic species with three endemic genera (Table 1) (Ranawana, 2005).

Darwin initiative Land Survey has also resulted in recording 18 exotic species of snails and slugs (Table 2) with seven previously unrecorded species (*Arion intermedius, Cochlicopa lubrica, Deroceras laeve, D. reticulatum, Milax gagates*, *Oxychilus alliarius* and a *Semperula* sp.) (Naggs et al., 2003). Most of the exotic species are recorded in association with agricultural land, especially in Nuwara Eliya area, where climatic conditions are conducive for their survival and reproduction. Although the exotic *Lissachatina fulica* occurs along the forest edges, no other exotic species have been found inside natural forests. The threats from these exotics to the survival of the endemic land snail fauna in the country are yet to be evaluated.

Table 1: Land snail distribution in the Knuckles region (+ present, - absent, * Endemic species , ** Endemic Genera Habitats: MF – Montane Forest; MC – Montane Cardamom; SMF – Submontane Forest; SMC- Submontane Cardamom. SMGL- Submontane Grasslands; IMF- Intermediate Zone Forests; IMHG - Intermediate Zone Home Gardens.)

Family	Species	Montane zone		Sub montnae zone			Intermediate Zone	
		MF	MC	SMF	SMC	SMGL	IMF	IMHG
Pulmonata								
ACAVIDAE	*Oligospira polei***	+	-	+	+	+	+	-
ACHATINIDAE	*Achatina fulica*	-	-	-	-	-	+	+
ARIOPHANTIDAE	*Cryptozona bistrialis*	+	-	+	+	+	+	+
	*Cryptozona ceraria**	+	+	-	-	-	+	-
	*Cryptozona chenui**	+	+	+	+	-	+	-
	*Euplecta colletti**	-	+	+	-	-	-	-
	Euplecta indica	-	-	-	-	-	+	-
	*Euplecta layardi**	-	-	-	-	-	-	+
	Euplecta Sp A	+	+	+	+	+	+	-
	Euplecta new Sp. B	+	+	+	+	+	+	-
	*Euplecta partita**	+	+	+	+	-	+	-
	*Euplecta prestoni**	-	-	-	+	-	-	-
	Euplecta semidecussata	+	+	+	+	-	+	+
	Euplecta travancorica	+	+	+	+	+	+	+
	*Macrochlamys nepas**	+	-	-	-	-	-	-
	Macrochlamys woodina	+	-	+	+	+	+	+
	*Rathnadvipia irradians***	+	-	+	+	+	-	+
	*Ravana politissima***	-	-	+	-	-	-	+

BULIMINIDAE	*Mirus stalix**	+	-	-	-	-	+	-
CAMAENIDAE	*Beddomea albizonata**	+	-	+	+	+	+	+
CAMAENIDAE	*Beddomea trifasciatus**	-	-	+	+	-	+	+
CHAROPIDAE	*Ruthvenia sp A*	+	+	+	+	+	+	+
CHAROPIDAE	*Thysanota elegans**	-	-	-	+	-	-	-
CORILLIDAE	*Corilla colletti**	+	+	+	+	+	-	+
	*Corilla gudei**	+	+	+	+	+	+	-
ENDODONTIDAE	*Philalanka sp A*	+	+	+	-	-	+	-
EUCONULIDAE	*Eurychlamys regulata**	-	-	+	-	-	+	+
GLESSULIDAE	*Allopeas layardi**	-	+	-	+	-	-	-
	Glessula sp A	+	+	+	+	+	+	+
	Glessula sp B	+	+	+	+	+	+	+
STEPTAXIDAE	*Indoartemom layardianus**	+	-	-	-	-	+	-
SUBULINIDAE	*Subulina octona*	-	+	-	+	+	+	+
VERONICELLIDAE	*Laevicaulis alte*	-	-	-	-	-	-	+
VERTIGINIDAE	*Pupisoma longstaffae**	+	-	+	-	-	+	-
Prosobranchia								
CYCLOPHORIDAE	*Aulopoma grande***	+	+	+	+	-	+	+
	Aulopoma Sp.A.**	+	+	+	+	+	+	+
	Aulopoma Sp B**	+	-	+	-	-	+	-
	*Cyclophorus ceylanicus**	-	+	+	+	-	+	+
	*Japonia vesca**	+	-	-	-	+	+	-
	*Leptopomoides poecilus**	-	-	+	-	-	+	-
	Leptopoma Sp.A	-	+	+	+	+	-	-
	Pterocyclus cumingi	+	-	-	-	-	+	-
	*Theobaldius annulatus**	+	+	+	+	+	+	+
	*Theobaldius bairdi**	+	+	+	+	+	-	-
	Theobaldius Sp. A	+	+	+	+	+	+	-
	*Theobaldius subplicatus**	+	-	-	-	-	-	-
PUPINIDAE	*Tortulosa nevilli**	+	+	-	-	-	-	-
	Tortulosa Sp A	+	+	+	-	-	-	-
	Tortulosa Sp B	+	-	+	-	-	-	-

Table 2: Distribution of the 18 exotic land snail species across the four major climatic zones of Sri Lanka (source: Naggs *et al.*, 2003)
lowlands (<1000m altitude) and highlands (>1000m altitude) of the wet zone
[a] include plantations, vegetable field and home gardens
* occur in natural forest, which has been subjected to intensive selective logging in the last three decades.

SPECIES	**CLIMATIC ZONE**				**HABITAT**	
	Lowland Wet	**Highland Wet**	**Inter mediate**	**Dry**	**Modi fied[a]**	**Natural Forest**
Allopeas gracile	+	+	+	-	+	-
A. panayensis	+	-	+	-	+	-
Arion intermedius	-	+	-	-	+	-
Bradybaena similaris	+	+	-	-	+	-
Cochlicopa lubrica	-	+	-	-	+	-
Deroceras laeve	-	+	-	-	+	-
D. reticulatum	-	+	-	-	+	-
Eustreptaxis kibweziensis	-	-	+	-	+	-
Gulella bicolor	-	-	+	+	+	-
Kaliella barrakporensis	+	+	-	+	+	+*
Laevicaulis alte	+	-	+	-	+	+*
Lissachatina fulica	+	+	+	+	+	+ *
Mariaella dussumieri	+	+	+	-	+	-
Milax gagates	-	+	-	-	+	-
Oxychilus alliarius	-	+	-	-	+	-
Phaedusa ceylanica	-	+	-	-	+	-
Semperula sp.	+	-	-	-	+	+*
Subulina octona	+	0	+	0	+	-
Total	**9**	**12**	**8**	**3**	**18**	**4***

Conservation issues

Habitat loss is the main threat faced by land snails in the country today. The high diversity areas such as lowland rainforests of the wet zone are highly fragmented. Ground cover of the mountain regions like Knuckles Region is cleared for cardamom cultivation. Since most of our land snails are leaf litter inhabitants, clearance of forest floor is detrimental to their survival. Vast are of land in the wet zone of Sri Lanka was inundated due to large scale dam construction for river diversion (especially the Mahaweli river) and hydroelectric generations. Such land losses due to development activities either minimize the area available for land snails or completely wipe out a species from the area due to habitat loss. Frequent fires in the grasslands, scrublands and forests are detrimental to the survival of land snails and as a result very few land snail species are recorded from the grasslands, which are subjected to repeated fires. Use of agrochemicals is also harmful to native land snail species found in association with human settlements. Species belonging to endemic genera such as *Acavus* and *Ratnadvipia*, which are found in synanthropic habitats are severely affected by agrochemicals.

Conclusions and Recommendations

Lowland rainforests in the wet zone and the montane zone forests harbour a significant portion of island's land snail diversity and endemism with many species restricted to localized areas in these zones. Survival of highly diverse land snail fauna of Sri Lanka is therefore dependent on the effective conservation of the country's remaining rainforest fragments and the montane forests. The following recommendations are made to promote research and conservation activities of land snails of Sri Lanka:

- Conduct research on the ecology and distribution of land snails of Sri Lanka, with particular emphasis on the endemic and relict taxa which intern help us to identify the land snail hotspots
- Develop plans for population restoration of endemic and relict species which are facing the danger of extinction due to habitat loss (such as development activities, inundation of land due to dam building). The affected taxa could be translocated to a suitable areas having similar habitat conditions.
- There should be a strict regulation to control the entry of exotic land snails in to the country. These exotic species have entered the country mainly through the import trade of vegetables and foliage plants. In the mean time attempts should be made to control these exotic species as much as possible before they colonize natural forest habitats in the country
- Care should be taken to control the spread of some predatory gastropods, which has been introduced to the country in early 1950's to control *Lissachatina fulica.* Still individuals of predatory gastropod *Eustreptaxis kibweziensis* are recorded from Peradeniya, where it was first introduced. This predatory carnivore population has to be eradicated before it enters the natural habitats.

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Appendix 1: Checklist of Land Snails in Sri Lanka
(reproduced with permission from Naggs and Raheem, 2003)

*** : Endemic species**
**** : Endemic Genus**

CLASS : GASTROPODA
SUBCLASS : PULMONATA
SUPERORDER : STYLOMMATOPHORA
SUPERFAMILY : PUPILLOIDEA
FAMILY : PUPILLOIDEA
Sub Family : Pupillinae
1. *Microstele muscerda* (Benson 1853)
2. *Pupoides coenopictus* Hutton 1834

FAMILY : VERTIGINICLAE
Sub Family : Gastrocoptinae
3. *Gastrocopta (Gastrocopta) mimula** (Benson 1853)

Sub Family : Nesopupinae
4. *Nesopupa (Indopupa) cinghalensis** (Gude 1914)
5. *Pupisoma longstaffae** Godwm-Austen 1912
6. *Pupisoma miccyla** (Benson 1860)

FAMILY : PYRAMIDULIDAE
7. *Pyramidula halyi** (Jousseaume 1894)

Subfamily : Buliminінae
FAMILY : BULIMININAE
Subfamily : Buliminінae
8. *Mirus panos** (Benson 1853)
9. *Mirus proletaria** (Pfeiffer 1855)
10. *Mirus stalix** (Benson 1863)

FAMILY : CERASTUIDAE
11. *Rachis punctatus* (Anton 1839)
12. *Rhachistia adumhratus** (Pfeiffer 1855)
13. *Rhachistia pulcher* (Gray 1825)

SUPERFAMILY : PUNCTOIDEA
FAMILY : ENDODONTIDAE
14. *Philalanka circumsculpta** Sykes 1897
15. *Philalanka depressa** (Preston 1909)
16. *Philalanka edithae** (Preston 1909)
17. *Philalanka lamcabensis** Jousseaume 1894
18. *Philalanka liratula** (Pfeiffer 1860)
19. *Philalanka mononema* *(Benson 1853)
20. *Philalanka secessa** Godwin-Austen 1898

21. *Philalanka sinhila* *(Godwin-Austen 1897)
    var. *suavis* (Jousseaume 1894)
22. *Philalanka thwaitesi** (Pfeiffer 1854)
23. *Philalanka trifilosa** (Pfeiffer 1854)

FAMILY : CHAROPIDAE
Subfamily : Charopinae

24. *Ruthvenia biciliata** (Pfeiffer 1855)
25. *Ruthvenia caliginosa** (Sykes 1898)
26. *Ruthvenia clathratula* * *(Pfeiffer 1850)*
    var. *compressa* (Sykes 1898)
27. *Thysanota elegans** Preston 1909
28. *Thysanota eumita** Sykes 1898
29. *Thysanota hispida** Sykes1898

SUPERFAMILY : CLAUSILIOIDEA
FAMILY : CLAUSILIDAE
Subfamily : Phaedusinae

30. *Phaedusa ceylanica** (Benson 1863)

SUPERFAMILY : GASTRODONTOIDEA
FAMILY : GASTRODONTIDAE

31. *Zonitoides arboreus* (Say 1816)

SUPERFAMILY : HELICARIONOIDEA
FAMILY : EUCONULIDAE

32. *Eurychlamys layardi** (Benson manuscript name)
33. *Eurychlamys regulala* *(Benson 1860)
34. *Eurychltiniys winifredae** (Preston 1909)

FAMILY : HELICARIONIDAE
Subfamily : Sesarinae

35. *Kaliella barrakporensis* (Pfeiffer 1853)
36. *Kaliella colletti** Sykes 1899
37. *Kaliella delectabilis** Sykes 1898
38. *Kaliella leithiana** Godwin-Austen 1883
39. *Kaliella salicensis** Godwin-Austen 1897
40. *Sivella galerus** (Benson 1856)
41. *Sivella hyptiucyclos* * *(Benson 1863)*

FAMILY : ARIOPHANTIDAE
Subfamily : Ariophantinae

42. *Cryptozona bistrialis* (Beck 1837)
43. *Cryptozona ceraria** (Benson 1853)
44. *Cryptozona chenui** (Pfeiffer 1847)
45. *Cryptozona Juliana** (Gray 1834)
    var. *ganoma* (Pfeiffer 1854)

46. *Cryptozona novella** (Pfeiffer 1855)
47. Cryptozona semirugata (Beck 1837)
48. *Euplecta acuducta* (Benson 1850)
49. *Euplecta albnonata* (Dohm 1858)
50. *Euplecta binoyaensis** Godwin-Austen 1899
51. *Euplecta colletti** Sykes 1897
52. *Euplecta concavospira** (Pfeiffer 1854)
53. *Euplectu emiliana* * (Pfeiffer 1853)
54. *Euplecta gardeneri** (Pfeiffer 1846)
55. *Euplecta hyphasma** (Pfeiffer 1854)
56. *Euplecta indica* (Pfeiffer 1846)
57. *Euplecta isabellina** (Pfeiffer 1854)
58. *Euplecta laevis** Blanford 1901
59. *Euplecta lankaensis** Preston 1909
60. *Euplecta layardi** (Pfeiffer 1853)
61. *Euplecta neglecta*[11]* Preston 1909
62. *Euplecta partita** (Pfeiffer 1854)
63. *Euplecta phidias** (Hanley & Theobald 1876)
64. *Euplecta prestoni** (Godwin-Austen 1897)
65. *Euplecta rosamonda** (Benson 1860)
66. *Euplecta scobinoides** Sykes 1897
67. *Euplecta semidecussata* (Pfeiffer 1853)
68. *Eiip!ecta subopaca** (Pfeiffer 1854)
69. *Euplecta trimeni** (Jousseaume 1894)
70. *Euplectaturritella* (H. Adams 1869)
71. *Euplecta travancoricii* (Benson 1865) [= *praeeminens* Sykes 1898]
72. *Euplecta verrucula** (Pfeiffer 1855)
73. *Ratnadvipia edgariana*** (Benson 1853)
74. *Ratnadvipia irradians*** (Pfeiffer 1853)
75. *Ravana politissima*** (Pfeiffer 1854)
76. *Mariaella dussumieri* Gray 1855

Subfamily : Macrochlamydinae

77. *Macrochlamys mdica* Godwin-Austen 1883
78. *Macrochlamys kandiensis** Godwin-Austen 1883
79. *Macrochlamys neaps** (Pfeiffer 1855)
80. *Macrochlamys perfucata** (Benson 1853)
81. *Macrochlamys tratanensis** (Jousseaume 1894)
82. *Macrachlmys umbrina** (Pfeiffer 1859)
83. *Macrachlmy vilipensa* (Benson 1853)
84. *Macrochlamys woodiana (*Pfeiffer 1853)
85. *Microcystina bintennensis** Godwin-Auten1899
86. *Microcystina lita** Sykes 1898

Subfamily : Durgellinae

87. *Satiella membranacea** (Benson 1853)
88. *Sitala operiens** Sykes 1898

89. *Sitala phyll.ophila** (Benson 1863)
90. *Sitala pyramidalis** Sykes 1898

SUPERFAMILY : LIMACOIDEA
FAMILY : LIRNACIDAE
91. *Deroceras reticulatum* (Miiller 1774)

SUPERFAMILY : ACHATINOIDEA
FAMILY : FERUSSACIIDAE?
92. *Digoniaxis? cingalensis** (Benson 1863)

FAMILY : GLESSULIDAE
Subfamily : Glessulinae
93. *Glessula capillacea* (Pfeiffer 1855)
94. *Glessula ceylanica** (Pfeiffer 1845)
95. *Glessula collettae** Sykes 1898
96. *Glessula deshayesi* (Pfeiffer 1853)
97. *Glessula fulgens** (Pfeiffer 1858)
98. *Glessula inornata** (Pfeiffer 1853)
var. *minor* Beddome 1906
99. *Glessula lankana** Pilsbry 1908
100. *Glessula layardi** Pilsbry 1908
101. *Glessula nitens** (Gray 1825)
102. *Glessula pachycheila** (Benson 1853)
var. *taprobanicci* Pilsbry 1908
103.*Glessula pullens** Beddome 1906
104. *Glessula panaethu** (Benson 1860)
105. *Glessula pwahilis** (Benson 1856)
106. *Glessula prestoni** Ci ude 1914
107. *Glessulapunctogallana** (Pfeiffer 1852)
108. *Glessula pusilla* Beddome 1906
109. *Glessula reynelli** Gude 1914
var. *immitis* Gude 1914
110. *Glessula sattaraensis* (Hanley & Theobald 1874)
111. *Glessula serena** (Benson 1860)
112. *Glessula simony** (Jousseaume 1894)
113. *Glessula sinhila** Preston 1909
114. *Glessula veruina** (Benson 1853)

FAMILY : SUBULINIDAE
Subfamily : Subulinidae
115. *Subulina octona* (Bruguiere 1789)
116. *Allopeas gracile* (Hutton 1834)
var. *panayensis* (Weiffer 1846)
117. *Allopeas layardi** (Benson 1863)
118. *Allopeas marine** (Jousseaume 1894)
119. *Allopeas prestoni** (Sykes 1898)

120. *Allopeas pussilus** (H.. Adams 1867)
121. *Allopeas sykesi** (Pilsbry 1906)
122. *Paropeas achatinaceum* (Pfeiffer 1846)

Sub Family : Ruminінae

123. *Zootecus insularis* (Ehrenberg 1831)

FAMILY : ACHATINIDAE

124. *Achatina fulica* Bowdich 1822

FAMILY : STREPTAXIDAE

Subfamily : Streptaxinae

125. *Indoartemon cingalensis** (Benson 1853)
126. *Indoartemon gracilis** (Collet 1898)
127. *Indoartemon layardianus** (Benson 1853)
128. *Perrottetia peroteti* (Petit de la Saussaye 1841)
129. *Perrottetia ravanae** Blanford 1899

Subfamily : Enneinae

130. *Gulella bicolor* (Hutton 1834)
131. *Sinoennea planguncula* (Benson 1863)

SUPERFAMILY : ACAVOIDEA

FAMILY : ACAVIDAE

Subfamily : Acavinae

132. *Acavus haemastoma*** (Linnaeus 1758)
    [=*concolor* (Pilsbry 1890), *conns* (Pilsbry 1890), *fastosus* (Albers 1854) and *melanotragus* (born 1778)
133. *Acavus phoenix*** (Pfeiffer 1854)
    [= *prosperus* (Albers 1857)]
134. *Acavus superbus***
    (Pfeiffer 1850) species complex including *grevillei* (Pfeiffer 1857) and *reseolabiata* (Nevill 1881)
135. *Oligospira polei*** (Collet 1899)
136. *Oligospira skinneri*** (Reeve 1854)
137. *Oligospira waltoni*** (Reeve 1842)

SUPERFAMILY : CORILLIDOIDEA (=PLECTOPYLIDOIDEA?)

FAMILY : CORILLIDAE (=PLECTOPYLIDAE?)

138. *Corilla adamsi** Gude 1914
    var. *hinidunensis* Nevill 1871
139. *Corilla beddomeae* * (Hanley 1875)
140. *Corilla carabmata** (Ferussac 1821)
141. *Corilla colletti** Sykes 1897
142. *Corilla erronea** (Albers 1853)
    var. *eronella* Gude 1896
143. *Corilla fryae** Gude 1896
144. *Corilla giidei** Sykes 1897
145. *Corilla humberti** (Brot 1864)

146. *Corilla lesleyae* *Barnacle 1959
147. *Corilla odontophora* * (Benson 1865)

SUPERFAMILY : CAMAENOIDEA
FAMILY : CAMAENIDAE
Subfamily : Camaeninae

148. *Beddomea albizonatus** (Reeve 1849)
 var. *simoni* (Jousseaume 1894)
149. *Beddomea ceylanicus**(Pfeiffer 1846)
150. *Beddomea intermedius** (Pfeiffer 1855)
151. *Beddomea frifasciatus** (Gmelin 1786)
 var. *rufopicta* (Benson 1856)
152. *Trachia fallaciosa* (Ferussac 1821)
153. *Trachia vittata* (Muller 1774)
154. *Landouria radleyi** (Jousseaume 1894)

SUPERFAMILY : HELICOIDEA
FAMILY : BRADYBAENIDAE
Subfamily : Bradybinaenae

155. *Bradybaena similaris* (Femssac 1822)

Subfamily : Succineinae

156. *Succinea ceylanica* Pfeiffer 1855

ORDER : SYSTEUOMMATOPHORA
FAMILY : VERONICELLIDAE

157. *Laevicaulis alte* (Femssac 1821)
158. *Semperula maculata* (Tempieton 1888)
159. *Semperula siamensis* (Martens 1867)

SUBCLASS : PROSOBRANCHIA
SUPERFAMILY : CYCLOPHOROIDEA
FAMILY : CYCLOPHORIDAE
Subfamily : Cyclophorinae

160. *Cyclophorus alabastrimis** (Pfeiffer 1855)
161. *Cyclophorus ceylanicus** (Pfeiffer 1849)
162. *Cyclophorus involvulus* (Muller 1774)
163. *Cyc!ophorus menkeanus* * (Philippi 1848)
164. *Aulopoma grande** * (Pfeiffer 1855)
165. *Aulopoma helicinum* ** (Chemnitz 1786)
166. *Aulopoma itieri*** (Guerin 1847)
 Ver. *Hofmeisteri* Troshcel 1847
167. *Aulopoma sphaeroideum*** Dohrn 1857
168. *Cyathopoma (Cyathopoma) album* Beddome 1875
169. *Cyathopoma (Cyathopoma) artatum** Sykes 1897
170. *Cyathopoma (Jerdonia) ceylanicum** Beddome 1875
171. *Cyathopoma (Jerdonia) colletti** Sykes 1898

172. *Cyathopoma (Jerdonia) conoideum** Sykes 1898
173. *Cyathopoma (Jerdonia) innocens** Sykes 1899
174. *Cyathopoma (Cyathopoma) leptomita** Sykes 1898
175. *Cyathopoma (Cyathopoma) mariae** Jousseaume 1894
176. *Cyathopoma (Jerdonia) ogdenianum** Preston 1909
177. *Cyathopoma (Jerdonia) perconoideum** Preston 1909
178. *Cyathopoma (Cyathopoma) prestoni** Sykes 1897
179. *Cyathopoma (Jerdonia) serendibense** Preston 1903
180. *Cyathopoma {Jerdonia) turbinatum** Sykes 1897
181. *Cyathopoma (Jerdonia) uvaense** Preston 1909
182. *Japonia binoyae** (Sykes 1899)
183. *Japonia occulta** Sykes 1899
184. *Japonia vesca* *(Sykes 1899)
185. *Leptopoma apicatum** Benson 1856
186. *Leptopoma elatum** Pfeiffer 1852
187. *Leptopoma semiclausum** (Pfeiffer 1855)
188. *Leptopomoides conulus** (Pfeiffer 1855)
189. *Leptopomoides flammeus** (Pfeiffer 1855)
190. *Leptopomoides halophilus** (Benson 1851)
191. *Leptopomoides orophilus** (Benson 1853)
192. *Leptopomoides poecilus** (Pfeiffer 1855)
193. *Leptopomoides taprobanensis*[26]* (Preston 1909)
194. *Micraulax coeloconus* (Benson 1851)
195. *Scabrina brounae** (Sykes 1898)
196. *Scabrina liratula** (Preston 1909)
197. *Theobaldius annulatus** (Pfeiffer 1847)
    var. *discus* Kobelt 1902
198. *Theobaldius bairdi** (Pfeiffer 1854)
199. *Theobaldius cadiscus** (Benson 1860)
200. *Theobaldius cratera** (Benson 1856)
201. *Theobaldius cytopoma** (Benson 1860)
202. *Theobaldius layardi** (H. Adams 1868)
203. *Theobaldius liliputianus** (Preston 1909)
204. *Theobaldius loxostoma** (Pfeiffer 1854)
205. *Theobaldius parapsis** (Benson 1853)
206. *Theobaldius parma** (Benson 1856)
207. *Theobaldius subplicatulus** (Beddome 1875)
208. *Theobaldius thwaitesi** (PfeifFer 1855)

Subfamily : Pterocyclinae (?)

209. *Pterocyclus bifrons** PfeifFer 1855
210. *Pterocyclus bilabialus* Sowerby 1835 var. *cornice* Nevill 1878
211. *Pterocyclus cingalensis** Benson 1853
212. *Pterocyclus cumingi* PfeifFer 1851
213. *Pterocyclus troscheli** Benson 1851

FAMILY : DIPLOMATINIDAE
Subfamily : Diplomatininae

214. *Nicida catathymia** (Sykes 1898)
215. *Nicida ceylamca** (Beddome 1875)
216. *Nicida delectabilis** (Preston 1905)
217. *Nicida lankaensis** (Preston 1905)
218. *Nicida pedronis** (Beddome 1875)
219. *Nicida prestomi** (Sykes 1897)

FAMILY : PUPINIDAE
Subfamily : Pupininae

220. *Tortulosa aurea** (PfeifFer 1855)
221. *Tortulosa austeniana** (Benson 1853)
222. *Tortulosa barnaclei** Tomlin 1928
223. *Tortulosa blanfordi** (Dohrn 1862)
224. *Tortulosa colletti** (Sykes 1898)
225. *Tortulosa congener** (Sykes 1905)
226. *Tortulosa connectens** (Fulton 1903)
227. *Tortulosa cumingi** (PfeifFer 1857)
228. *Tortulosa decora** (Benson 1853)
229. *Tortulosa duplicate** (PfeifFer 1855)
230. *Tortulosa eurytrema** (PfeifFer 1852)
231. *Tortulosa greeni** (Sykes 1899)
    var. *robusta* (Fulton 1903)
232. *Tortulosa haemastoma** (PfeifFer 1857)
233. *Tortulosa hartleyi** Tomlin 1928
234. *Tortulosa layardi* * (PfeifFer 1851)
235. *Tortulosa leucocheilus** (A. Adams & Sowerby 1866)
236. *Tortulosa marginata** (PfeifFer 1854)
    var. *crenulata* (Fulton 1904)
    var. *notata* (Sykes 1905)
237. *Tortulosa nevilli** (Sykes 1898)
    vsz.*flaveola* (Fulton 1904)
238. *Tortulosa metneri** (Nevill 1871)
    var. *caperata* (Collett 1899)
    var. *unicolor* (Collett 1899)
239. *Tortulosa prestoni**(Sykes 1905)
240. *Tortulosa pyramidata** (PfeifFer 1852)
241. *Tortulosa rugosa* *(Fulton 1904)
242. *Tortulosa smithi** (Sykes 1905)
243. *Tortulosa sykesi** (Fulton 1904)
244. *Tortulosa templemani** (Pfeiffer 1852)
245. *Tortulosa thwaitesi** (Pfeiffer 1852)

SUPERFAMILY : RISSOIDEA
FAMILY : TRUNCATELLIDAE

246. *Truncatella ceylanica* * Pfeiffsr 1856

Section 2:

Status of Vertebrate Fauna in Sri Lanka

Trachypithecus vetulus
Vimukthi Weeratunga

Philautus femoralis
Wildlife Heritage Trust

Ceratophora stoddartii
Vimukthi Weeratunga

Puntius srilankensis
Wildlife Heritage Trust

Urocissa ornata
Vimukthi Weeratunga

The Fauna of Sri Lanka (2006): 103-112

Conservation of Sri Lankan Freshwater Fishes

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Abstract

The paper highlights the species richness of freshwater fish in Sri Lanka, which consist of 82 species, including 44 endemics. It provides a discussion on conservation issues that pose a threat to the island's freshwater fish fauna, mainly invasive alien species, hydrological alterations and degradation of aquatic habitats and recommends specific conservation actions.

Key words: *Freshwater fish, Taxonomy, Conservation, Issues, Invasive species*

Introduction

Sri Lanka has one of the world's best known freshwater-fish faunas thanks to it having been well represented in the international ornamental fish trade from its beginnings in the 1930s, when wild-caught fish were exported to Europe and the United States. This trade was conducted necessarily using sea freight, involving passages of several weeks in widely varying environments, and succeeded only because the economics allowed for extremely high mortality. The Red Ruby Barb *(Puntius nigrofasciatus)*, the Cherry Barb *(P. titteya)*, the killifishes (*Aplocheilus* spp.) and many others have thus played a prominent part in international trade for decades, diminishing only when the principle of sustainability was absorbed into the regulatory process in the wake of the 1992 Convention on Biological Diversity.

The island's freshwater fish fauna has received significant attention in the technical literature, beginning with the description of specimens sent by expatriate enthusiasts to the British Museum (now The Natural History Museum) in the 1860s (e.g. Günther, 1864, 1868). Prior to this, the only fish descriptions from Sri Lanka had been based on a single collection made ca 1827 near the Kinniyar hot springs north of Trincomalee by A. Reynaud, a French explorer, based on which Georges Cuvier and Achille Valenciennes described several species as new (Cuvier & Valenciennes, 1828–49). The first local exploration of this fauna by an expert, however, occurred only in the early 1860s, when the Dutch ichthyologist P. Bleeker broke journey at Galle and made a collection from the Gin River basin, from which he described several new species. In 1900, Bleeker's work drew George Duncker, a German ichthyologist, to the same river and several other localities, based on which work the first checklist of Sri Lankan freshwater fishes was published (Duncker, 1912).

Following Duncker's work, the freshwater fishes received detailed attention in the work of P. E. P. Deraniyagala, who described several new species and the first illustrated faunal treatment (Deraniyagala, 1952), to which were added synopses by way of Mendis (1954) and Munro (1955). The first systematic exploration of the island's fish fauna however, took place only in the late 1970s in the seminal work of Senanayake (1980), which sadly remains unpublished. Senanayake (1982) and Senanayake et al. (1987) also reviewed, for the first time, the conservation of Sri Lanka's freshwater fishes. This work was supplemented by the work of Pethiyagoda (1990; 1994) and through the description of several additional new species.

Current taxonomic status of freshwater fish

Despite the early attention to freshwater fish in Sri Lanka, several novelties remain to be described (Pethiyagoda, in progress; see also Appendix 1), an activity retarded by the need to address several taxonomic and nomenclatural problems in the Indian literature (e.g. see Pethiyagoda & Kottelat 2005a,b). At present, a total of 82 species of freshwater fishes (44 species, 54% of them endemic) are known from the island, including diadromous species but not adventitious marine species that sometimes enter fresh and brackish waters (see Appendix 1). Thirteen of these species remain to be identified and/or described (Pethiyagoda, in progress).

A fuller understanding of Sri Lanka's freshwater fish fauna is also likely to develop as the results of molecular analyses now in progress become available (e.g. see Bossuyt et al., 2004; Meegaskumbura & Pethiyagoda, work in progress). This approach is likely to be particularly important in informing conservation-management decisions relating to populations that show distinct inter-basin differences.

Conservation Status

Endangered Species. At present, nine species of freshwater fish in Sri Lanka are considered as globally threatened (IUCN, 2004), while 39 species have been identified as nationally threatened (IUCN Sri Lanka, 2000) (see Table 1).

Extinctions. The populations of two species (*Labeo lankae* and *Macrognathus aral*) have crashed precipitously and they may be extinct (Pethiyagoda, 1994). Trends in almost all other species are not documented, and with no comprehensive assessment having been made over the past 15 years, it is possible that several other species have disappeared or are on the brink of extinction. The foremost priority for the conservation of this fauna therefore is a competent scientific national assessment based on fresh sampling.

Conservation Issues

Invasive species: While the primary cause of Sri Lanka's amphibian extinctions has probably been habitat loss, invasive species are likely to be flagged as the key agent for the extinction of freshwater fishes. Some nine alien species of freshwater fishes (and several other aquatic organisms) are now naturalised in Sri Lanka (Bambaradeniya, 2002), many of them invasive. Many other exotic species are recorded sporadically, and persist as potential invasives.

Both the freshwater fishery and the ornamental fish industry are clearly implicated in the introduction of freshwater invasive species to Sri Lanka. The first alien species introduced was the rainbow trout, in the 1880s to the highlands, to support a sport fishery. Two unidentified species of fishes recorded from an altitude of 1,800 m in the 1840s by Kelaart (1852) disappeared after the introduction of trout. The decline of the trout fly fishery in the 1970s led to the rapid decline of the population of this fish through poisoning for local consumption everywhere except in the Belihul Oya within Horton Plains National Park, where this species is strictly protected. Given that trout have inhabited this stream for more than a century now, it is likely that they have already done such damage as they are capable of doing and have reached a 'steady state' ecological position. The protection accorded to them is, however, a poor reflection on conservation science in Sri Lanka, especially given that they occur syntopically with several restricted-range endemics such as the crabs *Ceylonthelphusa sorror, Perbrinckia punctata and P. glabra;* and the shrimp *Lancaris singhalensis.*

Fishes introduced the lowland reservoir fishery, however, pose far more serious problems. Beginning with *Oreochromis mossambicus* in the 1950s, several tilapiine cichlids and their hybrids have been introduced to Sri Lanka (e.g., *O. niloticus, O. urolepis, Tilapia rendalli, T. zillii*) in a continuing fisheries development programme. Tilapias represent between 70 and 90 percent of the freshwater fish harvest at present, and a major share of the national freshwater fish biomass. Apart from the effects of competition and predation, increasingly more intensive gill-net fisheries also impact directly on the larger species of indigenous fishes (e.g. *Wallago attu, Channa ara,* which are now extremely rare). They may also have impacted on *Labeo lankae,* which was in fact represented incidentally in the reservoir fishery (Senanayake, 1980), and led to the near extirpation of freshwater turtles in most reservoirs that support a fishery.

Approximately 30,000 MT of freshwater fish (all of them alien) are harvested annually in Sri Lanka, representing an important source of nutrition and employment for rural communities. Yet, this fishery represents less than 0.1% of annual per capita GNP, which suggests that it is not indispensable in economic terms. Tragically, international fisheries development agencies such as the Asian Development Bank and the UN Food and Agriculture Organization have continued indiscriminately to support the introduction of alien species with no consideration of the environmental consequences involved. Indeed, an environmental impact assessment has not been made or mandated for the introduction of even one of the dozen or so alien species released in Sri Lanka by the fishery, and fisheries scientists continue to ignore the potential for negative consequences (see De Silva et al., 2004, for a review).

Given that no other causes have been implicated in the population crash of *Labeo lankae* (an endemic carp the distribution of which overlapped completely with that of tilapia), it is necessary to recognize that tilapia appears to have been responsible for at least a single species extinction in Sri Lanka. Given also that tilapias have extended their range to rivers, streams and estuaries, and even to the highlands (Pethiyagoda, 1994), it is time to consider controls in respect of both past and future introductions. The problem of invasive alien species is particularly important because the declines of indigenous fish populations they precipitate tend to be sharp and catastrophic, allowing little time of remedial interventions to be planned (Moyle et al., 1986). No possibilities for reducing existing tilapia populations present themselves, except by way of yet-to-be-developed biological controls, towards which international fisheries development agencies such as the ADB and FAO are yet to direct significant attention or investment. Given the "sustainable development" rhetoric these agencies espouse, their role in this tragic outcome needs to be highlighted, and the need for them to engage in the development of controls canvassed internationally. It is also necessary that any future intended release of exotic organisms in Sri Lanka (whether aquatic or otherwise) be informed by an environmental impact assessment, together with safeguards against their potential for invasiveness. This is especially necessary given that fisheries agencies have consistently ignored the provisions of Sections 37 and 38 of the Fauna and Flora Protection Ordinance, which regulate the import and release of live organisms to Sri Lanka.

Ornamental fish industry: The ornamental fish industry too, has been less than responsible in its management of exotic aquatic organisms. Several species of fishes imported for the local aquarium trade have become established in natural habitats as a result of (e.g.) escapes from ponds during floods, or deliberate release of redundant specimens because of widespread religious and ethical aversion to destroying life. Given the increasing number of organisms entering international trade, it is necessary even now that a "positive list" of organisms that can be imported or kept for trade be developed and enforced, choosing only from among species that pose little risk of becoming established should they be released.

While the collection of freshwater fishes for the ornamental fish trade has diminished significantly in the course of the last decade, it needs to be recognized that such collection does impact also on non-target species, especially as it occurs largely in habitats in which there is no food fishery (and therefore no other harvesting). In the interest of sustainability therefore, the industry should be encouraged, through appropriate incentives and regulation, to shift entirely from collection to culture. While the ornamental fish industry poses threats as detailed above, it also presents a unique opportunity through its capacity for *ex situ* conservation. The industry possesses important knowledge and technology for breeding fishes, and has already engaged in conservation programmes for three threatened species, *Puntius bandula, P. srilankensis* and *Devario pathirana* (A. Pathirana, pers. comm.). Engagement with the industry, and commissioning competent institutions and individuals within it to undertake the sustainable and scientific maintenance of captive freshwater fish populations could prove to be the only strategy whereby future fish extinctions could be averted. The development of ex situ conservation strategy requires however, that an unfortunate oversight in Section 49A of the Fauna and Flora Protection Ordinance, which prohibits the keeping of animals (including fish), be revised.

It is important to emphasise here that extreme care must be taken in releasing fishes (or any organism), even in the course of conservation practice. The release of fishes from the Kelani Basin into the Mahaweli Basin has already been commented on (see Pethiyagoda, 1991: 36); similar releases should be discouraged in the future except perhaps in extreme circumstances, such as preventing an otherwise inevitable extinction. A practice has also evolved where animals confiscated by customs or wildlife authorities are released into natural habitats. While the ethics behind this are clear, the ecological consequences are potentially serious. A process for the safe disposal of such animals needs to be developed: e.g., they should be destroyed or maintained in captivity *in perpetuo,* e.g., in the National Zoological Gardens.

Hydrological alterations: Compared with invasive species, other impacts on Sri Lanka's freshwater fishes appear less important though not negligible. Sri Lanka has no natural lakes or perennial lentic habitats. In the course of the past two millennia however, widespread hydrological alterations have taken place, mainly in the construction of lowland impoundments, giving rise to thousands of reservoirs. The Accelerated Mahaweli Development Project between 1978 and 1988 resulted in the creation for the first time of several large highland reservoirs, and also perhaps more importantly, in a trans-basin diversion. The impacts of these historical hydrological alterations on fish faunas, while widely speculated on in the popular media, have never been objectively assessed; no direct negative impacts are known.

Degradation of habitats. Pollution of waterways by urban and industrial refuse has had local impacts in some areas, while silt deposition resulting from poor agricultural practices on highland slopes has had much more widespread effects (Hewawasam et al., 2003). Pesticides and agricultural chemicals too, pose a risk, especially as the regulatory process for their approval addresses only health, and not environmental, risks (Anon., 1980). Although Sri Lanka has experienced extensive deforestation, there is as yet no evidence that this, or the land use change that usually accompanies it, has directly impacted on freshwater fishes except where riparian shade has been lost (e.g. Helfman, 1981).

Fishes and other aquatic organisms need to be treated separately from other groups for conservation purposes. Protected areas provide only marginal overlap with aquatic ecosystems, and very few of Sri Lanka's many "point endemic" fishes (e.g., *Puntius bandula, P. srilankensis, Devario pathirana*) occurs in a protected area. Species-protection too, does not work well for these organisms because they are seldom targeted for exploitation. Their conservation therefore depends largely on beneficial engagement by civil society, especially local communities. Unfortunately, no provision exists in Sri Lanka's essentially protectionist legal framework to facilitate conservation, especially interventional management, and this deficiency needs to be addressed in future reforms.

Recommended conservation actions

1. A conservation assessment of the freshwater fauna is overdue, but for most species up to date information on populations and trends simply does not exist to facilitate one. A comprehensive assessment of the populations of all freshwater fish species based on fresh sampling is therefore an urgent necessity.
2. While fisheries managers maintain detailed catch records at several stations in Sri Lanka, taxonomic data are not acquired. The maintenance of records of the catch of each species, especially the indigenous-species by-catch, could provide a means to make trend analyses that could inform future conservation decisions.
3. All pesticides approved for release in Sri Lanka should be assessed for impact on non-target organisms and the environment in general, and the labelling of such products should include information on environmental safeguards.
4. All future releases of exotic fishes should be preceded by an environmental impact assessment involving specific safeguards against invasiveness.
5. A positive list of organisms that may be imported by the ornamental fish industry needs to be developed and enforced. The necessary legal provisions for this already exist in the Fauna and Flora Protection Ordinance.

6. Legal and institutional reforms need to be made to engage local communities in the *in situ* conservation of point-endemic freshwater fishes; and to engage the ornamental fish industry in *ex situ* conservation, especially the development of methodologies to breed "difficult" threatened species (e.g. *Puntius asoka*) in captivity.
7. International agencies, particularly the FAO and ADB should be informed of the negative consequences of their fisheries development projects in Sri Lanka and urged to engage in supporting the research and capacity-building necessary to manage the fishery sustainably into the future.
8. Incentives and regulatory measures need to be introduced to phase out, over a defined time scale (say 2-3 years), the harvesting of fishes from the wild by the ornamental fishery, while encouraging the culture of such species as for which there is commercial demand.
9. Finally, although its consequences will have minimal conservation benefit at this stage, the Department of Wildlife Conservation should take steps to eradicate the last population of rainbow trout in Sri Lanka, in Horton Plains National Park, at least so as to demonstrate that it is alive to the risk alien species pose to the indigenous biodiversity of Sri Lanka.

Table 1: Current IUCN *Global Red List* of Sri Lankan freshwater fishes (IUCN, 2004) and *National Red List* (IUCN Sri Lanka, 2000). CR – Critically endangered; EN – Endangered; VU – Vulnerable; LR – Lower Risk, DD – Data deficient.

Species	**Global status**	**National status**
1. *Acanthocobitis urophthalmus*	LR/cd	Threatened
2. *Aplocheilus dayi*	–	Threatened
3. *Aplocheilus werneri*	–	Threatened
4. *Belontia signata*	LR/cd	Threatened
5. *Channa ara*	–	Threatened
6. *Channa orientalis*	–	Threatened
7. *Clarias brachysoma*	–	Threatened
8. *Danio aequipinnulus* [sic] *aequipinnatus*	DD	Highly Threatened
9. *Danio pathirana*	CR	Highly Threatened
10. *Esomus thermoicos*	–	Threatened
11. *Garra ceylonensis*	–	Threatened
12. *Garra phillipsi*	DD	Threatened
13. *Heteropneustes microps*	VU	–
14. *Horadandia atukoralei*	–	Threatened
15. *Labeo fisheri*	EN	Threatened
16. *Labeo lankae*	CR	Highly Threatened
17. *Lepidocephalichthys jonklaasi*	EN	Threatened
18. *Macrognathus aral*	DD	Highly Threatened
19. *Malpulutta kretseri*	LR/cd	Threatened
20. *Microphis brachyurus*	–	Threatened
21. *Monopterus desilvai*	–	Highly Threatened
22. *Ophisternon bengalense*	–	Threatened
23. *Puntius asoka*	EN	Highly Threatened
24. *Puntius bandula*	CR	Highly Threatened

25. *Puntius cumingii*	LR/cd	Threatened
26. *Puntius martenstyni*	EN	Highly Threatened
27. *Puntius nigrofasciatus*	LR/cd	Threatened
28. *Puntius pleurotaenia*	LR/cd	Threatened
29. *Puntius srilankensis*	–	Threatened
30. *Puntius ticto*	–	Threatened
31. *Puntius titteya*	LR/cd	Highly Threatened
32. *Rasbora vaterifloris*	LR/cd	Threatened
33. *Rasbora wilpita*	EN	Threatened
34. *Schismatogobius deraniyagalai*	DD	Threatened
35. *Schistura notostigma*		Threatened
36. *Sicyopterus griseus*		Threatened
37. *Sicyopterus halei*	DD	Threatened
38. *Sicyopus jonklaasi*	DD	Threatened
39. *Stiphodon martenstyni*	–	Highly Threatened
40. *Xenentodon cancila*	–	Threatened

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Appendix 1: Provisional Checklist of Freshwater Fishes of Sri Lanka

(Note: Exotic species have been omitted. The use of “sp.” does not imply that the species is new: only that without further research, a name cannot reliably be assigned to it. ‘**E**’ refers to endemic species, it being noted that the diadromous sicydiine gobies are unlikely to be truly endemic.)

FAMILY: ANGUILLIDAE

1. *Anguilla nebulosa*
2. *Anguilla bicolour*

FAMILY: CYPRINIDAE

3. *Amblypharyngodon melettinus*
4. *Amblypharyngodon grandisquammis*[E]
5. *Chela ceylonensis*[E]
6. *Chela* sp. 1[E]
7. *Chela* sp. 2[E]
8. *Devario malabaricus*
9. *Devario pathirana*[E]
10. *Devario* sp.[E]
11. *Esomus thermoicos*[E]
12. *Garra ceylonensis*[E]
13. *Garra* sp.[E]
14. *Rasboroides atukorali*
15. *Rasboroides vaterifloris*[E]
16. *Labeo dussumieri*
17. *Labeo fisheri*[E]
18. *Labeo lankae*[E]
19. *Puntius asoka*[E]
20. *Puntius bandula*[E]
21. *Puntius bimaculatus*
22. *Puntius chola*
23. *Puntius cumingii*[E]
24. *Puntius dorsalis*
25. *Puntius martenstyni*[E]
26. *Puntius nigrofasciatus*[E]
27. *Puntius pleurotaenia*[E]
28. *Puntius sarana*[E]
29. *Puntius singhala*[E]
30. *Puntius srilankensis*[E]
31. *Puntius titteya*[E]
32. *Puntius vittatus*
33. *Puntius* sp. 1[E]
34. *Puntius* sp. 2[E]
35. *Puntius* sp. 3[E]
36. *Puntius* sp. 4[E]
37. *Puntius* sp. 5[E]
38. *Rasbora caverii*
39. *Rasbora daniconius*

40. *Rasbora wilpita*[E]
41. *Tor khudree*

Family: Balitoridae
42. *Acanthocobitis urophthalmus*[E]
43. *Schistura notostigma*[E]

Family: Cobitidae
44. *Lepidocephalichthys jonklaasi*[E]
45. *Lepidocephalichthys thermalis*

Family: Bagridae
46. *Mystus gulio*
47. *Mystus cavasius*
48. *Mystus vittatus*
49. *Mystus* sp.[E]

Family: Siluridae
50. *Ompok bimaculatus*
51. *Wallago attu*

Family: Clariidae
52. *Clarias brachysoma*[E]

Family: Heteropneustidae
53. *Heteropneustes fossilis*

Family: Adrianichthyidae
54. *Oryzias* sp. 1[E]
55. *Oryzias* sp. 2[E]

Family: Synbranchidae
56. *Ophisternon bengalense*
57. *Ophisternon desilvai*[E]

Family: Aplocheilidae
58. *Aplocheilus dayi*[E]
59. *Aplocheilus parvus*
60. *Aplocheilus werneri*[E]

Family: Cichlidae
61. *Etroplus maculatus*
62. *Etroplus suratensis*

Family: Anabantidae
63. *Anabas testudineus*

Family: Belontiidae

64. *Belontia signata*[E]
65. *Malpulutta kretseri*[E]
66. *Pseudosphromenus cupanus*

Family: Channidae

67. *Channa ara*[E]
68. *Channa gachua*
69. *Channa orientalis*[E]
70. *Channa punctata*
71. *Channa striata*

Family: Mastacembelidae

72. *Macrognathus* cf. *aral*
73. *Mastacembelus armatus*

Family: Gobiidae

74. *Awaous melanocephalus*
75. *Oligolepis acutipinnis*
76. *Sicyopterus griseus*
77. *Sicyopterus halei*
78. *Sicyopus jonklaasi*[E]
79. *Stenogobius malabaricus*
80. *Stiphodon martenstyni*[E]
81. *Schismatogobius deraniyagalai*
82. *Glossogobius giuris*

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Some Aspects of Ecology of Endemic Freshwater Fishes of Sri Lanka

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Abstract

Sri Lanka supports a diverse freshwater fishes, about 48% of which are endemic. Most of these endemic freshwater fish species occur in the hill country forested streams of the wet zone. There are sophisticated interactions between fish species in a fish community and its environment for food, space and/or spawning. As evident from the biology of cyprinids in hill streams in Sri Lanka, most of the endemic freshwater fish species tend to show well-defined niche segregation and ecological adaptations. Several anthropogenic activites such as deforestation, gem mining and uncontrolled use of agrochemicals, pose significant threats to survival of many endemic freshwater fish species in Sri Lanka. Exploitation of endemic fish species from the wild for ornamental fish trade is also a major cause of decline of their populations. Further, accidental introduction of clown knife fish *(Chitala ornatus)* and cleaner fish *(Ptrygoplichthys multiradiatus),* which poses threats to diversity of freshwater fishes in Sri Lanka, is an indirect adverse effect of ornamental fish trade. Although some introductions of exotic fish species such as African cichlids, most notably *Oreochromis mossambicus* and *O. niloticus*, have socio-economic benefits, effective strategies should be implemented to control transfer and introduction of aquatic organisms.

Key words: *Endemic fish, Ecology, Distribution*

Introduction

As mentioned by Greenwood (1992), fishes, no less than other organisms, are threatened by numerous human activities, but because fishes are less obvious than terrestrial life they are often overlooked, as is their role in global ecology. Literature on riverine fisheries (Welcomme 1979) and tropical fish ecology (Lowe-McConnell 1987) highlights Africa and the Neotropics and contains relatively little about most Asian rivers except the Mekong river basin (Rainboth 1996) and southern India and Western Ghats (Kurup et al., 2004). However in tropical Asia, there are more than 105 families of freshwater fishes compared to 74 in Africa and only 60 in South America (Dudgeon 2000). Sri Lanka supports a diverse freshwater fishes, about 48% of which are endemic. However, as in many parts of the tropical Asia (oriental region), information on the ecology of freshwater fish species in rivers and streams in Sri Lanka is scanty and not well-synthesized. Nevertheless, such information is imperative in order to identify conservation status of individual species, especially due to the fact that a number of endemic freshwater fish species are reported to be threatened with extinction and that others are depleted due to various anthropogenic activities (Senanayake and Moyle 1982). Although it is a fact that endemic freshwater fish species and other co-occuring non-endemic fish species share the same ecological conditions, ecology of former needs to be emphasized in relation to conservation of endemic freshwater fish species in Sri Lanka. In this paper, information on ecology of endemic freshwater fish species is reviewed with a view to identifying major threats to them and future needs to generate information required for planning conservation strategies.

Distribution of endemic freshwater fish species in Sri Lanka

Senanayake and Moyle (1982) have suggested that based on the distribution pattern of freshwater fish species, three ichthyofaunal provinces could be identified in Sri Lanka. They are, (i) the Southwestern Province; (ii) the Mahaweli Province; and (iii) the Dry Zone Province. The Southwestern Province consists of the river basins from the Nilwala Ganga in the south and to the Attanagalu Oya in the north, with the border of the second peneplain forming the boundary in the east. The Mahaweli Province is essentially the drainage basin of the Mahaweli River. This province covers all three peneplains and the fish fauna in the first peneplain of this ichthyofaunal province is largely identical to that in the Dry Zone Province. The Dry Zone Province covers all parts of the first peneplain except the area in the wet zone climatic region. Out of the total of 62 freshwater fish species, at least 30 species are endemic to Sri Lanka (Pethiyagoda 1991, 1994; Bailey and Gans 1998; Watson 1998; www.fishbase.org). List of endemic freshwater fish species in Sri Lanka and their occurrence in the three ichthyological provinces are presented in Table 1. The highest number of endemic freshwater fish species is found in the Southwestern ichthyological province. According to Pethiyagoda (1991), 25 out of 30 species (83.3%) occur in this province. In the Mahaweli ichthyological province 10 endemic species (33.3%) are found (Silva 1993). There are four endemic species in the Dry zone ichthyological province, which form only 13.3% of the total number of endemic freshwater fish species in Sri Lanka. However, the concept of ichthyological provinces in Sri Lanka is questionable when it is viewed on the basis of the comprehensive account by Pethiyagoda (1991) regarding distribution of freshwater fishes of Sri Lanka.

The taxonomy of the fishes of South Asia is however not very accurate (Kottelat 1989), hence it needs to be revised. Such revisions will undoubtedly increase the degree of endemism of freshwater fishes in Sri Lanka (Pethiyagoda 1994). For example, Pethiyagoda and Kottelat (2004) have shown that the cyprinid species, generally known as *Puntius filamentosus* (De Silva et al. 1981; Pethiyagoda 1991), is *P. singhala*, which is endemic to Sri Lanka. On the other hand, *Heteropneustes microps* is now considered as a junior synonym of *H. fossilis* (Pethiyagoda and Bahir 1998).

Table 1: List of endemic freshwater fish species in Sri Lanka and their occurrence in three ichthyofaunal provinces. SW – Southwestern ichthyofaunal province; M – Mahaweli ichthyofaunal province; D – Dry zone ichthyofaunal province (Senanayake and Moyle 1982). Occurrence of fish species in the three ichthyofaunal provinces was compiled on the basis of information given in Pethiyagoda (1991, 1994), Bailey and Gans (1998), Watson (1998) and www.fishbase.org.

Family	**Species**	**Ichthyofaunal Province**		
		SW	**M**	**D**
Belontiidae	*Belontia signata*	+	+	+
	Malpulutta kretseri	+		
Aplocheilidae	*Aplocheilus dayi*	+		
	Aplocheilus werneri	+		
Balitoridae	*Acanthocobitis urophthalmus*	+		
	Schistura notostigma	+	+	
Claridae	*Clarias brachysoma*	+	+	+
Cobitidae	*Lepidocephalichthys jonklaasi*	+		
Channidae	*Channa orientalis*	+		
Cyprinidae	*Danio (=Devario) pathirana*	+		
	Garra phillipsi		+	
	Garra ceylonensis	+	+	+
	Labeo fisheri		+	
	Labeo porcellus lankae			+
	Puntius asoka	+		

	Puntius bandula	+		
	Puntius cumingii	+		
	Puntius martenstyni		+	
	Puntius nigrofasciatus	+	+	
	Puntius pleurotaenia	+		
	Puntius srilankensis		+	
	Puntius titteya	+		
	Rasbora (=Rasboroides) vaterifloris	+		
	Rasbora wilpita	+		
Gobiidae	*Schismatogobius deraniyagalai*	+		
	Sicyopterus halei	+		
	Sicyopus jonklaasi	+		
	Stiphodon martenstyni	+		
Total	**30 species**	25	10	**04**
Percentages		83.3%	33.3%	**13.3%**

Endemic freshwater fish species and their ecology

As there are no natural lakes in Sri Lanka, all freshwater fish species indigenous to Sri Lanka are either riverine or marsh-dwelling species. Hence, endemic fish species occur in riverine habitats. It is known that the biology and ecology of riverine species, which complete their entire life cycle in riverine habitats, are closely linked with the annual hydrological regimes and flood patterns (Poff et al., 1997; Welcomme and Halls 2001). As mentioned by Kortmulder (1987), there are sophisticated interactions between fish species in a fish community and its environment. The interactions between species are for food, space and/or spawning. Any direct human influenece that works on this web of inter-relationships or through large disturbances such as erosion, pollution or climatic factors, are likely to have far-reaching and largely unpredictable effects (Kortmulder 1987). As such, better understanding of ecology of endemic fish species is necessary for planning conservation strategies for them.

Moyle and Senanayake (1984) have investigated resource partitioning among the fishes of small rainforest streams of Sri Lanka, which included 11 Cyprinidae, 2 Gobiidae, 2 Channidae, and one species each in the Cobitidae, Cyprinodontidae, Belontidae, Belonidae and Mastacembelidae. They have shown that although several species were habitat generalists, most species occurred in distinct habitats. Moyle and Senanayake (1984) have also shown that within the habitats of these fish communities, microhabitat overlap among co-occurring species was low, particularly in relation to position in the water column. They have also observed feeding specialization among the fish species co-occurring in rainforest streams in Sri Lanka. Based on a more detailed study however, the macro- and micro-habitats, and feeding habits of several *Barbus* species in Sri Lanka (Table 2; Kortmulder et al. 1990) indicate that habitat characteristics are common for most endemic and indigenous species. Wickramanayake and Moyle (1989) have suggested that fish assemblages in wet zone streams of Sri Lanka are co-evolved systems with competition serving as an important structuring force that reinforces species segregation.

Kortmulder (1987) has analyzed the altitudinal distribution of 11 *Puntius* species studied in Sri Lanka, beginning with headwaters and ending with brackishwater near the coast. The order of sequence was, *P. titteya, P. bimaculatus, P. pleurotaenia, P. nigrofasciatus, P. cumingii, P. dorsalis, P. filamentosus, P. vittatus, P. sarana, P. chola and P. amphibius.* The first five species in this list are endemic species which prefer higher altitudes.

Kortmulder (1987) further indicated that these *Puntius* species are distributed over a range of stream types. In the marshy brooks with relatively still water, *P. titteya* is found, while *P. bimaculatus* occurs in areas with strong currents. Also in rocky brooks with generally strong currents, only adult individuals of *P. bimaculatus* inhabit. Although they can withstand strong currents, they favour relatively quiet parts of the stream. In the irregular hill streams of the forested areas, *P. pleurotaenia* inhabits in deep parts with rapid flow, while *P. nigrofasciatus* inhabits in shallow areas of the stream with abated current. Kortmulder (1987) also mentioned that *P. cumingii* is found in deep pits of the lower courses of hill streams and torrents, with a relatively high current pattern. The latter species prefers these deep pits where there is a balance between the verge of current and non-current. According to Kortmulder (1987), endemic species did not occur in the lowland marshes and wet paddylands.

Table 2: Macro- and micro-habitats, feeding habits of some endemic freshwater fish species in Sri Lanka. Figures in column 3 indicate stream gradient (in %), depth (d. in cm) and width (w. in m) of the stream. (Adopted from Kortmulder et al.,1990).

Species	**Macro-distribution**		**Micro-distribution**		
	Altitude ranges	**Water bodies**	**Soils**	**Haunts**	**Feeding habits**
P. titteya	300-150 m	Marshy, slow-flowing streams, <0.5% 10-30 d., <1 w.mainly hill country	Red laterite, fine particulate and detrital	Mostly hidden, fallen leaves, overhanging vegetation	Picks or scrapes small items from bottom and vertical substrates; little moving about
P. nigrofasciatus	150-80 m	Clear, flowing rivulets, streams, 0.5%-2.5% 10-80 d., 0.5-10 w.hill country	Rocky or sandy	Sheltered relatively shallow areas where current is slow	Picks small items from bottom and vertical subs-trates, some from water column
P. pleurotaenia	150-10 m	Clear, flowing streams, rivers, 0.5-2.5% 80-300 d., 2-30 w.hill country	Sandy or rocky	Deep areas including pools and rapids, tolerates strong currents	Snaps foods from all substrates and water column, chops macrophytes
P. cumingii	100-60 m	Clear flowing rivulets and streams <0.5% 10-80 d., 2-20 w.boarder of hill country	Sandy	Near banks in pools with hanging tree roots; shallow channels; avoids strong currents	Like *P. nigrofasciatus*, slightly more water column

Many fishes in rivers and streams exhibit high seasonal feeding activity (Dudgeon 2000). However, no studies have been reported from Sri Lanka on the seasonal variation of feeding patterns in fishes of rivers and streams. Weliange and Amarasinghe (2003) have shown that in size-structured fish communities in three Sri Lankan reservoirs, feeding patterns vary seasonally. Many freshwater fishes in rivers and streams of Sri Lanka migrate within river systems and they are frequently associated with breeding (Silva and Davies 1986). Most fishes synchronize breeding activity with monsoon or flood season (De Silva et al. 1985). On the basis of the biology of cyprinids in hill streams in Sri Lanka (De Silva and Kortmulder 1977;

Kortmulder et al., 1978; De Silva et al. 1977, 1980; Kortmulder 1982), it can be seen that endemic species tend to show well-defined niche segregation and ecological adaptations as compared to indigenous species, which have come from the mainland. As such any form of habitat altration might pose threats to the existence of endemic freshwater fish species in Sri Lanka.

From the above review of literature, it is obvious that information on the ecology of endemic freshwater species is highly fragmented and restricted to a few river basins. Also, no comprehensive studies on these aspects have been reported for the last two decades. As such, it is imperative that further research on ecology of freshwater fish species be carried out in order to define effective strategies for conservation. This is of particular importance because it has been shown that the apparent biotic affinities between the Indian mainland and Sri Lanka, which have been hitherto interpreted as a result of frequent migrations of species during the recent periods of low water level, are due to limited biotic interchange between these areas (Bossuyt et al., 2004). As the endemism in Sri Lanka is much higher than hitherto suspected, Bossuyt et al. (2004) indicate that treating Western Ghats and Sri Lanka as a single biodiversity hotspot carries with it the danger of overlooking the strong biogeographic structure within this region.

Threats to diversity of endemic freshwater fish

Various authors have indicated a number of threats to endemic freshwater fish in the island. Dudgeon (2000) indicated that in Asian rivers and associated wetlands, anthropogenic influences imperil the biodiversity. According to him, the main threats include, (i) deforestation and drainage basin alteration that destroy or degrade instream and riparian habitats; (ii) river regulation, including flow modification and impoundment by dams, water extraction for irrigation etc.; (iii) pollution; and (iv) over-harvesting of fishes. In Sri Lanka too, decline of the native freshwater fish populations can be attributed to interaction of a number of factors, foremost of which are (i) deforestation; (ii) urbanization; (iii) river damming; (iv) gem mining; (v) improper use of pesticides; (vi) siltation and pollution; (vii) over-exploitation for ornamental fish trade; (viii) use of destructive fishing methods such as plant-derived poisons; and (ix) introduction of exotic species (Senanayake and Moyle 1982; Wijeyaratne 1993; Pethiyagoda 1994, 1998; Gunasekara 1996; Wijesekara and Yakupitiyage 2001).

Most of these factors are interrelated with each other. As such, habitat degradation due to these factors should be minimized through appropriate strategies in order to reduce threats to endemic freshwater fishes. Due to the changes in land-use patterns with increased human population, forest cover of Sri Lanka has reduced from 70% to about 22% of land area during the twentieth century (Anon. 1991). Deforestation, improper cultivation practices in upper catchment areas of drainage basins of rivers and gem mining cause heavy siltation in streams and rivers. Due to the loss of shade as a result of deforestation, some endangered endemic fish species such as *Lepidocephalichthys jonklaasi* and *Rasbora wilpita*, which prefer shaded habitats in forested areas (Pethiyagoda 1991) are adversely affected. Senanayake and Moyle (1982) have also shown that the abundance of endemic species, *P. pleurotaenia*, *P. nigrofasciatus* and *Acanthocobitis urophthalmus* in streams of Sri Lanka is correlated with the extent of riparian forest cover (shade). Many freshwater fish species of Sri Lanka, including endemic species such as *Danio (=Devario) pathirana*, *Garra phillipsi* and *Rasbora (=Rasboroides) vaterifloris* prefer habitats with unsilted clear water (Pethiyagoda 1991). Senanayake and Moyle (1982) have also identified siltation due to gem mining as a threatening factor for the survival of *B. signata*, *P. nigrofasciatus* and *Sicyopterus halei*. Pethiyagoda (1994) also showed that several endemic fish species such as *P. srilankensis, Labeo fisheri, R. vaterifloris* and *Malpulutta kretseri* are far less common in turbid water compared to clear water.

River damming is known to radically alter flood pattern. Fishes and other elements of lotic fauna are adapted to the flood patterns in rivers of tropical Asia. It has been reported that due to the damming of the Mahaweli river, *Labeo fisheri* was severely threatened (Senanayake and Moyle 1982). Smith and Jiffry (1986) have mentioned that due to the alteration of hydrological pattern in the flood plains of the Mahaweli river after construction of three major dams, reproductive biology of *Labeo dussumieri*, an indigenous species, had been adversely affected.

It is a fact that there is an increase in the use of pesticides and herbicides in Sri Lanka, which might pose a severe threat to aquatic biodiversity. However, due to lack of data, impact of these agrochemicals on freshwater fish populations is poorly understood.

It is well known that freshwater endemic fish species are caught from the wild for the aquarium trade (Evans 1981; Senanayake and Moyle 1982; Wijeyaratne 1993). Gunasekara (1996) has presented data on export quantities of five freshwater endemic species, based on the records of Sri Lanka Customs, Export Development Board, Department of Fisheries and Aquatic Resources, Board of Investment and information gathered from live fish exporters. Export quantities of five species of endemic freshwater fishes during 1994 are given in Table 3.

Table 3: Export quantities of five species of endemic freshwater fishes during four quarters in 1994 (Adopted from Gunasekara 1996).

Species	**1st Quarter**	**2nd Quarter**	**3rd Quarter**	**4th Quarter**
Puntius cumingii	46,800	15,000	8,770	9,750
P. nigrofasciatus	103,800	44,500	12,102	16,912
P. titteya	82,300	43,500	18,678	18,487
Belontia signata	43,100	14,500	7,331	10,390
Rasbora (=Rasboroides) vaterifloris	84,800	43,500	32,104	29,650
Total	**360,800**	**161,000**	**78,985**	**85,189**

Gunasekara (1996) has shown that a multinational company has exported three shipments of large quantities of five endemic fish species presented in Table 3 with much shorter time intervals than the time period required for captive breeding. He therefore suggested that it was virtually impossible to export such large volumes of endemic fish within short durations depending solely upon captive breeding. As such, most shipments of endemic freshwater fishes contain individuals caught from the wild. Gunasekara (1996) also indicated that the death rate of endemic fish reported at the air cargo terminal in Katunayake was 10-30% so that higher numbers are transported to the air cargo terminat in order to compensate for dead animals. On the other hand, captive breeding of most endemic freshwater species is possible (Chandrasoma et al. 1993; Kithsiri et al. 2003) and as such, strict regulations should be imposed in order to change the existing system of wild collection of freshwater fish species to captive breeding in the ornamental fish export industry. Unfortunately, the export trade of several nationally threatened fish species are not currently restricted and/ or regulated by the Fisheries and Aquatic Resources Act No. 2 of 1996 (see Table 4 for details).

Table 4: Fish species included in the IUCN red data list of 1999 and those protected under the Fisheries and Aquatic Resources Act No. 2 of 1996 (Source: Wijesekara and Yakupitiyage 2001; Ekaratne et al. 2003). HT – Highly threatened; TR – Threatened; (VU) – Vulnerable according to IUCN Global Red List.

Family/Species	**IUCN Red Data List of 1999**	**Fisheries and Aquatic Resources Act No. 2 of 1996**
Family: Cyprinidae		
Danio aequipinnatus	HT	No export restriction
Danio pathirana	HT	Export restricted
Esomus thermoicos	TR	No export restriction
Garra ceylonensis	TR	No export restriction
Garra phillipsi	TR	No export restriction
Horadandia atukorali	TR	No export restriction

Labeo fisheri	TR	Export prohibited
Labeo lankae	HT	Export prohibited
Puntius asoka	HT	Export prohibited
Puntius bandula	HT	Export prohibited
Puntius cumingii	TR	Export restricted
Puntius matenstyni	HT	Export prohibited
Puntius nigrofasciatus	TR	Export restricted
Puntius pleurotaenia	TR	No export restriction
Puntius srilankensis	TR	Export prohibited
Puntius ticto	TR	No export restriction
Puntius titteya	HT	Export restricted
Rasbora vaterifloris	TR	Export prohibited
Rasbora wilpita	TR	Export prohibited
Family: Cobitidae		
Lepidocephalichthys jonklaasi	TR	Export prohibited
Family: Balitoridae		
Acanthocobitis urophthalmus	TR	No export restriction
Schistura notostigma	TR	No export restriction
Family: Clariidae		
Clarias brachysoma	TR	Export restricted
Family: Heteropneustidae		
Heteropneustes microps (= H. fossilis)	(VU)	No export restriction
Family: Beloniidae		
Xenentodon cancila	TR	No export restriction
Family: Aplocheilidae		
Aplocheilus dayi	TR	No export restriction
Aplocheilus werneri	TR	No export restriction
Family: Synbranchiformes		
Monopterus desilvai	HT	No export restriction
Family: Gobiidae		
Schismatogobius deraniyagalai	TR	Export prohibited
Sicyopterus griseus	TR	No export restriction
Sicyopterus halei	TR	Export prohibited
Sicyopus jonklaasi	TR	Export prohibited
Stiphodon martenstyni	HT	No export restriction
Family: Belontiidae		
Belontia signata	TR	Export restricted
Malpulutta kretseri	TR	Export prohibited
Family: Mastecembelidae		
Macrognathus aral	HT	Export restricted
Family: Channidae		
Channa ara	TR	No export restriction
Channa orientalis	TR	Export prohibited

As mentioned earlier, information on the ecology of freshwater fish species in rivers and streams in Sri Lanka is scanty and not well-synthesized. Hence, most of the development plans are based on such incomplete information, which might adversely affect on aquatic biodiversity. For example, in Kukule Ganga hydropower project area in the Kalu Ganga river basin, *R. vaterifloris,* a nationally threatened species (IUCN 2000), was found prior to commencement of the project activities (Shirantha 2004). However, in the Environmental Impact Assessment (EIA) report of this hydropower project, this species has not been listed. The EIA report indicates that many of the endemic fish species such as *P. nigrofasciatus* and *P. titteya* found in the project area are also found in other river basins of the wet zone. However, as this EIA report was based on incomplete information on the distribution and abundance of endemic freshwater fish species, no mitigatory measures have been proposed to sustain the populations of the threatened fish species such as *R. vaterifloris.*

Do exotic species adversely affect endemic species?

Introduced African cichlids (*Oreochromis mossambicus, O. niloticus* and *Tilapia rendalli*) are ubiquitous in Sri Lankan reservoirs and support profitable fisheries. These species are essentially limnophilic fishes (Fryer and Iles 1972) so that when present in rivers and streams, they occur only in non-flowing parts. The Tilapia *(O. mossambicus)* is found in restricted areas of Debegama stream in Kelani river basin (Atalugama in Kagalle district) and Attanagalu Oya in Waharaka (Hettiarachchi, 2005), Dehiovita and Atulugama in the Kelani river basin and Kuruwita in the Kalu Ganga river basin (Fernando et al. 2002). Fernando et al. (2002) reported that during 278 fish collecting field visits in the Kelani river basin, 66 specimens of *O. mossambicus* were caught near a rubber estate in the village Dehiovita, that only 4 specimens of *O. mossambicus* were caught in the Kalu river basin during 240 fishing trials with cast nets and scoop nets and that they were escapees from fishponds close to the sampling sites in the two river basins. Fernando et al. (2002) also mentioned that during the fish collecting field visits to three other river basins of Sri Lanka (Gin Ganga – 42; Polwathu Oya – 44; Nilwala Ganga – 47) using electrofishing and cast netting, none of the exotic tilapia species was caught.

The indigenous riverine species have colonized artificial lacustrine habitats (tanks and reservoirs) as feeding grounds. Most endemic freshwater fish species such as *P. nigrofasciatus*, *P. cumingii, P. titteya* and *R. vaterifloris* are not found in reservoirs where tilapias are abundant, but occur in the streams and rivers in the central hill areas of Sri Lanka (Pethiyagoda 1991). As such, it is unlikely that introduced O. mossambicus may pose threats to endemic freshwater fish species in Sri Lanka. No published data are yet available on the temporal variation of the co-occurring pupulations of endemic fish species and exotic tilapias in order to come to a definite conclusion on the impact of exotic tilapias on endemic fish species in Sri Lanka.

However, accidental introduction of two exotic fish species (Clown Knife Fish - *Chitala ornatus* and Tank Cleaner - *Ptrygoplichthys multiradiatus*) has been reported recently. *Chitala ornatus,* which was first reported in Diyawanna Oya in 1994 (Gunawardane 2002), is widespread in streams and reservoirs in the wet zone of Sri Lanka (e.g., Diyawanna Oya, Panape Ela in Mellana (Horana), Wevita Wewa in Bandaragama, Weres Ganga in Moratuwa, Godangoda and Mathugama) (Mr. Jagath Gunawardena, pers. comm.; R.R.A.R.S., pers. obs.). The water bodies of the wet zone invaded by *Chitala ornatus* and *Ptrygoplichthys multiradiatus,* are known to harbour endemic fish species such as *Aplochielus dayi, Puntius nigrofasciatus, P. titteya, Belontia signata, Channa orientalis, Garra ceylonensis, Malpulutta kretseri, Micropterus desilvai, R. vaterifloris, Schistura notostigma* and *Sicyopus jonklaasi* (Mr. H.G.S. Maduranga, pers. comm.). *Chitala ornatus* is known to be a voracious piscivore. *Ptrygoplichthys multiradiatus* is found in Polgolla reservoir (Sumanasinghe, 2005), hence there is a possibility to expand its range of occurrence in the Mahaweli river basin. The scraping feeding habit of this species could change habitat/substrate quality, leading to detrimental effects on co-occuring species. Gunawardane (2002) mentioned that due to the increase in numbers of *C. ornatus,* abundance of several small, surface-dwelling fish species has decreased. According to Gunawardane (2002), since introduction of *C. ornatus* in 1994, decrease in abundance of *Aplochielus dayi*, *A. parvus*, *Horadandiya athukorali*, *P. vittatus*, *P. bimaculatus*, *R. daniconius* and *Amblypharyngodon melettinus* has taken place. These two alien invasive species have been introduced to Sri Lankan freshwaters accidentally through ornamental fish industry.

Conclusion

It is well understood that the endemic status of the species is primarily as a result of geographical isolation. As evident from the biology of cyprinids in hill streams in Sri Lanka (De Silva and Kortmulder 1977; De Silva et al. 1977, 1980; Kortmulder 1982), most of the endemic freshwater fish species in Sri Lanka tend to show well-defined niche segregation and ecological adaptations. As such, any form of habitat alteration might be detrimental to the existence of endemic fish species. Despite this, several anthropogenic activites such as deforestation, gem mining and uncontrolled use of agrochemicals, pose significant threats to survival of many endemic freshwater fish species in Sri Lanka. Exploitation of endemic fish species from the wild for ornametal fish trade is a major cause of decline of their populations. Accidental introduction of clown knife fish *(C. ornatus)* and cleaner fish *(P. multiradiatus),* which poses threats to biodiversity of freshwater fishes in Sri Lanka, is also an indirect adverse effect of ornamental fish trade. Although some introductions of exotic fish species such as African cichlids, most notably *Oreochromis mossambicus* and *O. niloticus*, have socio-economic benefits and do not pose any significant threats to freshwater fish biodiversity in Sri Lanka (Fernando et al. 2002), effective strategies should be implemented to control transfer and introduction of aquatic organisms. Wijeyaratne (1993) has shown that most of the endangered and vulnerable freshwater fish species (73%) occur only in lotic habitats. Most endemic freshwater fish species in Sri Lanka prefer forested streams in higher altitudes. As such, conservation and management of not only the aquatic habitats but also the associated terrestrial habitats such as riparian vegetation, land-use patterns of catchment areas of streams and rivers, especially in the higher altitudes of the country, should be part of the overall strategy for conservation of endemic freshwater fish species in Sri Lanka. There is little compatibility between conservation and legal status in Sri Lanka as regards to export of endemic freshwater fish species (Ekaratne et al. 2002). As Wijeyaratne (1993) has shown, conservation status of endemic freshwater fish species changes with time. Hence, legal framework pertaining to their conservation needs to be revised from time to time based on the prevailing conservation status of species. An effective means for rapid assessment of conservation status is therefore necessary for the endemic freshwater fish species in Sri Lanka. Scanty and incomplete information on the ecology of endemic freshwater fish species is of little use for the decision making process in the approval of development project proposals. A complete revision of the taxonomy of freshwater fish in Sri Lanka is a timely need.

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Sri Lankan Amphibians: Diversity, Uniqueness and Conservation

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Abstract

A recent acceleration of amphibian research in Sri Lanka has resulted in the discovery of more than 100 new species, with descriptions of 102 valid amphibian species been published up to now. A significant finding of research spanning the past decade is a unique endemic radiation among direct developing tree frogs belonging to the genus *Philautus* in Sri Lanka. The paper discusses conservation issues related to the amphibians in the island, and highlights research needs to facilitate their conservation.

Key words: *Amphibians, Taxonomy, Conservation, Research*

Introduction

Knowledge of Sri Lanka's amphibians has, during the past decade, increased rapidly. The first review of this fauna, Kirtisinghe (1957) recognized 35 species-group taxa. This figure was increased to 53 species by Dutta & Manamendra-Arachchi (1996), based on examination of museum materials and also a field survey that commenced in 1993. Based on this field survey, Pethiyagoda & Manamendra-Arachchi (1998) suggested that Sri Lanka's amphibian fauna might comprise of as many as 250 species, a figure revised to ~140 species by Meegaskumbura et al. (2002). As at now, descriptions of 102 valid amphibian species have been published (Manamendra-Arachchi & Pethiyagoda, 2005; Meegaskumbura & Manamendra-Arachchi, 2005), and a single species of caecilian remains identified but not yet described: see Table 1. A total of 94 species have been treated under the Global Amphibian Assessment (Stuart et al., 2004; www.globalamphibians.org), of which 79 (i.e. 84%) species are—or were—endemic to Sri Lanka. Several further species remain to be described.

The recent acceleration of research, both in southern India (e.g. Biju, 2001; Biju & Bossuyt, 2003) and Sri Lanka has resulted in a complete re-evaluation of the Amphibia of this region. Rarely has so much effort, across so many disciplines, been invested in the investigation of a fauna as has been done for the Amphibia of Sri Lanka. Manamendra-Arachchi & Pethiyagoda (2005) examined all the Sri Lankan type material and almost all the other preserved material, in museums in Europe, the U.S.A. and India, alongside extensive field surveys, in a project initiated by the Department of Wildlife Conservation in 1998. This facilitated the re-discovery of several species that had otherwise been known only from type specimens collected in the 19th century, and also provided data for conservation assessments to be made.

At the same time, several workers undertook molecular analyses to attempt resolution of interesting questions. Bossuyt et al. (2000) showed that the family Rhacophoridae (the tree frogs) contained more than one evolutionary lineage, and demonstrated that the striking morphological and reproductive resemblances between Madagascan and Asian tree frogs (such as direct-developing larvae that bypass the "conventional" tadpole stage) is the result of evolutionary convergence and not common ancestry. Meegaskumbura et al. (2002) confirmed that the Sri Lankan direct-developing rhacophorids all belong to a single genus, *Philautus,* and not several other genera such as *Theloderma* and *Rhacophorus,* which do not occur in the island. Another smaller group of rhacophorids, all but one endemic, are represented by five species of *Polypedates,* which build foam nests. Meegaskumbura et al. (2002) also showed that the Sri Lankan *Philautus* represent a large, endemic insular radiation, having evolved in the island from ancient ancestral populations.

While they demonstrate also that a few species had back-migrated to India, Bossuyt et al. (2004) show conclusively that the Sri Lankan *Philautus* have long been isolated from the Indian group, with no biotic exchange having taken place between the island and the mainland in the past ~ 500,000 years. This result is surprising as Sri Lanka has experienced prolonged terrestrial connections with India during the sea-level low-stands that accompany glacial maxima. For example, the most recent Ice Age resulted in sea levels that were ~ 120 m lower than today, and a ~ 140 km-wide land connection across what is now the Palk Strait. The reasons for this "land bridge" not serving as a medium for biotic exchange between the two land masses are not yet clearly understood, especially as Pleistocene climate is not well known at the local level (Pant & Rupa Kumar, 1997), both drier (Prematihilake & Risberg, 2003) and wetter (Ashton & Gunatilleke, 1987) climates having been postulated.

The presence in Sri Lanka of ancient lineages of amphibians was demonstrated also by Roelants et al. (2004), who showed that the endemic genus *Lankanectes* diverged from the mainstream of Ranidae before the India-Sri Lanka plate separated from the Madagascar plate, in the Upper Cretaceous. This species may in the future be classified as a monotypic family, beside some equally unique montane frog clades from southern India. Indeed, a new family of frogs was described from the same region by Biju & Bossuyt (2003), the first new amphibian family to be discovered worldwide in 75 years.

Sri Lanka's Amphibia then, are important not just for their species richness, but also for their representation of ancient lineages. Several species have been diagnosed but remain to be described (Meegaskumbura & Manamendra-Arachchi, in prep.). Others are known from molecular analyses (e.g. Gower et al., 2005) and await formal description.

While work on exploration, taxonomy and systematics has been progressing, little indeed is known of the biology of the Sri Lankan Amphibia. This appears paradoxical given that one of the world's best-studied amphibians is a Sri Lankan endemic. *Ichthyophis glutinosus* was the first species of amphibian to be described from Sri Lanka, by Seba (1735). Sarasin & Sarasin's (1887–1890) study of this species remains fundamental not just to the study of caecilians, but to embryology itself (Gower et al., 2005), while Plate's (1922–1931) study of its histology has not been improved on. Since then, apart from Kirtisinghe's (1946) casual observation of direct development in a species of Sri Lankan *Philautus,* little has been added, e.g. to knowledge of ecology, ethology and reproduction in this group of animals.

Recently, Bahir et al. (2005) reported in detail reproduction and development in 17 species of *Philautus* and Wickramasinghe et al. (2004) have summarized larval biology and life history in *Nannophrys ceylonensis*. However, large gaps remain in our knowledge of the natural history of other species of Sri Lankan amphibians. Breeding has not been observed in *Lankanectes corrugata* or *Nannophrys marmorata*, both of which represent endemic genera. Such observations could be crucial to future captive breeding projects, should populations of these species crash (the latter species is presently categorized as Critically Endangered in the IUCN Red List).

Conservation

The Global Amphibian Assessment (www.globalamphibians.org ; see also Stuart et al., 2004;) evaluated all 5,743 species of amphibians described and considered valid world-wide. Of these, 94 (i.e. 1.64%) are from Sri Lanka. While this is not a record amongst the biodiversity-rich countries of the world, the GAA analysis does award to this island a dismal record of failure: 19 of the 34 species of amphibians confirmed as extinct worldwide in the past 500 years are from Sri Lanka. These comprise of 17 species of *Philautus*, and one species each of the endemic genera *Adenomus* and *Nannophrys.* Three further apparently extinct species of *Philautus* are known from 19th century museum collections (Manamendra-Arachchi et al., work in progress).

A broad-based multi-stakeholder assessment of the amphibian fauna, together with the results of the WHT amphibian survey of 1993–, concluded that 63 (67%) of the 94 species then recognized are Threatened with extinction. In addition to the 19 extinct species, 11 species were evaluated as Critically Endangered, 28 as Endangered and 5 as Vulnerable. Sri Lanka's Amphibia are in trouble and little is being done about it.

The conservation of a sensitive fauna that is not victim to targeted exploitation, such as the Sri Lankan amphibians, is a challenge in the extreme. What are the threats? Habitat loss is the first cause to be implicated by most workers. The vast majority of the Sri Lankan amphibians are restricted to the south-western wet zone quarter of the island (Dutta & Manamendra-Arachchi, 1996) and more than 95% of the original forest cover has now vanished. Only ~ 800 km^2 of relatively undisturbed forest now remain in the wet zone, and even this is severely fragmented. Three fragments (Knuckles, Sinharaja, Peak Wilderness) account for half this estate: the balance 400 km^2 are contained in > 100 fragments of varying size, many of which exist only on maps. Clearly, fragmentation is a threat, and needs to be addressed through the active management of habitat quality at key sites, and through the establishment of habitat corridors between them.

Fragmentation per se, is however, unlikely to be the only significant threat. Pesticide use in Sri Lanka is still to be regulated: the Pesticides Control Act (Anon., 1980) addresses only threats to human health and not environmental health or impact on non-target organisms. Taken together with massive erosion from sloping lands (Hewawasam et al., 2003), aquatic ecosystems in general are gravely at risk, and these risks remain unassessed.

Air pollution too, is yet to be assessed in Sri Lanka except in the context of human health in urban areas. Acid rain and mist has been implicated in montane forest dieback (now widespread in key amphibian habitats including Horton Plains and Knuckles) in many other countries. The single report there has been of this phenomenon in Sri Lanka (Gunawardena et al., 1998), has largely been ignored by the conservation establishment.

While threats to amphibians such as the above are self-evident, the causes for the extreme rarity of many species are as yet not fully understood. In a phase during which new species continue to be discovered, it could be argued that a discussion of either rarity or extinction is inappropriate, and that rare and even "extinct" species could be discovered with further exploration. However, given the record of exploration of the last decade, Sri Lanka is now one of the better-explored countries with respect to amphibians. It is necessary to explain then, how it is that so many species are known from just one or a handful of specimens, albeit from relatively good-quality forest (Manamendra-Arachchi & Pethiyagoda, 2005).

Amphibian species may be under-sampled in surveys because their populations are in any case small, or because individuals are otherwise difficult to locate (e.g. cryptic coloration; small size; restriction to arboreal or canopy habitats; lacking prominent vocalisation in males). The population declines observed in many parts of the world (see www.globalamphibians.org) have as yet not been observed in Sri Lanka, but this could be because no populations have been monitored over sufficiently long periods of time. Such monitoring is now in place, but only at a single site (Agra-Bopath Forest Reserve, a montane cloud forest habitat, the surrounding anthropogenic habitats and a regenerating forest patch). It is imperative that monitoring be carried out, at least in major bio-geo-climatic zones and prominent habitats within these zones. In addition to monitoring populations, it is necessary also to acquire data on parameters known to pose threats to amphibians, such as UV-B radiation, water quality, climatic variation, and infection by known pathogens such as the oomycete, *Saprolegnia ferax* (Kiesecker et al., 2001) and the chytrid fungus *Batrachochytrium dendrobatidis* (Blaustein et al., 1994; Pounds et al., 2006).

Only in a single case has it been possible to obtain quantitative information on range shrinkage of an amphibian species in Sri Lanka, that of the torrent toad *Adenomus dasi*. Discovered only in 1997, this species is known from only a single location, the forest surrounding the Fishing Hut at Rajamally in Moray Estate, Maskeliya (Manamendra-Arachchi & Pethiyagoda, 1998). Even here, it is rare, though tadpoles have been seen in the stream that descends from the Peak Wilderness forest. *Adenomus* dasi is, however, well represented from 19th century museum collections made from around Nuwara Eliya ~ 30 km distant, from which its present locality is separated by the Dimbula Valley. Its representation in museum collections suggests that it was both widely distributed and abundant up to the 1880s. The species appears to be dependent on clear, unpolluted high altitude (> 1,300 m) streams: it has not been recorded, however from Horton Plains, in which the Belihul Oya is possibly the only unpolluted high altitude stream remaining in the island. At Rajamally, both adults and tadpoles were observed to be mostly aquatic. Ranked as Critically Endangered, *A. dasi* is clearly in need of conservation attention, and it would be a challenge to see it successfully reintroduced to its former habitat in Nuwara Eliya.

How could such a feat be achieved?

Research needs

Before research needs could be listed, it is necessary to note that research in general is discouraged by the regulatory framework that has evolved subsequent to the illusion of sovereign ownership of biodiversity that the Convention on Biological Diversity thrust on biodiversity-rich developing nations (Pethiyagoda, 2004). While keeping and breeding amphibians as a hobby is commonplace in much of the developed world, it is both illegal and unfashionable in Sri Lanka. Two consequences of this are a lack of popular empathy with amphibians (which are, by and large, treated with revulsion); and a lack of human resources skilled and interested in managing captive populations.

Captive breeding and reintroduction are clearly actions of last resort, but given a track record of 19 extinctions and a further 11 Critically Endangered, it is one that needs to be considered at least for some Sri Lankan species. Taking *A. dasi* as an example, the starting point would be the accumulation of local climatic and water quality data, together with *in situ* observations of activity patterns, diet, resource utilization, breeding behaviour and larval development, together with an assessment of threats at each life-history stage. Such a programme would also need examine possible *in situ* options, such as improved upstream water-quality management; the maintenance of riparian vegetation. With these data in hand, an informed judgement could be made with regard to restoring degraded former habitats of the species with a view to reintroduction within a rigorous monitoring regime. Even if *ex situ* measures were not to be implemented immediately, the importance of developing the methodologies for this cannot be over-emphasized. For example, the work of Bahir et al. (2005) has bestowed captive breeding potential for all seven Critically Endangered Sri Lankan *Philautus* species, a process that may otherwise have involved a lead-time of several years.

The keys provided by Dutta & Manamendra-Arachchi (1996); Manamendra-Arachchi & Pethiyagoda (2004) and Meegaskumbura & Manamendra-Arachchi (2005) facilitate the identification of all currently known Sri Lankan amphibians. With names and diagnoses available for these species, reliable work could commence on assessing populations, habitat requirements and distributions with a view to improving conservation practices. By offering only protection, the present regulatory framework discourages engagement with this fauna by scientists and interested citizens. The threats to amphibians in Sri Lanka however, will persist regardless of how effectively they are protected. The need of the hour is science-based conservation that seeks to address threats such as environmental pollution, climate change and habitat degradation.

Table 1: Provisional checklist of the amphibian species of Sri Lanka as at 1 Jan. 2006, giving also conservation as determined by the Global Amphibian Assessment (Stuart et al., 2004; www.globalamphibians.org). Where the conservation status has not yet been formally included in the IUCN Red List, the recommended status is represented by 'E' for endangered and 'V' for vulnerable.

Taxon	Endemicity	Conservation status
Bufonidae (8)		
Adenomus dasi Manamendra-Arachchi & Pethiyagoda, 1998	Endemic	Critically Endangered
Adenomus kandianus (Günther, 1872)	Endemic	Extinct
Adenomus kelaartii (Günther, 1858)	Endemic	Endangered
Bufo atukoralei Bogert & Senanayake, 1966	Endemic	Least Concern
Bufo kotagamai Fernando & Dayawansa, 1994	Endemic	Endangered
Bufo melanostictus Schneider, 1799	—	Least Concern
Bufo noellerti Manamendra-Arachchi & Pethiyagoda, 1998	Endemic	Endangered
Bufo scaber Schneider, 1799 (see Dubois & Ohler, 1999: 154)	—	Least Concern
Microhylidae (10)		
Kaloula taprobanica (Parker, 1934)	—	Least Concern
Microhyla karunaratnei Fernando & Siriwardhane, 1996	Endemic	Critically Endangered
Microhyla ornata (Duméril & Bibron, 1841)	—	Least Concern
Microhyla rubra (Jerdon, 1854)	—	Least Concern
Microhyla zeylanica Parker & Hill, 1949	Endemic	Endangered
Ramanella nagaoi Manamendra-Arachchi & Pethiyagoda, 2001	Endemic	Vulnerable
Ramanella obscura (Günther, 1864)	Endemic	Near Threatened
Ramanella palmata (Parker, 1934)	Endemic	Endangered
Ramanella variegata (Stoliczka, 1872)	—	Least Concern
Uperodon systoma (Schneider, 1799)	—	Least Concern
Ranidae (Raninae) (15)		
Euphlyctis cyanophlyctis (Schneider, 1799)	—	Least Concern
Euphlyctis hexadactylus (Lesson, 1834)	—	Least Concern
Fejervarya greenii (Boulenger, 1904)	Endemic	Endangered
Fejervarya kirtisinghei Manamendra-Arachchi & Gabadage, 1994	Endemic	Least Concern
Fejervarya limnocharis (Boie, 1835)	—	Least Concern
Hoplobatrachus crassus (Jerdon, 1853)	—	Least Concern
Lankanectes corrugatus (Peters, 1863)	Endemic	Least Concern
Nannophrys ceylonensis (Günther, 1868)	Endemic	Vulnerable
Nannophrys guentheri Boulenger, 1882	Endemic	Extinct
Nannophrys marmorata Kirtisinghe, 1946	Endemic	Critically Endangered
Rana aurantiaca Boulenger, 1904	—	Vulnerable
Rana gracilis Gravenhorst, 1829	Endemic	Least Concern
Rana temporalis (Günther, 1864)	Endemic	Near Threatened
Sphaerotheca breviceps (Schneider, 1799)	—	Least Concern
Sphaerotheca rolandae (Dubois, 1983)	—	Least Concern

Ranidae (Rhacophorinae) (66)		
Philautus abundus Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Least Concern
Philautus adspersus (Günther, 1872)	Endemic	Extinct
Philautus alto Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Endangered
Philautus asankai Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Endangered
Philautus auratus Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Endangered
Philautus caeruleus Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Endangered
Philautus cavirostris (Günther, 1869)	Endemic	Endangered
Philautus cuspis Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Endangered
Philautus decoris Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Endangered
Philautus dimbullae (Shreve, 1940)	Endemic	Extinct
Philautus eximius (Shreve, 1940)	Endemic	Extinct
Philautus extirpo Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Extinct
Philautus femoralis (Günther, 1864)	Endemic	Endangered
Philautus fergusonianus (Ahl, 1927)	Endemic	Least Concern
Philautus folicola Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Endangered
Philautus frankenbergi Meegaskumbura & Manamendra-Arachchi, 2005	Endemic	'E'
Philautus fulvus Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Endangered
Philautus hallidayi Meegaskumbura & Manamendra-Arachchi, 2005	Endemic	'V'
Philautus halyi (Boulenger, 1904)	Endemic	Extinct
Philautus hoffmanni Meegaskumbura & Manamendra-Arachchi, 2005	Endemic	'E'
Philautus hoipolloi Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Least Concern
Philautus hypomelas (Günther, 1876)	Endemic	Extinct
Philautus leucorhinus (Lichtenstein, Weinland & Von Martens, 1856)	Endemic	Extinct
Philautus limbus Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Critically Endangered
Philautus lunatus Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Critically Endangered
Philautus macropus (Günther, 1869)	Endemic	Critically Endangered
Philautus malcolmsmithi (Ahl, 1927)	Endemic	Extinct
Philautus microtympanum (Günther, 1859)	Endemic	Endangered
Philautus mittermeieri Meegaskumbura & Manamendra-Arachchi, 2005	Endemic	'V'
Philautus moororum Meegaskumbura & Manamendra-Arachchi, 2005	Endemic	'E'
Philautus nanus (Günther, 1869)	Endemic	Extinct
Philautus nasutus (Günther, 1869)	Endemic	Extinct
Philautus nemus Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Critically Endangered
Philautus ocularis Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Endangered
Philautus oxyrhynchus (Günther, 1872)	Endemic	Extinct
Philautus papillosus Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Critically Endangered
Philautus pleurotaenia (Boulenger, 1904)	Endemic	Endangered
Philautus poppiae Meegaskumbura & Manamendra-Arachchi, 2005	Endemic	'E'
Philautus popularis Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Least Concern
Philautus procax Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Critically Endangered
Philautus regius Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Data Deficient
Philautus reticulatus (Günther, 1864)	Endemic	Endangered

Philautus rugatus (Ahl, 1927)	Endemic	Extinct
Philautus rus Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Near Threatened
Philautus sarasinorum (Müller, 1887)	Endemic	Endangered
Philautus schmarda (Kelaart, 1854)	Endemic	Endangered
Philautus semiruber (Annandale, 1913)	Endemic	Data Deficient
Philautus silus Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Endangered
Philautus silvaticus Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Endangered
Philautus simba Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Critically Endangered
Philautus sordidus Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Near Threatened
Philautus stellatus (Kelaart, 1853)	Endemic	Extinct
Philautus steineri Meegaskumbura & Manamendra-Arachchi, 2005	Endemic	'E'
Philautus stictomerus (Günther, 1876)	Endemic	Near Threatened
Philautus stuarti Meegaskumbura & Manamendra-Arachchi, 2005	Endemic	'E'
Philautus temporalis (Günther, 1864)	Endemic	Extinct
Philautus variabilis (Günther, 1859)	Endemic	Extinct
Philautus viridis Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Endangered
Philautus zal Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Extinct
Philautus zimmeri (Ahl, 1927)	Endemic	Extinct
Philautus zorro Manamendra-Arachchi & Pethiyagoda, 2005	Endemic	Endangered
Polypedates cruciger Blyth, 1852	Endemic	Least Concern
Polypedates eques Günther, 1858	Endemic	Endangered
Polypedates fastigo Manamendra-Arachchi & Pethiyagoda, 2001	Endemic	Critically Endangered
Polypedates longinasus (Ahl, 1931)	Endemic	Endangered
Polypedates maculatus (Gray, 1834)	—	Least Concern
Ichthyophiidae (4)		
Ichthyophis glutinosus (Linnaeus, 1758)	Endemic	Least Concern
Ichthyophis orthoplicatus Taylor, 1965	Endemic	Vulnerable
Ichthyophis pseudangularis Taylor, 1965	Endemic	Vulnerable
Ichthyophis sp.	Endemic	-

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Current Status of the Reptiles of Sri Lanka

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Abstract

Sri Lanka is endowed with high herpetofaunal diversity and endemism. According to past research, a total of 184 reptile species occur in the island, of which 105 are endemic. The endemics include 22 species of saurian reptiles and 10 species of serpentoid reptiles which are considered geographical relicts. The present paper provides a detailed account on the current status of the reptiles in Sri Lanka, including their distribution, and conservation issues. It also highlights research gaps, and proposes several activities to promote the conservation of reptiles in Sri Lanka.

Keywords: *Reptiles, Research, Conservation,Threats*

Introduction

Sri Lanka ranks as a great herpetological paradise in the world. It is blessed with not only high amphibian and reptile diversity and endemism, but also relatively high densities of individuals interested in herpetology and publications, especially when compared with other countries in South Asia (refer bibliographies by de Silva 1998a, 1998b & 1998c for publications on herpetology up to December 1997). Within the last decade, however, herpetology in Sri Lanka has undergone a renaissance, spurred mainly by organizations such as the Amphibia and Reptile Research Organization of Sri Lanka (ARROS), the Wildlife Heritage Trust of Sri Lanka (WHT) and Turtle Conservation Project (TCP). In addition, organizations such as the Young Zoologists Association (YZA), Declining Amphibian Populations Task Force (DAPTF/IUCN/SSC) Working Group Sri Lanka, Wildlife Conservation Society (Galle), and the World Conservation Union (IUCN), have promoted the appreciation of amphibians and reptiles and provided outlets for the publication of research findings of these animals.

Several significant herpetological fora were held in Sri Lanka organized by ARROS in collaboration with the WHT. These were:

1. The First National Herpetological Conference held at the University of Peradeniya in 1995.
2. The First International Conference of South Asian Amphibians, Reptiles, and their Habitats in 1996 at the Institute of Fundamental Studies and University of Peradeniya
3. A CAMP (Conservation Assessment & Management Plan) workshop for amphibians and reptiles in 1998 at the University of Peradeniya,
4. The Fourth World Congress of Herpetology, held in Bentota in December 2001
5. The First PHVA (Population Habitat & Viability Assessment) for Geochelone elegans and CAMP workshop for chelonians of Sri Lanka in 2003 at the Zoological Gardens, Dehiwela.

The above herpetological meetings, especially the Fourth World Congress of Herpetology, were products of this renaissance and a benchmark for a new age in Sri Lankan herpetology, characterized both by increased international cooperation in research and by the blossoming of herpetology as a research discipline for many young Sri Lankan zoologists. Three recent volumes: The amphibia of Sri Lanka: recent research (2001), The herpetology of Sri Lanka: current research (2004) and The Diversity of the Dumbara Mountains (The Knuckles Massif, Sri Lanka): with special reference to its herpetofauna (2005 – in press) are perfect reflections of these trends. The Raffles Bulletin of Zoology, volume 12 (2005) is another significant issue with many herpetological contribution. Because the herpetofauna is so rich and varied, these many contributions merely scratch the surface of amphibian and reptile study in Sri Lanka. Nonetheless, they serve to illustrate the depth and breadth of topics currently under research and serve as evidence of the vitality of herpetology as a discipline in Sri Lanka.

The present paper focuses on the status of reptiles of Sri Lanka under five headings. It is envisaged that this will stimulate further research and studies into the natural history and distribution of amphibians and reptiles and initiate effective management and conservation strategies by the relevant government departments, researchers, and NGOs.

Carl Linnaeus [1707-1778] described the first reptile *(Cylindrophis maculata)* from Sri Lanka in 1754. Since then, a host of subsequent workers included descriptions of reptiles from Sri Lanka in their publications during the 18th, 19th, 20th and 21st centuries.

The reptile fauna of Sri Lanka is highly diverse and shows affinities to that of the Western Ghats of peninsular India. Though the wet zone of Sri Lanka is remarkably similar to the Western Ghats region in India, it is considered the 'least influenced by recent invasion from southern India' (Crusz & Nugaliyadde, 1977). In fact, recent molecular studies of some amphibians and uropeltid snakes show that Sri Lanka has maintained a fauna distinct from that of the Indian Mainland (Bossuyt et. al., 2004).

Knowledge of the Sri Lankan reptiles, however, is largely limited to species descriptions and basic information. The general and systematic treatments on the reptiles of Sri Lanka consist of outdated classics, such as those of Malcolm A. Smith (1933, 1935, 1943), Edward H. Taylor (1950a, 1950b, 1953), Paulus E. P. Deraniyagala (1953, 1955), P. H. D. H. de Silva (1980, 1969), and Frank Wall (1921). Three genera have been revised recently with descriptions of new species: *Aspidura* (Reptilia: Ophidia: Colubridae) by Gans & Fetcho, 1982; *Lankascincus* (Reptilia: Scincidae) by Greer, 1991 and *Ceratophora* (Reptilia: Agamidae) by Pethiyagoda & Manamendra-Arachchi, 1998. In addition five new species of geckos of the Genus *Cyrtodactylus* was described by Batuwita and Bahir (2005), while a new species of the Genus *Boiga* (Reptilia: colubridae) was recently described by Samarawickrama et al. (2005)

Reports published to date list 184 reptile species in Sri Lanka (Table 1, Appendix 1), of which 105 are endemic (Deraniyagala, 1953, 1955; de Silva, 1990a, 2001, de Silva, P.H.D.H., 1980; Gans & Fetcho, 1982; Greer, 1991; Pethiyagoda & Manamendra-Arachchi, 1998; Smith,1933, 1935, 1943 and Taylor, 1950a, 1950b, 1953, Bahir & Maduwage, 2005; Bahir & Silva, 2005 and Batuwita & Bahir, 2005). This number includes the 5 species of marine turtles that visit the beaches of Sri Lanka for nesting and the 13 species of marine snakes (Family Hydrophiidae) that inhabit the coastal waters, estuaries, mangroves, and river mouths of the country.

Of the reptiles, six endemic genera comprising of 22 species of saurian reptiles (*Chalcidoseps* – 1 species, *Lankascincus* – 6 species; *Nessia* – 8 species) and three of agamid lizards (*Ceratophora* – 5 species; *Lyriocephalus* – 1 species; *Cophotis* – 1 species), are considered geographical relicts (Crusz, 1986; Greer, 1991, de Silva 2001). Likewise, five endemic genera of serpentoid reptiles — one uropeltid genus (*Pseudotyphlops* – 1 species) and four colubrid genera (*Aspidura* – 6 species; *Cercaspis* – 1 species; *Haplocercus* – 1 species; *Balanophis* – 1 species) are considered geographical relicts (Crusz, 1986; de Silva, 1990a & 1990b). Several new species of geckos, lacertids, skinks, and snakes that have been discovered recently await description.

Table 1: Current taxonomic status of Reptiles in Sri Lanka (As at 2005)

Reptile Group	No of Genera	Endemic Genera	No of Species	Endemic Species	unique at the sub-species	Endemicity %
Crocodilia	01	Nil	02	Nil	Nil	Nil
Testudines	08	Nil	09	Nil	01	1
Sauria	25	06	76	48	06	63
Serpentes	46	05	97	46	05	47
Total	80	11	183	92	12	50

Source: Bahir & Maduwage, 2005; Bahir & Silva, 2005 and Batuwita & Bahir, 2005; de Silva, 1990a, 2001

Some of the current taxonomical studies of the reptiles of Sri Lanka include the following:

1. Studies of geckos, skinks, lacertids, and snakes indicate the presence of several new species in the island. Molecular and alpha taxonomy of these reptiles are being determined by Rohan Pethiyagoda, K. Manamendra-Arachchi, M. Bahir, Anslem de Silva, Aaron Bauer, Christopher Austin and Indraneil Das.
2. Studies of phylogenetic affinities within major lineages of these groups is in progress.
3. Preliminary molecular DNA sequencing to resolve the placement of Lankascincus within the larger lygosomine radiation shows that Lankascincus represents an independent lineage separate from the *Eugongylus*, *Mabuya*, *Egernia*, or *Sphenomorphus* groups (Austin, Das & de Silva 2004).
4. Guide to reptiles with easy keys and colour illustrations of all species are in print.
5. Preparation of a well preserved and identified collection of reptiles with relevant locality data for the National Museum has commenced.

Distribution of Reptiles in Sri Lanka

Published literature (de Silva, 1998a, 1998b & 1998c) and recent island-wide surveys of some reptiles give us a fair idea of the distribution of reptiles in the country. Reptile distribution has been studied using different parameters, such as the three climatic zones (de Silva, 1987, 1990a, 1992, 2003), seven vegetation zones (Crusz, 1984, 1986), the four biogeographic regions (Senanayake et al., 1977) and altitudinal stratification (Gans & Fetcho, 1982, Greer, 1991, Erdelen, 1984 & Pethiyagoda and Manamendra-Arachchi, 1998). Others have documented reptiles in specific locations or ecosystems such as Knuckles (Bambaradeniya & Ekanayake, 2003); Nilgala, (de Silva et al., 2004a; Goonewardene et al., 2004), Bolgoda (Ranwella, 1995), Sinharaja, (Jones et al., 1998), Polgolla (Nathaniel et al., 2004). The distribution of reptiles is fairly clearly determined by the three climatic zones (wet, intermediate and dry), with altitude forming another important parameter.

The relict species (all *Ceratophora*, *Cophotis*, *Lyriocephalus*, *Chalcidoseps*, *Nessia* and several species of *Lankascincus*, *Aspidura*, *Balanophis*, *Cercaspis* and *Haplocercus*) are confined to the wet and parts of the intermediate climatic zones from sea-level to 2200 m above the mean sea level. Within this altitudinal range, the species are distributed according to their ecological needs: e.g., *Ceratophora stoddartii* inhabits cloud forest from 1500 to 2200 m above the mean sea level. Appendix 2 shows the distribution of reptiles in the seven vegetation zones of Sri Lanka (Figure 1) used by Eisenberg & McKay (1970), Gaussen et al. (1964), and Crusz (1984).

Present Conservation Status of Reptiles

Deforestation, with consequent loss of wildlife habitats and habitat fragmentation, is the biggest threat faced by Sri Lanka's herpetofauna. The rate of depletion of forests and wild life habitats in Sri Lanka is considered one of the highest in South Asia (McNeely et. al., 1990). Forests were preserved untouched by the ancient rulers of the island as catchment areas and for security. Conservationists consider that the extensive felling of forests that took place during the last few hundreds of years would have had a tremendous impact on the endemic fauna of the country, as the majority of endemic amphibian and reptile species inhabit wet and intermediate lowland and montane forests. These forests today contain the most distinctive elements of the Sri Lankan reptile fauna that has been least influenced by recent invasions from the Indian mainland (Crusz 1984). During more recent times (commencing from the early 1980s) vast areas of the dry zone and monsoon forests were cleared once again under the Accelerated Mahaweli Project for agriculture and settlement.

The natural forest cover that was around 84% of the land area in 1880 is now reduced to 23% (Gunatilleke et al., 1995). Although there are laws and enactments pertaining to the protection of flora and fauna, these are routinely violated. Typical examples are the marine turtle hatcheries and the large scale robbing of turtle eggs and killing turtles for their flesh. The International Institute for Environment and Development (1992) and the Central Environmental Authority (1988) of Sri Lanka state that the enforcement of these laws has been very ineffective. They are outdated and have glaring inadequacies.

Reptiles are adaptable and less extinct-prone than most other vertebrates (Wilcox, 1980) that adapt poorly to environmental changes. This could be a reason we witness appreciable populations of many reptile species. However, our studies indicate that many endemic and relict reptiles face numerous threats. In 1998 during a five-day CAMP workshop on amphibians and reptiles of Sri Lanka held at the University of Peradeniya, 119 reptile species were assessed using IUCN Red List (1994) criteria and 43 species were classified as Vulnerable, 27 Endangered and 18 as Critically Endangered (de Silva et. al., 2000). The IUCN Sri Lanka, using different criteria reflecting the data available in the country, has determined that 86 species are threatened (IUCN Sri Lanka, 2000). The leaf nose lizard *(Ceratophora tennentii)* was listed as an endangered reptile in the IUCN Red List for many years. These lizards inhabit only the montane forests in the Knuckles Mountain range. Senanayake (1980) considers that this species may become extinct if its habitat is lost due to clearing of the primary forests for cardamom *(Elettaria cardamomum)* plantations. A recent study at Knuckles (de Silva et. al., 2005a) indicates the presence of healthy and appreciable populations of *Ceratophora tennentii* widely distributed in the Knuckles Mountain range. However, it was observed that there is a marked decline of Cophotis ceylanica in the Knuckles Mountain range though appreciable numbers were observed in the late 1970's and early 1980's.

In contrast, recent studies indicate that some species of reptiles which were earlier considered rare (e.g. *Lyriocephalus scutatus*, *Calodactylodes illingworthorum*, *Calotes liolepis*, *Balanophis ceylonensis*, etc) in the country exist in fairly healthy populations at present (de Silva et al., 2004 a, . 2004 b, de Silva et. al., 2005a, de Silva et. al., 2005b). They even occupy ranges larger than those hitherto reported by Deraniyagala (1953, 1955), P. H. D. H. de Silva (1980) and de Silva (1990a). In addition, the lack of data regarding the golden gecko (Calodactylodes illingworthorum) has led to the assumption that they were uncommon (e.g., Manamendra-Arachchi, 1997, Wickramsinghe and Somaweera, 2003). However, after investigating nearly 50 specific sites inhabited by the golden gecko, and counting the number of individuals sighted or heard in each of the study sites as well as the number of healthy egg clusters, it is our conclusion that *Calodactylodes illingworthorum* is the dominant gecko species in its range (de Silva et al., 2004a).

Most of the endemic fossorial reptiles (e.g. the species *Chalcidoseps thwaitesii* and the Genus *Nessia* etc) when kept out from their niche for 10 to 15 minutes the skin commences to dry and would then proceed to shrivel up. Thus, the coolness and moisture content in its microhabitat is a critical factor for the survival of these fossorial relict reptiles. *Chalcidoseps thwaitesii* is mainly confined to the Knuckles ecosystem. Studies on the annual rainfall of the Knuckles Range have shown a decrease in the rainfall

(Giragama & Madduma Bandara, 1993; Madduma Bandara 1991). In addition, the negative impacts of the cultivation of cardamom at the Knuckles have been extensively reported (Abeygunawardena & Vincent 1993; Gunawardane et al., 2003). Studies have shown that in natural forested areas without cardamom cultivation the ‘A’ horizon is well preserved and covered with mulch to a depth of 30-35 cm whilst in cardamom fields the mulch level has reduced to 15-25 cm (Madduma Bandara, 1991). This data is from a study conducted in mid 1980’s, thus, it is possible that at present this mulch level could be further reduced. When we measured the mulch level in some cardamom plantations at Kobonila in 2004, we found that it was less that 10 cm (de Silva et al., 2005). In addition, the soil erosion was high. Thus, we see possible long-term irreversible habitat degradation at the Knuckles that could affect the microhabitat of these and other fossorial animals that inhabit the cool moist humus and leaf litter of the forest floor and lay their eggs.

Threats Faced by Herpetofauna

Diminishing availability of natural habitats have pushed many reptiles to adapt to live in home gardens, plantations, and in degraded habitats (de Silva, 1990b, 2001). Some of these reptiles are *Lankascincus* species, *Lyriocephalus scutatus*, *Calotes liolepis*, *Otocryptis wiegmanni* etc. As a result these reptiles are presently over-exposed to predators such as domestic cats, poultry and the common coucal *(Centropus sinensis)* as well as climatic changes, human predation, and other threats.

Predators

Domestic cats, poultry and the Common Coucal *(Centropus sinensis)* are known predators of agamids, geckos, skinks and snakes. With increasing human population, domestic cats and poultry have also increased and have become an important threat to reptiles (de Silva, 2001).

A pilot study conducted in 99 households in a village in Gampola showed that cats were reared in 49 houses and poultry in 16. These animals had killed or killed and eaten 346 reptiles and amphibians within a period of 12 months. The three cats which I kept killed the following within a period of 12 months (1992) a total of 39 reptiles: *Calotes liolepis* = 2, *Calotes calotes* = 3, *C. versicolor* = 4, *Otocryptis wiegmanni* = 7, *Aspidura brachyorrhos* = 2, *Mabuya madaraszi* = 2, *Mabuya carinata* = 3, *Lankascincus fallax* = 5, Geckos = 11(de Silva, 2001).

Field observations conducted in the Gampola area (Central Province) over a period of ten years showed a sharp decrease in the numbers of the ground dwelling agamid Otocryptis wiegmanni due to preying by domestic cats and the common coucal. The common coucal is now commonly found near human habitations in rural and urban areas. Recent observations show that in addition to these predators, adult lizards prey on the young of other lizard species (de Silva 2001). Senanayake (1980) observed the common garden lizard *(Calotes versicolor)* predating on juvenile Rhino horned lizards *(Ceratophora stoddartii).* It is known that adult *Calotes versicolor* feed on young *Sitana ponticeriana* and that *Calotes nigrilabris* feed on young *Cophotis ceylanica* (de Silva, 2001).

Expansion of Human Settlements

A rapid increase in human population has occurred in Sri Lanka over the past century with much land being cleared for agriculture, plantations, and human settlements. Erdelen (1988) has shown that the area of natural forest cover is inversely proportional to population growth, thereby disturbing, fragmenting, and reducing the natural habitats of animals. Furthermore, the human consumption rate of the flesh and eggs of some reptiles such as sea and fresh water turtles, *Crocodylus palustris*, *C. porosus*, and *Varanus bengalensis* has also increased. Also a high rate in killing and excessive collecting of reptiles is also evident, with the expansion of settlements (de Silva, 1982, 1984, 1990a & 1990b; Gans, 1973; Crusz, 1973; 1984; Erdelen 1988; Richardson, 1994; Senanayake et al,1977; Whitaker and Whitaker, 1978).

The Accelerated Mahaweli Project was the biggest single human settlement scheme in recent years and resulted in the replacement of about 200,000 hectares of natural wildlife habitats with agriculture (Baldwin, 1991). It is one of the largest irrigation projects to be carried out in Asia and many reptiles were killed and considerable extents of their nesting habitats were destroyed in the process.

Forest fires

Over a thousand hectares of forests and grasslands are set on fire annually. These fires may be a serious threat to the herpetofauna, including their eggs that are laid in leaf litter. Daniels (1991) considers this a threat faced by amphibians in India.

Climatological changes

Increasing temperatures and decreasing annual rainfall is a trend seen in Sri Lanka in the recent past (Fernando & Chandrapala, 1991).This may have adverse effects on reptiles that require moist cool habitats (discussed above). In the first quarter of 1992 a catastrophic mortality of *Cophotis ceylanica* was observed around Hakgala (1,500 m) and Nuwara Eliya (1,800 m) where hundreds of dead specimens were found within a few days (de Silva, 1996, Palihawadana, 1998). Although post mortem and other pathological examinations were not conducted to ascertain the cause of death, an extended drought with high temperatures reported during this period is believed to have been a major contributory factor (de Silva, 1996). According to Fernando and Chandrapala (1991) there has been an increase in temperature and a decrease in the annual rain-fall in these areas during the past century.

Agrochemical use

Pesticides were first used in Sri Lanka to control malaria in 1946. Since then there has been a gradual increase in the use of pesticides. Presently some 100 active ingredients are used in both agriculture and in public health. Sri Lanka imports about 2000 metric tons of pesticides per year, 70 % being used in paddy cultivation. (Mubarak, 1986). Although there is no data regarding the direct effects of pesticides on reptiles, a considerable number of human deaths occur in Sri Lanka annually due to toxic effects of pesticides. According to the Ministry of Health (1999) it is the 5th leading cause of human death in Sri Lanka: often due to self ingestion while accidental poisoning is caused while spraying pesticides on paddy and vegetable fields. Frogs that were common in paddy fields in the past are now less common. It is reasonable to assume that use of pesticides and herbicides in paddy cultivation could be a factor responsible for reducing the frog populations. The author took part in a survey around Naula and Dambulla in 1970-80 to investigate the effects of spraying malathion for malaria mosquitoes. During this survey, all householders informed the author that since spraying they have not observed a single house gecko in their houses, which had been common earlier. High application rates of nitrogen fertilizer may be another contributory factor. Nearly one third of Sri Lanka’s land is cropped, and its farmers use 77-124 Kg of nitrogen fertilizer per hectare which is 2 to 8 times more fertilizer than is used in any other country in the region (Baldwin, 1991).

Road kills

In Sri Lanka an appreciable number of reptiles and amphibians are run over daily and killed by road traffic (Bambaradeniya et al., 2001; de Silva, 1999, 2001, 2003). One of the first reports on this aspect was documented by the author in a study of the herpetofauna of the Horton Plains National Park (de Silva. 1999). In a subsequent study along the Dolosbage road, Gampola was that used by the author daily to travel from his residence to Gampola town. This stretch of road is approximately 2.25 long. The authors’ house was built in the early 1970’s. Up to 1997 there was less traffic on this road, thus there was virtually no road deaths of reptiles and amphibians along this stretch of road. However, this increased to approximately six road kills per year since 1997. Forty-four reptiles comprising of 15 species and 4 amphibians comprising of 2 species were run over and killed by vehicles. The common (8) reptile that was run over and killed was

Calotes calotes. All were males. One *Coeloganthus helena* with a rat in its mouth was observed run over and killed. The present study, though observed twice a day by the author has shown 44 road deaths. However, several checks daily will show more as it was observed that during the day crows feed on road kills. However, these random observations made in 2.25 km stretch reflect the magnitude of road kills of reptiles and amphibians in Sri Lanka annually. Furthermore, many colleagues from different parts of the island too have informed the author of several road kills they observe regularly, including juvenile crocodiles.

Smuggling

Under the Fauna and Flora Protection Ordinance (Amendment-Schedule 1) all reptiles are protected except *Naja naja*, *Bungarus caeruleus*, *Bungarus ceylonicus*, *Daboia russelii,* and *Echis carinata.* Only occasional permission is given by the Department of Wildlife to zoos and researchers to study or export reptiles under the provisions of CITES. Nevertheless, there is evidence that reptiles are smuggled out of the Island quite often.

Killing of snakes

Snakes, both venomous and non-venomous, are widely killed in Sri Lanka through fear and ignorance, as a precautionary measure against snakebite. The high incidence of snakebite morbidity and mortality in Sri Lanka is the major contributory factor for this attitude (de Silva, 1981 & 1982. In the Accelerated Mahaweli areas the settlers are constantly exposed to snake bite (de Silva, 1981; de Silva & Ranasinghe, 1983; de Silva & Hewage, 1987; Deniyage & de Silva 1989). Field observations conducted in all the Mahaweli settlements indicated that many snakes are ‘over killed’, especially the Russell’s viper *(Daboia russelii)* and the common krait (Bungarus caeruleus). Furthermore, a host of other non-venomous and venomous snakes such as the Trinket snake *(Coeloganthus helena)*, common kukri snake *(Oligodon arnensis)* the Gamma cat snake and Forsten’s cat snake *(Boiga trigonata trigonata* and *Boiga forsteni)* and the green pit viper *(Trimeresurus trigonocephalus)* were also killed usually while clearing forests during preparation of land. Studies indicated that an average of five snakes was killed each day in the Mahaweli settlement areas alone (de Silva, 1982, de Silva & Ranasinghe 1983).

Species specific threats

Ongoing studies on geckos and skinks show that despite the fact that *Calodactylodes illingworthorum* is both widespread in the savannah and locally abundant where it occurs, it remains vulnerable to a variety of threats. Perhaps most importantly, the boulder outcrops with which it is associated are naturally discrete from one another, promoting the isolation of individual populations. Prior to human modification of the landscape, the surrounding monsoon forest would have provided corridors connecting boulder retreats. These forests, however, are now highly fragmented, in part due to extensive logging and clearing for agriculture over the past several centuries. As a result much of the region is covered by extensive grasslands and fire resistant trees such as *Terminalia chebula*, *Terminalia bellirica*, *Phyllanthus emblica* and *Careya arborea,* which are unsuitable for *Calodactylodes.* On a smaller scale, other possible threats are those associated with direct disturbance of rocky retreat sites and the immediately adjacent vegetation. Thus interesting scenarios of possible population “isolation” within the same locality of *Calodactylodes illingworthorum* was observed. This may lead to eventual extinction of the species.

Research Gaps and Proposals Pertaining to the Taxonomy of Reptiles in Sri Lanka

There are several difficulties faced by local taxonomists, such as:

- Lack of comparative material in the National Museum as well as in Zoology museums of Universities throughout the country.

- Lack of "properly" preserved collections in the National Museum.
- Lack of easy and reliable identification keys for most reptile groups.
- Lack of training facilities in taxonomy and field techniques.
- Though expertise is available, chemicals and other relevant material for molecular taxonomy is very expensive.
- The intraspecific variation is unstudied for most reptile species, explicit phylogenies being non-existent.
- Most subspecies erected by Deraniyagala need confirmation by comparison with more Indian and Sri Lankan samples and molecular studies.
- Studies on the ecology and behavior of reptiles are almost non-existent except for a few papers (de Silva, 1992; de Silva, 2003; de Silva et. al., 2004a, de Silva et. al., 2004b, de Silva et. al., 2005a, de Silva et. al., 2005b and Palihawadana, 1998 etc).
- The distribution of most species is incompletely known.
- Threats faced by reptiles are poorly understood.
- Conservation, conservation breeding, and management of reptiles are in early stages of development.
- There are difficulties in obtaining permits for research and research grants and for the exchange of material with international collaborators, universities, and museums.

The following initial steps are recommended:

- The National Museum to establish links with reputed museums that hold types and other specimens needed for comparative taxonomic studies
- Initiate collection of "properly" preserved specimens with detailed data including latitude and longitude coordinates of locations.
- Develop easy and reliable identification keys.
- Conduct workshops and hands-on-training in taxonomy and field techniques.
- Ensure availability of relevant material for molecular taxonomy.
- Initiate research on systematics, biology, and ecological aspects of the reptiles of Sri Lanka with the broader goal of placing these reptiles into their evolutionary and ecological contexts.
- Establish and encourage joint studies with India.
- Initiate and encourage island wide surveys.
- Identify threats to reptiles and initiate action to address the issues that arise.
- Initiate programs on conservation breeding by the National Zoological Gardens with assistance from relevant experts.
- Generate data that can be used to formulate conservation and management plans.
- Ensure availability of research grants; the Department of Wildlife Conservation (DWLC) to take a leading role in promoting research.

Conservation and Management of Reptiles of Sri Lanka

Some specific and general proposals regarding conservation, management and captive breeding of reptiles are listed below:

General proposals

1. Introduction of a module on reptile and amphibian diseases into the undergraduate curriculum.
2. Initiate well designed studies to gather information on the distribution and status of reptiles. It is on the basis of such studies that warnings could be given (Crusz, 1973).

3. Declare smaller isolated forests with high biodiversity as protected areas. These could serve as school “field laboratories”; to be managed and protected by the schoolchildren and NGO’s in the particular area.
4. Captive breeding of endangered and vulnerable taxa need high priority. Captive breeding programs should be initiated when the wild population is still in the thousands (1990 IUCN Red List).
5. Identify natural enemies and other threats.
6. Commercial breeding and harvesting of reptiles (monitor lizards, crocodiles and terrapins) at well supervised farms could be an effective way of controlling poaching.
7. Encouraging farmers to employ organic farming methods instead of using insecticides and artificial fertilizers.
8. Studying traditional beliefs and practices regarding reptiles will enable utilization of some of these beliefs in public awareness programs to reduce the wanton destruction and killing of these animals. For example, it is widely believed that the flesh of *Geochelone elegans* is poisonous and therefore it should not be killed. Geckos are not killed, as it is believed the geckos are indicators of either good or bad luck. The flesh and fat of *Varanus salvator* is considered highly poisonous, and the scavenging habits of the water monitor are perhaps reasons that Sri Lankans do not kill it for flesh.
9. Conduct awareness programs on the importance of reptiles.
10. Initiate immediate steps to reduce road kills.

Some Specific Proposals:

1. Protection of the chief nesting habitats of *Crocodylus porosus* along the south and west coasts of the island (e.g. ecosystems that support the flag plant - *Lagenandra toxicaria*).
2. Identify localities where *Crocodylus palustris* and *C. porosus* are killed for consumption and end the practice.
3. Monitor turtle hatcheries with immediate effect to ensure that accepted best practice codes are followed (Refer Hewavisenthi, 1993, Richardson, 1995, Weerasinghe & Walker, 1995 and de Silva, 1996).
4. Conduct awareness programs for cultivators in areas with large populations of *Geochelone elegans* in an attempt to minimize burns and other severe injuries to these animals during land preparation activities.
5. Initiate immediate conservation breeding programs for critically endangered reptiles such as *Ceratophora karu* and *C. erdelani* etc.
6. Establish a rapid response mechanism in the veterinary unit of the DWLC in collaboration with the Veterinary Faculty of the University of Peradeniya. Such a mechanism would have enabled quick investigation into the causes of the mass mortality of *Cophotis ceylanica* in 1992 around Hakgala and Nuwara Eliya.

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Appendix 1: Provisional checklist of the reptiles of Sri Lanka (As at June 2005).

The list of reptiles below is provisional, as the validity of some generic and species allocations needs to be examined with more samples. The families, genera, and species are listed alphabetically. Sources consulted in preparing this list are: Bahir & Maduwage, 2005; Bahir & Silva, 2005 and Batuwita & Bahir, 2005; Das, 1991, 1996; Deraniyagala, 1953, 1955; de Silva 1990a, 2001, de Silva, P. H. D. H., 1980; Greer, 1991; Kluge, 2001; Pethiyagoda & Manamendra-Arachchi, 1998, Taylor, 1950b, 1953, McDiarmid et al., 1999, Golay et al., 1993, David & Ineich, 1999 and Samarawickrama et. al., 2005. The endemic status according to current knowledge is given; but more taxa are presently being studied and may eventually be given endemic status.

FAMILY CROCODYLIDAE Gray, 1825

Genus: *Crocodylus* Laurenti, 1768.

1. *Crocodylus palustris* Lesson, 1831. English: Mugger or Marsh Crocodile, Sinhala: Hala Kimbula, Tamil: Kulathi Muthalei. Status: Not endemic.
2. *Crocodylus porosus* Schneider,1801. English: Saltwater or Estuarine Crocodile, Sinhala: Gata Kimbula, Tamil: Semmukku Muthalei. Status: Not endemic.

FAMILY BATAGURIDAE

Genus: *Melanochelys* Gray, 1869

3. *Melanochelys trijuga parkeri (Deraniyagala, 1939*). English: Parker's Black Turtle, Sinhala: Parkerge Gal Ibba. Status: unique at sub-species level
4. *Melanochelys trijuga thermalis* (Lesson, 1830). English: Black Turtle, Sinhala: Gal Ibba, Tamil: Amai, Karuppu amai. Status: Not endemic.

FAMILY CHELONIIDAE Gray, 1825

Genus: *Caretta* Rafinesque, 1814.

5. *Caretta caretta* (Linnaeus, 1758). English: Loggerhead Sea Turtle, Sinhala: Olugedi kasbaeva, Kannadi kasbaeva = Spectacled Turtle, Tamil: Perunthalai amai = bigheaded turtle. Status: Not endemic.

Genus: *Chelonia* Brongniart, 1800

6. *Chelonia mydas* (Linnaeus, 1758). English: Green turtle, Sinhala: Gal Kasbaeva (= rock turtle), Mas Kasbaeva = flesh turtle, Vali Kasbaeva (= sand turtle), Tamil: Pal Amai = Tamil. Status: Not endemic.

Genus: Eretmochelys Fitzinger, 1843.

7. *Eretmochelys imbricata* (Linnaeus, 1766). English: Hawksbill Sea Turtle, Sinhala: Pothu Kasbaeva = Scaly turtle, Leli Kasbaeva = Scally turtle, Tamil: Nanja Amai = poisonous Turtle. Status: Not endemic.

Genus: Lepidochelys Fitzinger, 1843.

8. *Lepidochelys olivacea* (Eschscholtz, 1829). English: Olive Ridley Sea Turtle, Sinhala: Batu Kasbaeva = Dwarf Turtle or Mada Kasbaeva = Mud Turtle, Tamil: Pul Amai = Grass turtle. Status: Not endemic.

FAMILY DERMOCHELYIDAE Stejneger, 1907

Genus: Dermochelys Blainville, 1816.

9. *Dermochelys coriacea* (Vandelli, 1761). English: Leatherback Sea Turtle, Sinhala: Dara Kasbaeva = ridge turtle or Tun Dara Kasbaeva = three ridge turtle, Tamil: Dhoni Amai = boat turtle. Status: Not endemic.

FAMILY TESTUDINIDAE Gray, 1825

Genus: Geochelone Fitzinger, 1835

10. *Geochelone elegans* (Schoepff, 1795). English: Indian Star Tortoise, Sinhala: Mevara Ibba = marked tortoise or Taraka Ibba = Star tortoise, Tamil: Katu Amai = forest tortoise, Kattupta Aamai. Status: Not endemic.

FAMILY TRIONYCHIDAE Bell, 1828

Genus: Lissemys Smith, 1931.

11. *Lissemys punctata punctata* (Bonnaterre, 1789). English: Flapshell Turtle, Sinhala: Kiri Ibba = milk turtle, Tamil: Pal Aamai = milk turtle. Status: Not endemic.

FAMILY AGAMIDAE Gray, 1827

Genus: Calotes Cuvier, 1817.

12. *Calotes calotes* (Linnaeus, 1758). English: Green garden lizard, Sinhala: Pala katussa = Green Lizard, Tamil: Pachai karata. Status: Not Endemic.
13. *Calotes ceylonensis* (Müller, 1887). English: Painted lip lizard, Sinhala: Thola-visituru katussa. Status: Endemic.
14. *Calotes desilvai* Bahir & Maduwage, 2005. English: Maculate lizard, Sinhala: Lapawan Katussa. Status: Endemic.
15. *Calotes liocephalus* Günther, 1872. English: Crestless lizard, Sinhala: Kondu datirahita katussa. Status: Endemic.
16. *Calotes liolepis* Boulenger, 1885. English: Whistling lizard, Forest lizard, Sinhala: Sivuruhandalana katussa. Status: Endemic.
17. *Calotes nigrilabris* Peters, 1860. English: Black cheek lizard, Sinhala: Kalu kopul katussa. Status: Endemic.
18. *Calotes versicolor versicolor* (Daudin, 1802). English: Common garden lizard, Sinhala: Gara katussa (= house lizard). Status: Not Endemic.

Genus: Ceratophora Gray, 1834.

19. *Ceratophora aspera* Günther, 1864. English: Rough horn lizard, Sinhala: Raluang katussa Kuru angkatussa. Status: Endemic.
20. *Ceratophora erdeleni* Pethiyagoda & Manamendra-Arachchi. 1998. English: Erdelen's horn lizard, Sinhala: Erdelenge angkatussa. Status: Endemic.
21. *Ceratophora karu* Pethiyagoda & Manamendra-Arachchi. 1998. English: Karunaratne's horn lizard, Sinhala: Karunaratnage angkatusua. Status: Endemic.
22. *Ceratophora stoddartii* Gray, 1835. English: Rhinohorn lizard, Sinhala: Kagamuva angkatussa. Status: Endemic.
23. *Ceratophora tennentii* Günther and Gray, 1861. English: Leafnose lizard, Sinhala: Pethi angkatussa. Status: Endemic.

Genus: Cophotis Peters, 1861.

24. *Cophotis ceylanica* Peters, 1861. English: Pygmy lizard, Sinhala: Kandukara kurukatussa. Status: Endemic.

Genus: Lyriocephalus Merrem, 1820.

25. *Lyriocephalus scutatus* (Linnaeus, 1758). English: Lyre head lizard, Hump snout Lizard, Sinhala: Gatahombu katussa = Humpsnout lizard, Karamal bodiliya = Crested lizard, Kandukara bodiliya = Montane lizard, Sondura = Beloved. Status: Endemic.

Genus: Otocryptis Wagler, 1830.

26. *Otocryptis nigristigma* Bahir & Silva, 2005. English: Lowland kangaroo lizard, Sinhala: Thalawe . talikatussa = lowland Pendant lizard. Status: Endemic.
27. *Otocryptis wiegmanni* Wagler, 1830. English: Upland kangaroo lizard, Sinhala: Gomu talikatussa = Forest Pendant lizard; Pinum katussa = Jumping lizard, Tali katussa = pendant lizard, Kala katussa. Status: Endemic.

Genus: Sitana Cuvier, 1829.

28. *Sitana ponticeriana* Cuvier, 1829. English: Fanthroat lizard, Sinhala: Pulina talikatussa = Sand pendant lizard, Vali katussa = Sand lizard, Pullibim katussa = spotted ground lizard. Tamil: Veeseri wona. Status: Not Endemic.

FAMILY CHAMAELEONIDAE Gray, 1825

Genus: Chamaeleo Laurenti, 1768.

29. *Chamaeleo zeylanicus* Laurenti, 1768. English: Sri Lankan Chameleon, Sinhala: Bodilima, Bodiliya, Tamil: Pachai wona. Status: Not endemic.

FAMILY GEKKONIDAE Boulenger, 1885

Genus: Calodactylodes Strand, 1926.

30. *Calodactylodes illingworthorum* Deraniyagala, 1953. English: Sri Lankan golden gecko, Sinhala: Maha galhuna. Status: Endemic.

Genus: Cnemaspis Strauch 1887.

31. *Cnemaspis jerdonii scalpensis* (Ferguson, 1877). English: Jerdon’s day gecko, Sinhala: Jerdonge divasarihuna. Status: unique at sub-species level
32. *Cnemaspis kandiana* (Kelaart, 1853 “1852”). English: Kandyan day gecko, Sinhala: Kandukara divasarihuna. Status: Endemic.
33. *Cnemaspis podihuna* Deraniyagala, 1944. English: Dwarf day gecko, Sinhala: Kuda divasarihuna, Podi galhuna. Status: Endemic.
34. *Cnemaspis tropidogaster* (Boulenger, 1885). English: Roughbelly day gecko, Sinhala: Ralodara divasarihuna. Status: Not endemic.

Genus: Cosymbotus Fitzinger, 1843.

35. *Cosymbotus platyurus* (Schneider, 1792). English: Frilltail Gecko, Sinhala: Nagutavakarali huna. Status: Not endemic.

Genus: Cyrtodactylus. Gray, 1827.

36. *Cyrtodactylus cracens* Batuwita & Bahir, 2005. English: Sinharaja bent-toe gecko, Sinhala: Sinharaja vakaniya huna. Status: Endemic
37. *Cyrtodactylus edwardtaylori* Batuwita & Bahir, 2005. English: Namunukula bent-toe gecko, Sinhala: Namunukula vakaniya huna. Status: Endemic
38. *Cyrtodactylus fraenatus* (Günther, 1864). English: Great forest gecko, Sinhala: Maha kalae huna or Mukalam huna. Status: Endemic.
39. *Cyrtodactylus ramboda* Batuwita & Bahir, 2005. English: Ramboda bent-toe gecko, Sinhala: Ramboda vakaniya huna. Status: Endemic
40. *Cyrtodactylus soba* Batuwita & Bahir, 2005. English: Dumbara bent-toe gecko, Sinhala: Dumbara vakaniya huna. Status: Endemic
41. *Cyrtodactylus subsolanus* Batuwita & Bahir, 2005. English: Dolahena bent-toe gecko, Sinhala: Dolahena vakaniya huna. Status: Endemic

Genus: Geckoella Gray 1867.

42. *Geckoella collegalensis* (Beddome, 1870). English: Collegal rockgecko, Sinhala: Collegalge vakaniyahuna. Status: Not endemic.
43. *Geckoella triedrus* (Günther, 1864). English: Spotted bowfinger gecko, Sinhala: Pulli vakaniyahuna. Status: Endemic.
44. *Geckoella yakhuna* (Deraniyagala, 1945). English: Blotch bowfinger gecko; Demon gecko, Sinhala: Lapavan vakaniyahuna, Yak huna = demon gecko. Status: Endemic.

Genus: Gehyra Gray, 1834.

45. *Gehyra mutilata* (Wiegmann, 1834). English: Four-claw gecko, Sinhala: Caturanguli huna. Status: Not endemic.

Genus: Hemidactylus Oken, 1817

46. *Hemidactylus brookii parvimaculatus* Deraniyagala, 1953. English: Spotted housegecko, Sinhala: Pulli gehuna. Status: unique at sub-species level
47. *Hemidactylus depressus* Gray, 1842. English: Kandyan gecko, Sinhala: Hali gehuna. Status: Endemic.
48. *Hemidactylus frenatus* Duméril & Bibron, 1836. English: Common house-gecko, Sinhala: Sulaba gehuna. Status: Not Endemic.
49. *Hemidactylus leschenaultii* Duméril & Bibron, 1836. English: Bark or Sycamore gecko, Sinhala: Kimbul huna = crocodile gecko, Gas huna = tree or Kumbuk huna = Terminalia arjuna. Status: Not Endemic.
50. *Hemidactylus maculatus hunae* Deraniyagala, 1937. English: Spotted giantgecko or Rock gecko. Sinhala: Davanta tit huna. Status: Not endemic
51. *Hemidactylus scabriceps* (Annandale, 1906). English: Scaly gecko, Sinhala: Korapotu huna. Status: Not endemic.
52. *Hemidactylus triedrus lankae* Deraniyagala, 1953. English: Termite hill gecko, Sinhala: Humbas huna. Status: unique at sub-species level

Genus: Hemiphyllodactylus Bleeker, 1860.

53. *Hemiphyllodactylus typus* Bleeker, 1860. English: Slender gecko, Sinhala: Sihin huna. Status: Not endemic.

Genus: Lepidodactylus Fitzinger 1843.

54. *Lepidodactylus lugubris* (Duméril & Bibron, 1836). English: Scaly-finger gecko or Mourning gecko, Sinhala: Salkapa huna. Status: Not endemic.

FAMILY LACERTIDAE Gray, 1825

Genus: Ophisops. Ménétries, 1832.

55. *Ophisops leschenaultii lankae* (Deraniyagala, 1953). English: Leschenault's Snake eye Lizard, Sinhala: Panduru sarpakshi katusa. Status: unique at sub-species level
56. *Ophisops minor minor* (Deraniyagala, 1971). English: Lesser snake eye lizard, Sinhala: Kuda sarpakshi katusa. Status: unique at sub-species level

FAMILY SCINCIDAE Gray, 1825

Genus: Chalcidoseps Boulenger 1887.

57. *Chalcidoseps thwaitesii* (Günther, 1872). English: Fourtoe snakeskink, Sinhala: Caturanguli sarpiyahikanala. Status: Endemic.

Genus: Dasia Gray, 1839.

58. *Dasia halianus* (Haly & Nevill in: Nevill, 1887). English: Haly's treeskink, Sinhala: Helige rukhiraluva. Status: Not endemic.

Genus: Lankascincus Greer, 1991.

59. *Lankascincus deignani* (Taylor, 1950). English: Deignan's lankaskink, Sinhala: Deignange lakhiraluva. Status: Endemic.
60. *Lankascincus deraniyagalae* Greer, 1991. English: Deraniyagal's lankaskink, Sinhala: Daraniyagalge lakhiraluva. Status: Endemic.
61. *Lankascincus fallax* (Peters, 1860). English: Common lankaskink, Sinhala: Sulaba lakhiraluva. Status: Endemic.
62. *Lankascincus gansi* Greer, 1991. English: Gans's lankaskink, Sinhala: Gansge lakhiraluva. Status: Endemic.
63. *Lankascincus taprobanensis* (Kelaart, 1854). English: Smooth lanka skink, Sinhala: Sumudu lakhiraluva. Status: Endemic.
64. *Lankascincus taylori* Greer, 1991. English: Taylor's lanka skink, Sinhala: Telorge lakhiraluva. Status: Endemic.

Genus: Lygosoma

65. *Lygosoma punctatus* (Gmelin, 1799). English: Dotted skink, Sinhala: Tit hiraluhikanala. Status: Not endemic.
66. *Lygosoma singha* (Taylor, 1950). English: Taylor's skink, Sinhala: Taylorge hiraluhikanala. Status: Endemic.

Genus: Mabuya Fitzinger, 1826.

67. *Mabuya beddomii* (Jerdon, 1870). English: Beddome's stripe skink, Sinhala: Vairan hikanala. Status: Not endemic.
68. *Mabuya bibronii* (Gray, 1838). English: Bibron's sand skink, Sinhala: Vali hikanala. Status: Not endemic.
69. *Mabuya carinata lankae* Deraniyagala, 1953. English: Common skink, Sinhala: Sulaba hikanala. Status: unique at sub-species level
70. *Mabuya floweri* Taylor, 1950. English: Taylor's skink, Sinhala: Taylorge hikanala. Status: Endemic.
71. *Mabuya macularia maculara* (Blyth, 1853). English: Bronzegreen little skink, Sinhala: Pingu hikanala. Status: Not endemic.
72. *Mabuya madaraszi* Méhely, 1897. English: Spotted skink, Sinhala: Pulli hikanala. Status: Endemic.

Genus: Nessia Gray, 1839.

73. *Nessia bipes* Smith, 1935. English: Smith's snakeskink, Sinhala: Smithge sarpahiraluva. Status: Endemic.
74. *Nessia burtonii* Gray, 1839. English: Threetoe Snakeskink, Sinhala: Triyanguli sarpahiraluva. Status: Endemic.
75. *Nessia deraniyagalai* Taylor, 1950. English: Deraniyagala's snakeskink, Sinhala: Derniyagalage sarpahiraluva. Status: Endemic.
76. *Nessia didactylus* (Deraniyagala, 1934). English: Two toe snakeskink, Sinhala: Dvayanguli sarpahiraluva. Status: Endemic.
77. *Nessia hickanala* Deraniyagala, 1940. English: Sharkhead snakeskink, Sinhala: Morahis sarpahiraluva. Status: Endemic.
78. *Nessia layardi* (Kelaart, 1854). English: Layard's snakeskink, Sinhala: Leyardge sarpahiraluva. Status: Endemic.

79. *Nessia monodactylus* (Gray, 1839). English: Toeless snakeskink, Sinhala: Ananguli sarpahiraluva. Status: Endemic.
80. *Nessia sarasinorum* (Müller, 1889). English: Sarasin's snakeskink, Sinhala: Sarasinge sarpahiraluva. Status: Endemic.

Genus: Sphenomorphus Fitzinger 1843.

81. *Sphenomorphus dorsicatenatus* Deraniyagala, 1953. English: Catenated litter skink, Sinhala: Damwal singitihikanala. Status: Endemic.
82. *Sphenomorphus dussumieri* (Duméril & Bibron, 1839). English: Dussumier's litter skink, Sinhala: Salkasahita singitihikanala. Status: Not endemic.
83. *Sphenomorphus megalops* (Annandale, 1906). English: Annandale's litter skink, Sinhala: Annandalege singitihikanala. Status: Endemic.
84. *Sphenomorphus rufogulus* (Taylor, 1950). English: Redthroat litter skink, Sinhala: Taylorge singitihikanala. Status: Endemic.
85. *Sphenomorphus striatopunctatus* (Ahl, 1925). English: Ahl's litter skinks, Sinhala: Ahlge singitihikanala. Status: Endemic.

FAMILY VARANIDAE Gray, 1827

Genus: Varanus Merrem, 1820.

86. *Varanus bengalensis* (Daudin, 1802). English: Land monitor, Sinhala: Talagoya. Status: Not endemic.
87. *Varanus salvator salvator* (Laurenti, 1768). English: Water monitor, Sinhala: Kabaragoya. Status: Not Endemic.

ORDER SERPENTES

FAMILY ACROCHORDIDAE Bonaparte, 1831

Genus: Acrochordus Hornstedt, 1787

88. *Acrochordus granulatus* (Schneider, 1799). English: Wart snake, Sinhala: Diya goya, redi naya. Status: Not endemic.

FAMILY BOIDAE Gray, 1825

Sub Family Erycinae Bonaparte, 1831

Genus: Gongylophis Wagler, 1830.

89. *Gongylophis conica brevis* (Deraniyagala, 1951) English: Sand boa, Sinhala: Vali pimbura, kota pimbura. Status: unique at sub-species level

Sub Family Pythonidae Fitzinger, 1826

Genus: Python Daudin, 1803

90. *Python molurus molurus* (Linnaeus, 1758). English: Indian python, Pimbura. Status: Not endemic.

FAMILY CYLINDROPHIIDAE Fitzinger, 1843

Genus: Cylindrophis Wagler, 1828

91. *Cylindrophis maculata* (Linnaeus, 1758). English: Pipe snake, Sinhala: Depath naya. Status: Endemic.

FAMILY COLUBRIDAE

Genus: Ahaetulla Link, 1807

92. *Ahaetulla nasuta* (Lacépčde, 1789): English: Green vine snake, Sinhala: Ahaetulla. Status: Not endemic.
93. *Ahaetulla pulverulenta* (Duméril, Bibron & Duméril, 1854). English: Brown vine snake, Sinhala: Henakandaya. Status: Not endemic.

Genus: Amphiesma Duméril, Bibron & Duméril, 1854.

94. *Amphiesma stolatum* (Linnaeus, 1758). English: Buff striped keelback, Sinhala: Aharukuka. Status: Not endemic.

Genus: Argyrogena Werner, 1924.

95. *Argyrogena fasciolata* (Shaw, 1802). English: Banded racer, Sinhala: Wal gerandiya. Status: Not endemic.

Genus: Aspidura Wagler, 1830

96. *Aspidura brachyorrhos* (Boie, 1827). English: Boie's roughside, Sinhala: Le madilla. Status: Endemic.
97. *Aspidura copei* Günther, 1864, English: Cope's roughside, Sinhala:Kalumedilla. Status: Endemic.
98. *Aspidura deraniyagalae* Gans & Fetcho, 1982. English: Deraniyagala's roughside, Sinhala: Kandu madilla. Status: Endemic.
99. *Aspidura drummondhayi* Boulenger, 1904. English: Guenther's Drummond – Hay's roughside, Sinhala: Ketiwalmadilla. Status: Endemic.
100. *Aspidura guentheri* Ferguson, 1876. English: Ferguson's roughside, Sinhala: Kudamadilla. Status: Endemic.
101. *Aspidura trachyprocta* Cope, 1860. English: Common roughside, Sinhala: Dalawa madilla. Status: Endemic.

Genus: Atretium Cope, 1861

102. *Atretium schistosum* (Daudin, 1803). English: The Olive keelback watersnake, Sinhala: Diyawarna. Status: Not endemic.

Genus: Balanophis Smith, 1938

103. *Balanophis ceylonensis* (Günther, 1858). English: Sri Lanka keelback, Sinhala: Nihaluwa. Status: Endemic.

Genus: Boiga Fitzinger, 1826

104. *Boiga barnesii* (Günther, 1869). English: Barnes's cat snake, Sinhala: Panduru mapila. Status: Endemic.
105. *Boiga beddomei* (Wall, 1909). English: Beddoms cat snake, Sinhala: Kaha mapila. Status: Not endemic.
106. *Boiga ceylonensis* (Günther, 1858). English: Sri Lanka cat snake, Sinhala: Nidi mapila. Status: Not endemic.
107. *Boiga forsteni* (Duméril, Bibron and Duméril, 1854). English: Forsten's cat snake, Sinhala: Naga mapila. Status: Not endemic.
108. *Boiga trigonatus trigonatus* (Schneider, 1802). English: Gamma cat snake, Sinhala: Ran mapila. Status: Not endemic.
109. *Boiga ranawanei* Samarawickrama, 2005. Ranawana's Golden cat snake. Status: Endemic.

Genus: Cerberus Cuvier, 1829

110. *Cerberus rynchops* (Schneider, 1799). English: Dog-faced water snake, Sinhala:Kuna diya kaluwa. Status: Not endemic.

Genus: Cercaspis Wagler, 1830

111. Cercaspis carinata (Kuhl, 1820). English: The Sri Lanka wolf snake, Sinhala: Dhara radanakaya. Status: Endemic.

Genus: Chrysopelea Boie, 1826

112. *Chrysopelea ornata ornata* (Shaw, 1802). English: Ornate flying snake, Sinhala: Malsara. Status: Not Endemic.
113. *Chrysopelea taprobanica* (Smith, 1943). English: Striped flying snake, Sinhala: Dangara danda. Status: Endemic.

Genus: Coeloganthus Fitzinger, 1843.

114. *Coeloganthus helena* (Daudin, 1803). English: Trinket snake, Sinhala: Katakaluwa. Status: Not endemic

Genus: Dendrelaphis Boulenger, 1890

115. *Dendrelaphis bifrenalis* (Boulenger, 1890). English: Boulenger's bronze back, Sinhala: Pandura haldanda. Status: Not endemic.
116. *Dendrelaphis caudolineolatus* (Günther, 1869). English: Gunther's bronze back, Sinhala: Viri haldanda. Status: Not endemic.
117. *Dendrelaphis oliveri* (Taylor, 1950). English: Oliver's bronze back, Sinhala: Oliverge haldanda. Status: Endemic.
118. *Dendrelaphis tristis* (Daudin, 1803). English: Common bronze back Sinhala: Tura haldanda. Status: Not endemic.

Genus: Dryocalamus Günther, 1858.

119. *Dryocalamus gracilis* (Günther, 1864). English: The scarce bridal snake, Sinhala: Megata radanakaya. Status: Not endemic. .
120. *Dryocalamus nympha* (Daudin, 1803). English: Bridal snake, Sinhala: Geta Radanakaya, Geta karawala. Status: Not endemic.

Genus: Gerarda Gray, 1849

121. *Gerarda prevostianus* (Eydoux & Gervais, 1837). English: Gerard's water snake, Sinhala: Prevostge diyabariya. Status: Not endemic.

Genus: Haplocercus Günther, 1858

122. *Haplocercus ceylonensis* Günther, 1858. English: The black spine snake, mould snake, Sinhala: Kurunkarawala. Status: Endemic.

Genus: Liopeltis Fitzinger, 1843

123. *Liopeltis calamaria* (Günther, 1858). English: Reed snake, Sinhala: Punbariya. Status: Not endemic.

Genus: Lycodon Boie in: Fitzinger, 1826

124. *Lycodon aulicus* (Linnaeus, 1758). English: Wolf snake, house snake, Sinhala: Alu radanakaya. Status: Not endemic.
125. *Lycodon osmanhilli* (Taylor, 1950). Flowery wolf snake, Sinhala: Mal radanakaya. Status: Endemic.
126. *Lycodon striatus sinhaleyus* Deraniyagala, 1955. English: Shaw's wolf snake, Sinhala: Kabara radanakaya. Status: unique at sub-species level

Genus: Macropisthodon Boulenger, 1893

127. *Macropisthodon plumbicolor palabariya* Deraniyagala, 1955. English: The green keelback, Sinhala: Palabariya. Status: Endemic.

Genus: Oligodon Boie in: Fitzinger, 1826

128. *Oligodon arnensis* (Shaw, 1802). English: Common kukri snake, Banded Kukri, Sinhala: Arani dath ketiya. Status: Not endemic.
129. *Oligodon calamarius* (Linnaeus, 1758). English: Templeton's kukri snake, Sinhala: Kabara dath ketiya. Status: Endemic.
130. *Oligodon sublineatus* Duméril, Bibron & Duméril, 1854. English: Dumerul's kuki snake, Sinhala: Pulli dath ketiya. Status: Endemic.

131. *Oligodon taeniolata* ceylonicus Wall, 1921. English: The variegated kukri snake, Sinhala: Wairi dath ketiya. Status: unique at sub-species level
132. *Oligodon taeniolata fasciatus* (Günther, 1864). English: Russell's kukri snake, Sinhala: Pulli dath ketiya. Status: Not endemic.

Genus: Ptyas Fitzinger, 1843

133. *Ptyas mucosa maxima* (Deraniyagala, 1955). English: Rat snake, Sinhala: Gerandiya. . Status: unique at sub-species level

Genus: Sibynophis Fitzinger, 1864

134. *Sibynophis subpunctatus* (Duméril, Bibron & Duméril, 1854). English: Jerdon's polyodent, Sinhala: Dathigomaraya. Status: Not endemic.

Genus: Xenochrophis Günther, 1864

135. *Xenochrophis asperrimus* (Boulenger, 1891). English: The checkered keelback, Sinhala: Diya polonga, Diya bariya. Status: Endemic.
136. *Xenochrophis piscator piscator* (Schneider, 1799). English: The Checkered keelback, Sinhala: Diya naya, Diya bariya. Status: Not endemic.

FAMILY ELAPIDAE

Genus: Bungarus Daudin, 1803

137. *Bungarus caeruleus* (Schneider, 1801). English: The common krait, Sinhala: Thel karawala. Status: Not endemic.
138. *Bungarus ceylonicus ceylonicus* Günther, 1864. English: Sri Lanka (= Ceylon) krait, Sinhala: Madu karawala. Status: Endemic.
139. *Bungarus ceylonicus karavala* Deraniyagala, 1955. English: Sri Lanka (= Ceylon) krait, Sinhala: Hath karawala. Status: Endemic.

Genus: Calliophis Gray, 1834

140. *Calliophis melanurus sinhaleyus* Deraniyagala, 1951. English: Sri Lanka coral snake, Sinhala: Depath kaluwa. Status: unique at sub-species level

Genus: Naja Laurenti, 1768

141. *Naja naja* (Linnaeus, 1758). English: Indian cobra, Sinhala: Naya. Status: Not endemic.

FAMILY HYDROPHIIDAE

Genus: Astrotia Fischer, 1855

142. *Astrotia stokesii* (Gray in Stokes, 1846). English: Stoke's sea snake, Sinhala: Mahavalakkadiya. Status: Not endemic.

Genus: Enhydrina Gray, 1849

143. *Enhydrina schistosa* (Daudin, 1803). English: Hook nose sea snake, Sinhala: Valakkadiya. Status: Not endemic.

Genus: Hydrophis Latreille in Sonnini & Latreille, 1801

144. *Hydrophis bituberculatus* Peters, "1872" 1873. English: Peter's sea snake, Peterge muhudunaya. Status: Not endemic.
145. *Hydrophis cyanocinctus* (Daudin, 1803). English: The chitul, Sinhala: Wairan muhudunaya. Status: Not endemic
146. *Hydrophis gracilis* (Shaw, 1802). English: John's sea snake, Sinhala: Kudahis Muhudu naya. Status: Not endemic.

147. *Hydrophis lapemoides* (Gray, 1849). English: Persian Gulf seasnake, Sinhala: Persiyanu bokke muhudu naya. Status: Not endemic
148. *Hydrophis ornatus ornatus* (Gray, 1842). English: Gray's sea snake, Sinhala: Grayge Muhudu naya. Status: Not endemic.
149. *Hydrophis spiralis* (Shaw, 1802). English: Narrow banded sea snake, Sinhala: Sihin Mudhu naya. Status: Not endemic
150. *Hydrophis stricticollis* (Günther, 1864). English: Guenther's sea snake, Guntherge muhudunaya. Status: Not endemic.

Genus: Kerilia Gray, 1849

151. *Kerilia jerdonii* (Gray, 1849). English: Jerdon's sea snake Sinhala: Jerdonge Muhudu naya. Status: Not endemic.

Genus: Lapemis Gray, "1834" (1835)

152. *Lapemis curtus* (Shaw, 1802). English: Shaw's sea snake, Sinhala: Shawge kuda muhudunaya. Status: Not endemic.

Genus: Pelamis Daudin, 1803

153. *Pelamis platurus* (Linnaeus, 1766). English: Yellow bellied sea snake, Sinhala: Badakaha muhudu naya. Status: Not endemic.

Genus: Thalassophina Smith, 1929

154. *Thalassophina viperina* (Schmidt, 1852). English: Schmidt's sea snake, Sinhala: Polon muhudunaya. Status: Not endemic.

FAMILY TYPHLOPIDAE Merrm, 1820.

Genus: Ramphotyphlops Fitzinger, 1843

155. *Ramphotyphlops braminus* (Daudin, 1803). English: Common blind snake, Sinhala: Dumuta kanaulla. Status: Not endemic.

Genus: Typhlops, Oppel, 1811

156. *Typhlops ceylonicus* Smith, 1943. English: Smith's blind snake, Sinhala: Smithge kanaulla. Status: Endemic.
157. *Typhlops lankaensis* Taylor, 1947. English: Lanka blind snake, Sinhala: Lak kanaulla. Status: Endemic.
158. *Typhlops leucomelas* Boulenger, 1890. English: Pied typhlops, Sinhala: Dewarna kanaulla. Status: Endemic.
159. *Typhlops malcolmi* Taylor, 1947. English: Malcolm's blind snake, Sinhala: Malcomge kanaulla. Status: Endemic.
160. *Typhlops mirus* Jan in: Jan and Sordelli, 1860. English: Jan's blind snake, Sinhala: Heenkanaulla. Status: Endemic.
161. *Typhlops porrectus* Stoliczka, 1871. English: Stoliczka's blind snake, Sinhala: Stoliczkage kanaulla. Status: Not endemic.
162. *Typhlops tenebrarum* Taylor, 1947. English: Taylor's blind snake, Sinhala: Taylorge kanaulla. Status: Endemic.
163. *Typhlops veddae* Taylor, 1947. English: Veddha's blind snake, Sinhala: Veddage kanaulla. Status: Endemic.
164. *Typhlops violaceus* Taylor, 1947. English: Violet blind snake, Sinhala: Dan kanaulla. Status: Endemic.

FAMILY UROPELTIDAE Müller, 1832

Genus: Platyplectrurus Günther, 1868

165. *Platyplectrurus madurensis ruhunae* Deraniyagala, 1954. Status: Endemic. DOUBTFUL SPECIES.

Genus: Pseudotyphlops Schlegel, 1839

166. *Pseudotyphlops philippinus* (Schlegel, 1839). English: Large shield tail, Sinhala: Maha bimulla. Status: Endemic.

Genus: Rhinophis Hemprich, 1820

167. *Rhinophis blythii* (Kelaart, 1853). English Blyth's earth snake, Sinhala: Gomarathudulla. Status: Endemic.
168. *Rhinophis dorsimaculatus* (Deraniyagala, 1941). English: Orange shield tail, Sinhala: Thambapani walga ebaya. Status: Endemic.
169. *Rhinophis drummondhayi* (Wall, 1921). English: Drummond-Hay's earth snake, Sinhala: Thapothudulla. Status: Endemic.
170. *Rhinophis homolepis* (Hemprich, 182). English: Kelaarts earth snake, Sinhala: Depaththudulla. Status: Endemic
171. *Rhinophis oxyrynchus* (Schneider, 1801). English: Schneider's earth snake, Sinhala: Ulthudulla. Status: Endemic.
172. *Rhinophis philippinus* (Cuvier, 1829). English: Cuvier's earth snake, Sinhala: Cuvierge walga ebaya. Status: Endemic.
173. *Rhinophis porrectus* (Wall, 1921). English: Willey's earth snake, Sinhala: Digthudulla. Status: Endemic.
174. *Rhinophis punctatus* (Müller, 1832). English: Muller's earth snake, Sinhala: Ticthudulla. Status: Endemic.
175. *Rhinophis tricoloratus* (Deraniyagala, 1975). English: Deraniyagala's shield tail, Sinhala: Deraniyagalage walga ebaya. Status: Endemic.

Genus: Uropeltis Duméril, Bibron & Duméril, 1854.

176. *Uropeltis melanogaster* (Gray, 1858). English: Black shield tail, Sinhala: Kaluwakatulla. Status: Endemic.
177. *Uropeltis phillipsi* (Nicholls, 1929). English: Phillips's shield tail, Sinhala: Iriwakatulla. Status: Endemic.
178. *Uropeltis ruhunae* (Deraniyagala, 1954). Status: Endemic. DOUBTFUL SPECEIS.

FAMILY VIPERIDAE Oppel, 1811

Genus: Daboia Gray, 1842

179. *Daboia russelii russelii* (Shaw & Nodder, 1797). English: Russell's viper, Sinhala: Tith Polonga. Status: Not endemic.

Genus: Echis Merrem, 1820

180. *Echis carinatus carinatus* (Schneider, 1801). English: Saw scale viper, Sinhala: Vali polonga. Status: Not endemic.

Genus: Hypnale Fitzinger, 1843

181. *Hypnale hypnale* (Merrem, 1820). English: The Merrem's Hump nose viper, Sinhala: Polonthelissa. Status: Not endemic.
182. *Hypnale nepa* (Laurenti, 1768). English: Merrem's hump-nosed viper, Sinhala: Mukalan thelissa. Status: Endemic.
183. *Hypnale walli* (Gloyd, 1977). English: Gloyd's Hump-nosed viper, Sinhala: Kuda mukalan thelissa. Status: Endemic.

Genus: Trimeresurus (Lacépčde, 1804)

184. *Trimeresurus trigonocephalus* (Latereille in: Sonini & Latreille, 1801). English: Green pit viper, Sinhala: Pala polonga. Status: Endemic.

Appendix 2: Distribution of reptiles of Sri Lanka in the seven vegetation zones

Distribution zones:

A1 = Monsoon scrub jungle - extreme north and North West.

A2 = Monsoon scrub jungle - extreme south east

B = Monsoon forest and grassland

C = Inter monsoon forests

D1 = Rain forest and grassland – below 900 m

D2 = Rain forest and grassland – 900 to 1500 m

D3 = Rain forest and grassland – above 1500 m

* = Five species of marine turtles that visit the beaches of A1, A2, B, C, and D1

** = Marine and snakes that inhabit estuaries, mangroves along the beaches of A1, A2, B, C, and D1

●% = The species of the genus *Sphenomorphus* is presently subjected to revision. Thus not listed under vegetation zones.

Occurrence: P – present, Ab – Absent, NR – not recorded

Source: Bahir & Maduwage, 2005; Bahir & Silva, 2005 and Batuwita & Bahir, 2005; de Silva, 2001, Das & de Silva, 2005.

Species	**A1**	**A2**	**B**	**C**	**D1**	**D2**	**D3**
1. *Crocodylus palustris*	P	P	P	P	NR	Ab	Ab
2. Crocodylus porosus	P	P	P	P	P	Ab	Ab
CROCODILIA	2	2	2	2	1	Ab	Ab
3. *Melanochelys trijuga parkeri*	NR	NR	P	NR	Ab	Ab	Ab
4. *Melanochelys trijuga thermalis*	P	P	P	P	P	NR	Ab
5. *Caretta caretta* *	P	P	NR	P	P	Ab	Ab
6. *Chelonia mydas* *	P	P	P	P	P	Ab	Ab
7. *Eretmochelys imbricata* *	P	P	P	P	P	Ab	Ab
8. *Lepidochelys olivacea* *	P	P	P	P	P	Ab	Ab
9. *Dermochelys coriacea* *	P	P	P	P	P	Ab	Ab
10. *Geochelone elegans*	P	P	P	P	Ab	Ab	Ab
11. *Lissemys punctata punctata*	P	P	P	P	P	Ab	Ab
TESTUDINES	8	8	8	8	7	Ab	Ab
12. *Calotes calotes*	P	P	P	P	P	P	Ab
13. *Calotes ceylonensis*	NR	NR	P	P	NR	Ab	Ab
14. *Calotes desilvai*	Ab	Ab	Ab	Ab	P	NR	Ab
15. *Calotes liocephalus*	Ab	Ab	Ab	Ab	P	P	Ab
16. *Calotes liolepis*	Ab	Ab	P	P	P	P	Ab
17. *Calotes nigrilabris*	Ab	Ab	Ab	Ab	Ab	P	P
18. *Calotes versicolor versicolor*	P	P	P	P	P	P	P
19. *Ceratophora aspera*	Ab	Ab	Ab	Ab	P	Ab	Ab
20. *Ceratophora erdeleni*	Ab	Ab	Ab	Ab	P	NR	Ab
21. *Ceratophora karu*	Ab	Ab	Ab	Ab	P	NR	Ab
22. *Ceratophora stoddartii*	Ab	Ab	Ab	Ab	Ab	P	P

23. *Ceratophora tennentii*	Ab	Ab	Ab	Ab	Ab	P	P
24. *Cophotis ceylanica*	Ab	Ab	Ab	Ab	Ab	P	P
25. *Lyriocephalus scutatus*	Ab	Ab	NR	NR	P	P	Ab
26. *Otocryptis nigristigma*	NR	NR	P	P	Ab	Ab	Ab
27. *Otocryptis wiegmanni*	NR	NR	NR	P	P	P	Ab
28. *Sitana ponticeriana*	P	P	P	P	Ab	Ab	Ab
29. *Chamaeleo zeylanicus*	P	P	P	NR	Ab	Ab	Ab
30. *Calodactylodes illingworthorum*	Ab	Ab	P	P	Ab	Ab	Ab
31. *Cnemaspis jerdoni scalpensis*	Ab	Ab	P	P	P	Ab	Ab
32. *Cnemaspis kandiana*	Ab	Ab	Ab	P	P	P	Ab
33. *Cnemaspis podihuna*	Ab	Ab	P	P	NR	Ab	Ab
34. *Cnemaspis tropidogaster*	Ab	Ab	NR	P	P	P	Ab
35. *Cosymbotus platyurus*	NR	NR	NR	NR	NR	NR	NR
36. *Cyrtodactylus cracens*	Ab	Ab	Ab	Ab	P	NR	Ab
37. *Cyrtodactylus edwardtaylori*	Ab	Ab	Ab	Ab	Ab	P	Ab
38. *Cyrtodactylus fraenatus*	Ab	Ab	Ab	Ab	P	Ab	Ab
39. *Cyrtodactylus ramboda*	Ab	Ab	Ab	Ab	P	NR	Ab
40. *Cyrtodactylus soba*	Ab	Ab	Ab	Ab	P	P	Ab
41. *Cyrtodactylus subsolanus*	Ab	Ab	Ab	Ab	P	Ab	Ab
42. *Geckoella collegalensis*	Ab	Ab	P	Ab	Ab	Ab	Ab
43. *Geckoella triedrus*	Ab	Ab	Ab	NR	P	P	NR
44. *Geckoella yakhuna*	P	NR	P	P	Ab	Ab	Ab
45. *Gehyra mutilata*	P	P	P	P	P	P	NR
46. *Hemidactylus brookii parvimaculatus*	P	P	P	P	P	NR	Ab
47. *Hemidactylus depressus*	P	P	P	P	P	NR	Ab
48. *Hemidactylus frenatus*	P	P	P	P	P	P	NR
49. *Hemidactylus leschenaultii*	P	P	P	P	NR	Ab	Ab
50. *Hemidactylus maculatus hunae*	Ab	Ab	P	P	NR	Ab	Ab
51. *Hemidactylus scabriceps*	P	Ab	Ab	Ab	Ab	Ab	Ab
52. *Hemidactylus triedrus lankae*	P	NR	P	P	P	Ab	Ab
53. *Hemiphyllodactylus typus*	Ab	Ab	NR	P	P	Ab	Ab
54. *Lepidodactylus lugubris*	Ab	Ab	Ab	NR	P	Ab	Ab
55. *Ophisops leschenaultii lankae*	P	Ab	P	NR	Ab	Ab	Ab
56. *Ophisops minor minor*	P	Ab	P	NR	Ab	Ab	Ab
57. *Chalcidoseps thwaitesii*	Ab	Ab	Ab	Ab	P	P	Ab
58. *Dasia halianus*	P	P	P	P	P	Ab	Ab
59. *Lankascincus deignani*	Ab	Ab	Ab	Ab	P	P	Ab
60. *Lankascincus deraniyagalae*	Ab	Ab	Ab	Ab	P	P	Ab
61. *Lankascincus fallax*	P	P	P	P	P	P	NR
62. *Lankascincus gansi*	Ab	Ab	Ab	Ab	P	NR	Ab
63. *Lankascincus taprobanensis*	Ab	Ab	Ab	Ab	P	P	P
64. *Lankascincus taylori*	Ab	Ab	Ab	Ab	P	P	NR

65. *Lygosoma punctatus*	P	P	P	P	P	Ab	Ab
66. *Lygosoma singha*	NR	NR	P	NR	Ab	Ab	Ab
67. *Mabuya beddomii*	P	NR	NR	NR	Ab	Ab	Ab
68. *Mabuya bibronii*	P	P	P	NR	Ab	Ab	Ab
69. *Mabuya carinata lankae*	P	P	P	P	P	P	Ab
70. *Mabuya floweri*	P	Ab	P	Ab	Ab	Ab	Ab
71. *Mabuya macularia maculara*	P	P	P	P	P	Ab	Ab
72. *Mabuya madaraszi*	P	NR	P	P	P	Ab	Ab
73. *Nessia bipes*	Ab	Ab	Ab	Ab	Ab	P	Ab
74. *Nessia burtonii*	Ab	Ab	Ab	Ab	P	P	Ab
75. *Nessia deraniyagalai*	Ab	Ab	P	Ab	Ab	Ab	Ab
76. *Nessia didactylus*	Ab	Ab	Ab	Ab	P	Ab	Ab
77. *Nessia hickanala*	P	Ab	Ab	Ab	Ab	Ab	Ab
78. *Nessia layardi*	Ab	Ab	Ab	Ab	P	Ab	Ab
79. *Nessia monodactylus*	Ab	Ab	Ab	Ab	P	Ab	Ab
80. *Nessia sarasinorum*	Ab	Ab	P	P	P	Ab	Ab
81. *Sphenomorphus dorsicatenatus* ●							
82. *Sphenomorphus dussumieri* ●							
83. *Sphenomorphus megalops* ●							
84. *Sphenomorphus rufogulus* ●							
85. *Sphenomorphus striatopunctatus* ●							
86. *Varanus bengalensis*	P	P	P	P	P	Ab	Ab
87. *Varanus salvator salvator*	P	P	P	P	P	Ab	Ab
SAURIA	26	17	34	30	45	26	6
88. *Acrochordus granulatus* **	P	P	P	P	P	Ab	Ab
89. *Gongylophis conica brevis*	P	P	P	Ab	Ab	Ab	Ab
90. *Python molurus molurus*	P	P	P	P	P	Ab	Ab
91. *Cylindrophis maculate*	P	Ab	P	P	P	Ab	Ab
92. *Ahaetulla nasuta*	P	P	P	P	P	Ab	Ab
93. *Ahaetulla pulverulenta*	P	P	P	P	P	Ab	Ab
94. *Amphiesma stolatum*	P	P	P	P	P	Ab	Ab
95. *Argyrogena fasciolata*	P	Ab	P	Ab	Ab	Ab	Ab
96. *Aspidura brachyorrhos*	Ab	Ab	Ab	P	P	Ab	Ab
97. *Aspidura copei*	Ab	Ab	Ab	Ab	NR	P	Ab
98. *Aspidura deraniyagalae*	Ab	Ab	Ab	Ab	Ab	NR	P
99. *Aspidura drummondhayi*	Ab	Ab	Ab	Ab	Ab	P	NR
100. *Aspidura guentheri*	Ab	Ab	Ab	Ab	P	Ab	Ab
101. *Aspidura trachyprocta*	Ab	Ab	Ab	Ab	Ab	P	P
102. *Atretium schistosum*	P	P	P	P	P	Ab	Ab
103. *Balanophis ceylonensis*	Ab	Ab	Ab	Ab	P	Ab	Ab
104. *Boiga barnesii*	Ab	Ab	Ab	Ab	P	P	Ab
105. *Boiga beddomei*	P	Ab	P	P	Ab	Ab	Ab

106. *Boiga ceylonensis*	Ab	Ab	P	P	P	P	Ab
107. *Boiga forsteni*	P	NR	P	P	P	Ab	Ab
108. *Boiga trigonatus trigonatus*	P	P	P	P	P	Ab	Ab
109. *Cerberus rynchops* **	P	P	P	P	P	Ab	Ab
110. *Cercaspis carinata*	Ab	Ab	Ab	Ab	P	Ab	Ab
111. *Chrysopelea ornata ornata*	NR	Ab	P	P	P	Ab	Ab
112. *Chrysopelea taprobanica*	P	NR	P	P	Ab	Ab	Ab
113. *Coeloganthus helena*	P	P	P	P	P	Ab	Ab
114. *Dendrelaphis bifrenalis*	P	NR	P	NR	P	Ab	Ab
115. *Dendrelaphis caudolineolatus*	Ab	Ab	NR	NR	P	NR	Ab
116. *Dendrelaphis oliveri*	P	Ab	P	Ab	Ab	Ab	Ab
117. *Dendrelaphis tristis*	P	Ab	P	P	P	Ab	Ab
118. *Dryocalamus gracilis*	P	Ab	P	P	P	Ab	Ab
119. *Dryocalamus nympha*	P	Ab	P	P	P	Ab	Ab
120. *Gerarda prevostianus* **	P	NR	P	P	P	Ab	Ab
121. *Haplocercus ceylonensis*	Ab	Ab	Ab	Ab	P	P	Ab
122. *Liopeltis calamaria*	P	Ab	P	P	P	Ab	Ab
123. *Lycodon aulicus*	P	P	P	P	P	Ab	Ab
124. *Lycodon osmanhilli*	Ab	Ab	Ab	Ab	P	Ab	Ab
125. *Lycodon striatus sinhaleyus*	Ab	Ab	Ab	P	P	Ab	Ab
126. *Macropisthodon plumbicolor palabariya*	Ab	Ab	P	P	P	P	Ab
127. *Oligodon arnensis*	P	P	P	P	P	Ab	Ab
128. *Oligodon calamarius*	Ab	Ab	Ab	Ab	P	Ab	Ab
129. *Oligodon sublineatus*	Ab	Ab	Ab	P	P	Ab	Ab
130. *Oligodon taeniolata ceylonicus*	P	P	P	P	Ab	Ab	Ab
131. *Oligodon taeniolata fasciatus*	Ab	Ab	Ab	Ab	P	Ab	Ab
132. *Ptyas mucosa maxima*	P	P	P	P	P	P	P
133. *Sibynophis subpunctatus*	Ab	Ab	P	P	P	Ab	Ab
134. *Xenochrophis asperrimus*	P	P	P	P	P	Ab	Ab
135. *Xenochrophis piscator piscator*	P	P	P	P	P	Ab	Ab
136. *Bungarus caeruleus*	P	P	P	P	Ab	Ab	Ab
137. *Bungarus ceylonicus ceylonicus*	Ab	Ab	Ab	P	P	P	Ab
138. *Bungarus ceylonicus karavala*	Ab	Ab	Ab	Ab	Ab	P	P
139. *Calliophis melanurus sinhaleyus*	P	P	P	P	P	Ab	Ab
140. *Naja naja*	P	P	P	P	P	P	Ab
141. *Astrotia stokesii* **	P	P	P	P	P	Ab	Ab
142. *Enhydrina schistosa* **	P	P	P	P	P	Ab	Ab
143. *Hydrophis bituberculatus* **	P	P	P	P	P	Ab	Ab
144. *Hydrophis cyanocinctus* **	P	P	P	P	P	Ab	Ab
145. *Hydrophis gracilis***	P	P	P	P	P	Ab	Ab
146. *Hydrophis lapemoides***	P	P	P	P	P	Ab	Ab
147. *Hydrophis ornatus ornatus***	P	P	P	P	P	Ab	Ab

148. *Hydrophis spiralis***	P	P	P	P	P	Ab	Ab
149. *Hydrophis stricticollis***	P	P	P	P	P	Ab	Ab
150. *Kerilia jerdonii* **	P	P	P	P	P	Ab	Ab
151. *Lapemis curtus* **	P	P	P	P	P	Ab	Ab
152. *Pelamis platurus* **	P	P	P	P	P	Ab	Ab
153. *Thalassophina viperina* **	P	P	P	P	P	Ab	Ab
154. *Ramphotyphlops braminus*	P	P	P	P	P	Ab	Ab
155. *Typhlops ceylonicus*	Ab	Ab	Ab	Ab	P	Ab	Ab
156. *Typhlops lankaensis*	Ab	Ab	P	Ab	Ab	Ab	Ab
157. *Typhlops leucomelas*	Ab	Ab	Ab	P	P	Ab	Ab
158. *Typhlops malcolmi*	Ab	Ab	P	Ab	Ab	Ab	Ab
159. *Typhlops mirus*	Ab	Ab	Ab	Ab	P	Ab	Ab
160. *Typhlops porrectus*	Ab	Ab	Ab	Ab	P	P	Ab
161. *Typhlops tenebrarum*	Ab	Ab	P	Ab	Ab	Ab	Ab
162. *Typhlops veddae*	Ab	Ab	P	Ab	Ab	Ab	Ab
163. *Typhlops violaceus*	Ab	Ab	P	Ab	Ab	Ab	Ab
164. *Platyplectrurus madurensis ruhunae*	Ab	Ab	Ab	Ab	P	Ab	Ab
165. *Pseudotyphlops philippinus*	Ab	Ab	P	P	P	Ab	Ab
166. *Rhinophis blythii*	Ab	Ab	Ab	Ab	P	P	P
167. *Rhinophis dorsimaculatus*	P	Ab	Ab	Ab	Ab	Ab	Ab
168. *Rhinophis drummondhayi*	Ab	Ab	Ab	P	P	P	Ab
169. *Rhinophis homolepis*	Ab	Ab	Ab	Ab	P	Ab	Ab
170. *Rhinophis oxyrynchus*	P	Ab	P	Ab	Ab	Ab	Ab
171. *Rhinophis philippinus*	Ab	Ab	Ab	Ab	P	Ab	Ab
172. *Rhinophis porrectus*	P	Ab	Ab	Ab	Ab	Ab	Ab
173. *Rhinophis punctatus*	Ab	Ab	Ab	Ab	P	Ab	Ab
174. *Rhinophis tricoloratus*	Ab	Ab	Ab	Ab	P	Ab	Ab
175. *Uropeltis melanogaster*	Ab	Ab	Ab	Ab	P	P	Ab
176. *Uropeltis phillipsi*	Ab	Ab	Ab	Ab	P	P	Ab
177. *Uropeltis ruhunae*	Ab	Ab	Ab	Ab	P	Ab	Ab
178. *Daboia russelii russelii*	P	P	P	P	P	P	Ab
179. *Echis carinatus carinatus*	P	P	P	P	Ab	Ab	Ab
180. *Hypnale hypnale*	P	P	P	P	P	P	Ab
181. *Hypnale nepa*	Ab	Ab	Ab	Ab	P	P	P
182. *Hypnale walli*	Ab	Ab	Ab	Ab	P	P	P
183. *Trimeresurus trigonocephalus*	P	P	P	P	P	P	P
SERPENTES	52	37	59	56	75	21	8
GRAND TOTAL (except Sphenomorphus)	88	64	103	96	128	47	14

THE FAUNA OF SRI LANKA (2006): 164-203

Avifaunal List of Sri Lanka

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Abstract

The paper elaborates on a scientific discussion related to the avifaunal richness in Sri Lanka, and presents the current avifaunal list in the island, based on a set of scientific criteria and principles. The list includes 482 species, under eleven categories. These include 220 breeding residents. Aspects related to their distribution, research and conservation is also discussed briefly.

Key Words: *Birds, Endemics, Conservation*

Introduction

Avian taxonomy has undergone vast changes over the last 15 years. These have caused tremendous debate among professional ornithologists, it is only now, and that some settlement is seen in the literature. New techniques in the identification of species using DNA-DNA hybridization methodologies resulted in this primary change.

In 1990 Sibley and Monroe (Sibley Monroe 1990) stunned the ornithological world by publishing the "Distribution and Taxonomy of Birds of the World" based on the new method (Sibley & Ahlquist 1990). Their publication presented a highly novel taxonomic scheme for birds of the world. Secondly, they also proposed revisions to common English names for some known species. Their classification has been highly controversial among professional ornithologists, but was nevertheless adopted by the Oriental Bird Club. The result was too much for even the professional ornithological taxonomist, so that the acceptance of the revised classification was almost suspended for need of further verification. Further work over the year has now clearly resulted in its acceptance as evident from the numerous publications that are coming out.

The avifaunal list of a country is further complicated by the large number of amateur birdwatchers who are not scientists but merely persons interested in the avian organism; this phenomenon is not present in most other faunal groups. Further, over the years with the upsurge of interest in biodiversity and the consequent commercialization of bird watching; species lists have been flouted to enhance the "image of the country's bird life with absolute disregard to the principles of taxonomy. This unscientific approach to listing species has affected most seriously the endemic species.

Species names and certain classification changes are recognized by taxonomists, even though it is not always accepted or appreciated by amateur bird watchers. One other factor that affects the species list of a country is the character of birds migrating and appearing in unexpected locations because of their flying ability. The decision as to whether to include such sight records in the "country list" has always been difficult. However, considering the positive contributions that such sight records can have; the authors have adopted a system following already accepted practices.

Species richness of birds in Sri Lanka

Bird species lists for Sri Lanka have been published by Phillips (1978), Ripley (1982), Perera and Kotagama (1983), De Silva (1990), Wijesinghe (1994), Inskipp et al (1996), and Grimmett et al (1998) over the last two decades. Except for Wijesinghe (1994), all the other publications of the 90's have followed the same principles of taxonomy.

There are numerous apparent inconsistencies between the lists and the taxonomy adopted by some authors, requires us to state some basic principles on which the list must be based on. Therefore, this “Avifaunal list of Sri Lanka” is based on the following criteria and principles.

1. Taxonomy (includes scientific nomenclature and classification)

We have followed the taxonomy (nomenclature and classification) of Grimmett et al (1998) which is based on Inskipp et al (1996). The nomenclature and classification of both these publications is based on Sibley and Monroe (1990). This is not new to Sri Lanka as the senior author had already used Sibley and Monroe’s classification in A Field Guide to the Birds of Sri Lanka (Kotagama and Fernando 1994) and in the Sinhala publication Sirilaka Kurullo (Kotagama and Wijayasinha 1998).

The scientific names in the recent publication by Rasmussen & Anderton (2005) “are those of Ali & Ripley (1983) with some changes adopted by Inskipp et al (1996) and subsequent authors”. A closer look at the taxonomic status of species in the new publication, has however opened up a new situation. The taxonomic status of some species has been given as “ Taxonomy-dependent”. The definition given in the glossary of the book is “ Used here to indicate that extralimital range statement depends on species limits adopted”. We interpret this, to mean that there is some more taxonomic work needed to be done, to make such a species a definitive species. Accordingly, we have not changed the scientific names in this list from that published for Sri Lanka previously (Kotagama and Wijayasinha 1998). However, for reference we have indicated as foot notes all such changes proposed by Rasmussen & Anderton (2005).

Even though text or illustrations distributed electronically (e.g. by means of the World Wide Web) are treated as “unpublished” by the ICZN 4th Edition; Article 9/9.8, we have included literature source information for taxa from the most widely published electronic version of the avifaunal taxonomy compiled and updated by Alan P Peterson. (www.zoonomen.net/avtax). This electronic version is constantly being updated. A visit to this site will give an indication of the complications of avifaunal taxonomy and its constant changes.

2. Species List

The species list is based on the following principles taking in to consideration the factor of flight, and the large number of “bird watchers” both local and foreign now looking out for birds in the country. “An annotated species list of the birds of Sri Lanka” (Kotagama et al in press) is to be published shortly.

Over the years the species number has increased considerably as there are more observers looking for birds than in the past. This has also become a problem, as the acceptance of some of these sightings, being subjective, has caused groups taking opposing stands on the issue. Including these subjective identifications in a scientific listing of species within a geographic area will always be controversial. We believe our principles will however overcome this problem without unduly affecting the contributions of bird watchers.

The list of species compiled for Sri Lanka in the current article includes 482 species (Appendix 1), under eleven categories (Table 1), based on the criteria and principles explained here.

Table 1: Present avifaunal richness in Sri Lanka

Catergory	Number
Breeding Residents (BrR)	220
Winter Visitors (WV)	127
Winter Vagrants (WVa)	69
Status Uncertain (SU)	38
Vagrant (Va)	10

Summer Visitor (SV)	4
Passage Migrants (PM)	2
Breeding Resident and Winter Visitor (BrR & WV)	5
Breeding Resident and Summer Visitor (BrR & SV)	1
Breeding Resident/ Uncertain Winter Visitor (BrR/UWV)	5
Winter Visitor/ Uncertain Breeding Resident (WV/UBr)	1
Total species number	**482**

3. Format of species categorization

The following categorization of species is modified from a system devised by the Records Committee of the British Ornithologists' Union. While accepting that this categorization is, to some extent arbitrary; it is our opinion that this represents the best compromise under the circumstances. It is hoped that this will encourage naturalists to report new sightings and that ornithologists will pay more attention to species in List III.

List I. Includes species whose presence is confirmed by one or more specimens in Legge (1983), Wait (1931), Whistler (1946), Phillips (1978) and other confirmed publications and sight records within the last 25 years. A total of 359 belongs to List. I (Appendix 1)

List II. Includes species for which there are three or more sight records. Sightings should be confirmed by more than one observer or documented by valid description in a recognized refereed ornithological or scientific publication. Species with specimens but not recorded (sighted) within last 25 years are also included here. A total of 41 species belongs to List II (Appendix II).

List III. Includes species for which there are one or two sight- records. [Observers are encouraged to pay particular attention to species in this list, some of which may be more common than the records indicate]. A total of 82 species belongs to List III (Appendix 1).

4. Sub-species

The number of birds present in Sri Lanka has been boosted with the use of sub species, e.g. Phillips (1978) lists "427 birds", but the same author has listed only 100 mammal species (Phillips 1980, 1981, 1984). If his mammal lists were expanded to sub-species level the list would increase to 130!

The recognition of sub species is however more difficult in the present dynamic "taxonomically volatile environment". With a great desire to revise the traditional taxonomy using modern tools, and also the new emphasis on biodiversity, endemic species and conservation of isolated species, has resulted in many sub species being upgraded to species level. Further, the boundaries of discrimination needed for differentiation have been severely questioned. All these have resulted in the practice of listing organisms in a country at "species level", unless the sub species is definitely distinctive.

In order avoid further confusions, the species listing adopted here is based on "definitive full or true species" and not sub species.

5. Endemic Species

The number of endemic species has undergone numerous changes over the years. Much of this has been the result of "close taxonomic revisions" (Table 2). Since 1977 the numbers basically settled at around 21. This increased with the addition of two species in 1990 bringing the total to 23. The number in Sibley & Monroe (1990), Kotagama and Fernando (1994), Kotagama and Wijayasinha (1998), Harrison (1999), Inskipp et al (1996) and Grimmett et al (1998) is 23 definitive endemic species.

Table 2: Changes in the number of endemic birds recognized for Sri Lanka since 1872

Year	Number of Species	Reference	Comment
1872	37	Holdsworth – *Catalogue of Birds found in Ceylon*	
1880	47	Legge – *A history of birds of Ceylon*	Including 17 species in the present list
1931	25	Wait – *Manual of Birds of Ceylon*	Excluded the Red faced-Malkoha
1944	22	Whistler – *Avifaunal survey of Ceylon*	
1946	20	Ripley – *Comments to Endemic Birds of Ceylon*	Grey Hornbill, Rufous Babbler and Red- faced Malkoha were excluded
1952	21	Phillips – *Revised Checklist of Birds of Ceylon*	Red- faced Malkoha and Ceylon Grackle included
1975	20	Phillips – *Revised Checklist of Birds of Ceylon*	Black capped Bulbul excluded
1977	21	Flemming – *Notes on endemic birds of Ceylon*	Rufous Babbler included
1978	21	Phillips – *Revised checklist of Birds of Ceylon*	
1990	23+1	Sibley & Monroe – *Distribution and Taxonomy of Birds of the World*	Crimson fronted Barbet suggested as Endemic
1994	23+1	Kotagama and Fernando – *A field guide to the Birds of Sri Lanka*	Follow Sibley and Monroe
1994	23+3	Wijesinghe – *A checklist of the birds of Sri Lanka*	3 species are suggested as Endemic
1996	23+3	Inskip *et al.* – *An Annotated Checklist of the Birds of the Oriental Region*	Follow Sibley and Monroe refers to Wijesinghe
1998	23	Grimmett *et al.* – *Birds of the Indian Subcontinent*	
1999	23	Harrison – *A Field Guide to the Birds of Sri Lanka*	

Wijesinghe (1994) published a “checklist” which considered an addition of three more species, which did not receive widespread acceptance because its treatment was not in keeping with sound taxonomic practice. None of the subsequent publications on the avifauna of the region and Sri Lanka have listed these three species as endemics (Inskipp et al 1996, Grimmett et al 1998).

We have always maintained that the definitive number of endemic species for Sri Lanka was 23 and that three others were “proposed” by Wijesinghe (1994). Subsequently, Warakagoda and Rasmussen (2005) described a new bird species (Serendib Scops Owl - Otus thilohofmanni) that is endemic to Sri Lanka.

However, within Sri Lanka some sectors considered the endemic species proposed by Wijesinghe (1994) as acceptable; although they violated basic principles of scientific taxonomy. This may be due to an over enthusiasm in boosting endemic numbers to create a better ornithological image and increase demand in “commercial bird watching”.

This has now been put to rest by the publication of Rasmussen and Anderton (2005) were the new number of endemics has been given as 33.

In a personal electronic communication prior to the publication Rasmussen (Sri Lanka Wildlife News-April 2004) indicated that the number of endemic species would rise to 33. In her note she stated:

"Based on this work, which will be described fully in the forthcoming book, the proposed list of thirty three Sri Lankan Endemic Birds is given below." Further, she stated, "The ten newly recognized endemics, which will doubtless attract renewed interest, are listed below for convenience."

The "taxonomic status" assigned to these 33 birds however, has complicated the final number of endemic species. Some of them are "taxonomic-dependent", while others are not (Table 3). Two species that were definitive species under Grimmett et al. (1998) have been given as "taxonomic-dependent" – in this case we retain the former status till verified fully.

Accordingly, based on our interpretation of "taxonomic-dependent", we propose that the number of endemics should be "25 definitive and eight as proposed, making a total of 33 species", as highlighted in Table 3.

Table 3: Status change of endemic species based on Rasmussen & Anderton (2005)

Species	**Grimmett et al. 1998**	**Rasmussen & Anderton (2005)**
GALLIFORMES: 1.*Galloperdix bicalcarata*	Endemic	Endemic
2. *Gallus lafayetii*	Endemic	Endemic
PICIFORMES 3. *Chrysocolaptes lucidus*	-	**Endemic; Taxonomy dependent** *Chrysocolaptes lucidus stricklandi* upgraded to *C. stricklandi*
4. *Megalaima flavifrons*	Endemic	Endemic
5. *Megalaima rubricapilla*	-	Endemic - *M. r. rubricapilla* upgraded to *M. rubricapilla*
BUCEROTIFORMES: 6. *Ocyceros gingalensis*	Endemic	Endemic
CUCULIFORMES: 7. *Phaenicophaeus pyrrhocephalus*	Endemic	Endemic
8. *Centropus chlororhynchus*	Endemic	Endemic
PSITTACIFORMES: 9. *Loriculus beryllinus*	Endemic	Endemic
10. *Psittacula calthropae*	Endemic	Endemic
STRIGIFORMES: 11. *Otus thilohofmanni*		Endemic
12. *Glaucidium castanonotum*	Endemic	**Endemic; taxonomy-dependent**
COLUMBIFORMES: **13. *Columba torringtoni***	Endemic	**Endemic**
14. *Treron pompadora*	-	Endemic; taxonomy dependent *T.p.pompodora* upgraded to *T. pompodara*
PASSERIFORMES: 15. *Urocissa ornate*	Endemic	Endemic

*16. *Dicrurus paradiseus lophorhinus*	-	Endemic; taxonomy dependent*Dicrurus paradiseus lophorhinus* upgraded to *D. lophorhinus*
*17. *Tephrodornis pondicerianus*	-	Endemic; taxonomy dependent*T. pondicerianus affinis* upgraded to *T. affinis*
18. *Myophonus blighi*	Endemic	Endemic
19. *Zoothera spiloptera*	Endemic	Endemic
20. *Zoothera dauma*	-	Endemic; taxonomy dependent *Z. dauma imbricata* upgraded to *Z. imbricata*
21. *Eumyias sordida*	Endemic	Endemic
22. *Sturnus albofrontatus*	Endemic	Endemic
23. *Gracula ptilogenys*	Endemic	Endemic; taxonomy dependent
24. *Pycnonotus penicillatus*	Endemic	Endemic
25. *Pycnonotus melanicterus*	Endemic	Endemic; taxonomy dependent *P. m. melanicterus* upgraded to *P. melanicterus*
26. *Zosterops ceylonensis*	Endemic	Endemic
27. *Bradypterus palliseri*	Endemic	Endemic
28. *Garrulax cinereifrons*	Endemic	Endemic
29. *Pellorneum fuscocapillum*	Endemic	Endemic
30. *Pomatorhinus horsfieldii*	-	Endemic; taxonomy dependent *P. schisticeps melanurus* and *P.s. holdsworthii* upgraded to *P (schisticeps) melanurus*
31. *Turdoides rufescens*	Endemic	Endemic
32. *Dicaeum vincens*	Endemic	Endemic
33. *Hirundo daurica*	-	Endemic; taxonomy dependent Sub species *H. daurica hyperythra* Upgraded to *H. hyperythra*

6. Vernacular names

We are well aware that vernacular names have no place in scientific taxonomy. However, because of the unusual interest in birds and the growing public interest in "bird watching" both internationally and locally, we felt that it would justify the inclusion of the vernacular names. The names are available only for English and Sinhala, while Tamil names are in preparation. Hence, they are not included here.

6.1 English vernacular names

The English names follow Grimmett et al (1998). It must be emphasized here that the use of country prefix (Sri Lanka) in common names has been restricted to endemic species only. We do not agree with the reason for use of Ceylon by Sibley & Monroe (1990), as we do not agree with their reason for retaining "Ceylon" which is - " Sri Lanka occupies the island of Ceylon, but the geographical name is normally used for bird ranges (as Madagascar is used rather than its nation, the Malagasy Republic." This is totally unacceptable in any geographical sense.

We also do not agree with the reasoning given in the ENVIS list (Manakadan & Pittie 2001) for retaining "Ceylon".

We take the stand that the change of the English name from Ceylon to Sri Lanka should be properly reflected and it should therefore be used only for endemic birds as was proposed by the senior author and accepted by most authorities since 1983.

6.2 Sinhala vernacular names

The Sinhala names follow the principles developed by Perera & Kotagama (1983), modified and published in Kotagama & Wijayasinha (1998). These principles bring the Sinhala vernacular names in line with the scientific names and enable the coining of Sinhala names for all avian species for the world as well as higher taxonomic levels. The higher taxonomic names are not given in this publication.

7. Distribution

The distribution of birds is based very much on subjective deductions supplemented by observations over the years. No formal distributional survey has been conducted to date. The initial attempts to rectify this situation were done with the first Zoological Survey programme launched by the National Science Foundation (then NARESA) in 1984.

The Survey enabled the acceptance of the use of the 10 km2 grid system for the study of the bird distribution. This grid system was developed and applied on an experimental basis and showed that distribution can be given with greater accuracy than with earlier methodology (Kotagama 1986). For lack of funds, the study never took off beyond the initial stage. Thus, the distribution of birds in Sri Lanka is still very much a subjective representation.

The present distribution is based on climatic-topographical delineations recognized as zones, e.g. Dry Zone, Low Country Wet Zone etc. The distribution is also given on the basis of the Avifaunal zones (Kotagama 1986).

Avifaunal zones were recognized using as a basis, studies of the available published distributional information (Kotagama 1986). The zones were an improvement on zones recognized by Legge (1881). Allocation of all the birds to these zones is not yet possible because of limited data availability on the birds.

Use of more refined methods and instruments involving opportunistic observational records, in-depth transect and mist-netting applications should be pursued using the grid; further refined to 5 km2 which is made possible by using accurate GPS coordinates. With the application of GIS, more descriptive and refined distribution patterns could be recognized in the future. This aspect has to be a major component of future research directions

8. Research

Taxonomic research has never been properly achieved in Sri Lanka. Any taxonomic study requires adequate samples and these do not exist even at the National Museum. Numerous foreigners made the earlier collections, and most of the specimens have been deposited in museums across the globe. Duplicate collections no doubt may have been left behind but such specimens are not known to exist. The most comprehensive recent Avifaunal Survey was last conducted in 1936–1939 by Hugh Whistler. What is left of his specimens are in very bad condition.

Very recently, a fairly good collection of specimens appeared on the pavement of Nugegoda town. This was fortunately recovered and handed over to the Museum in 1990. This collection, referred to as the "Zoysa collection", was a personal one made by a Mr. Zoysa, who was a member of the collection team of Hugh Whistler. The specimens have not been described and published by the Museum to date.

Today, it would not be necessary to pursue a specimen collection survey as was done in the past. However, birds will need to be captured where possible without killing them and fresh tissues/blood samples collected for use in modern molecular biological taxonomic treatments such as DNA analysis. Such an exercise would reveal more interesting taxonomic information about the avifauna of the country. This can easily be coupled with a distributional study. The time is right for such a survey and we hope the conservation community will be enlightened by such a benign (“ahimsa”) technique, which will enable us to understand the avifauna and assist in its future conservation.

9. Conservation

The natural habitats of birds have undergone considerable change over the years. These changes have affected the distribution and abundance of birds. The impacts of these changes were presented by Kotagama (1996). The effect can be recognized under three groups:-

- species that have been threatened due to reduction in habitat,
- species that have expanded in response to habitat changes, and
- species with apparently no effect

9.1 Threatened Species

Various authors have over the years tried to recognize affected species. Kotagama (1989) had considered the biology and ecology in an attempt to bring objective considerations into play for the recognition opf threatened species. Moving in this direction, we now have the list in the Asian Red Data Book (2001). These efforts culminated with the BirdLife International / IUCN threatened species listing of 2000, Threatened Birds of the World. These publications recognize 16 species as threatened in Sri Lanka (Table 4). The list contains 1 critical, 2 endangered, and 13 vulnerable species.

Table 4: Threatened Birds of Sri Lanka (based on IUCN criteria) ARDB/ BirdLife / IUCN 2000.

(Status: End – Endemic, BrR – Breeding resident, Vag – Vagrant, Mig – Migrant;
Habitat: For – Forest, Wet – Wetland, OC – Ocean)

CRITICAL

1. Christmas Island Frigatebird *Fregata andrewsi*, Vag, OC

ENDANGERED

2. Spotted Greenshank *Tringa guttifer,* Vag, WET
3. Sri Lanka Whistling-thrush *Myophonus blighi* End, For

VULNERABLE

4. Spot-billed Pelican *Pelecanus philippensis* BrR, Wet
5. Lesser Adjutant *Leptoptilos javanicus* BrR, Wet
6. Lesser Kestrel *Falco naumanni* Mig, For
7. Sociable Lapwing *Vanellus gregarious* Vag, Wet
8. Wood Snipe *Gallinago nemoricola* Mig, Wet
9. Spoon-billed Sand piper *Eurynorhynchus pygmeus* Mig, Wet
10. Sri Lanka Wood-pigeon *Columba torringtoni* End, For
11. Red-faced Malkoha *Phaenicophaeus pyrrhocephalus* End, For
12. Green-billed Coucal *Centropus chlororhynchos* End, For
13. Ashy-headed Laughing Thrush *Garrulax cinereifrons* End, For
14. Kashmir Flycatcher *Ficedula subrubra* Mig, For
15. White faced Starling *Sturnus albofrontatus* End, For
16. Sri Lanka Magpie – *Urocissa ornata* End, For

Near Threatened

- Malabar Pied Hornbill *Anthracoceros cronatus* BrR, For
- Sri Lanka Chestnut-backed Owlet *Glaucidiuim cstanonotum* End,For
- Great Snipe *Gallinago media* Vag, Wet
- Asian Dowithcher *linmodromus semipalmattus* Vag, Wet
- Grey-headed Fish Eagle *Ichthyophaga ichthyaetus* BrR, Wet
- Pallied Harrier *Circus macrourus* Mig, Open Land
- Darter *Anhinga melanogaster* BrR, Wet
- Black headed Ibis *Threskiornis melanocephalus* BrR, Wet
- Painted Stork *Mycteria leucocephala* BrR, Wet
- Black -necked Stork *Ephippiorhynchus asiaticus* BrR, Wet
- Sri Lanka Spot-winged Thrush *Zoothera spiloptera* End,For
- Sri Lanka Dull-blue Flycatcher *Eumyias sordida* End, For
- Sri Lanka Myna *Gracular ptilogenys* End, For
- Sri Lanka Yellow-eared Bullbull *Pycnonotus penicllatus* End, For
- Sri Lanka Bush Warbler *Bradypterus palliseri* End, For
- Sri Lanka Orange-billed Babbler *Tudoides ruffescens* End, For
- Sri Lanka Legge’s Flowerpecker *Dicaeum vincens* End, For

Critical species

The critical species is a pelagic species. It is not a breeding resident of the country and as such, there is very little we can do other than ensuring its total protection when sighted within the territorial waters of Sri Lanka.

Endangered Species

The Endangered species contain one endemic species and one migrant species. The status of the migrant species in the country is “vagrant” and the current records indicate less than three sightings. Providing full protection is the only action possible, as there does not appear any site tenacity to enable site-specific conservation action for such a migrant species.

On the other hand the endemic species is generally found in very restricted locations. Current information justifies recognizing some specific areas for its conservation, and it is also necessary to have some specific research and study instituted to enable development of conservation plans for this species.

Vulnerable species

The strategy for vulnerable species will have to be the same. With very little information on their actual distribution, biology and ecology, any action is going to have very limited impact.

Further to this list a feature (only in birds) is the “near threatened” category. There are 17 species in this category. An analysis of the total threatened and near threatened birds indicates 15 endemics, 8 breeding residents, 5 regular migrants and 5 vagrants. With respect to habitats there are 18 forest birds, 15 wetland birds, one ocean bird and one open habitat bird.

The international criteria developed recognize threatened species at the international level, but fail to recognize some species that are of national concern. This has resulted in the application of modified criteria for recognizing “Nationally threatened species”. The national list initially published in 1989; revised in 1993

(Wijesinghe et al 1989, 1993) contained 56 species. This exercise was further developed by application of modified IUCN criteria by Weerakoon et al in the 2000 List of Threatened fauna and flora of Sri Lanka (IUCN 2000). The work recognized 60 species (Table 4). A further revision is being undertaken with further revised criteria.

9.2 Threats

The principle threat is habitat loss. Most of the species recognized as threatened have been brought to this status due to habitat loss in forests and wetlands. Conservation action requires protecting existing natural habitats. Limited to a few locations and at rather insignificant level is the killing of birds for food etc.

A new threat that has an adverse effect on the avifauna is the "commercialization of bird watching". The use of tape lures to attract rare and elusive birds (mostly endemics) to be shown to foreign visitors by using breeding or communication calls has clearly had its impact. The practice, on the merit of clear evidence, resulted in prohibiting tape lures within Sinharaja Wilderness Area. We wish to record our gratitude to the Conservator of Forest for the prompt action and the Forest Officer at Sinharaja who was enlightened enough to recognize the impact immediately it was reported and acted swiftly to take remedial measures.

The Field Ornithology Group of Sri Lanka (FOGSL) in recognition of potential impacts of "over-watching" has already instituted a Code of Ethics, which it enforces strictly among its members.

9.3 Research constraints

The major constraints related to avifaunal research in Sri Lanka include the following:

1. The lack of due recognition for the science of taxonomy at all levels. Starting from the portals of higher education and research, taxonomy receives the lowest priority. It is often not part of the curriculum and is often excused by the (invalid) argument "that there are no employment prospects for taxonomists". The research/ education institutes do not get the necessary funds and cadres for taxonomy as it is of low priority. Thus, we get caught in the "chicken and egg" situation and the net result being the negative effect on the knowledge of biodiversity.
2. The absence of a proper referral collection to compare and study, to enable any worthwhile taxonomic work to be done. The poor state of specimens in the Museum and inability to have proper access, are some of the problems faced by researchers.
3. The absence of original descriptive literature,
4. The conservation conscious "activists" who are ever ready to voice concern about "biodiversity rich Sri Lanka", are extremely critical if not naive about identifying species based on taxonomic principles.
5. The lack of willingness to apply the "rigor of science" in data collection for gathering information needed for specific conservation actions beyond the designation of areas for protection.

10. Current conservation actions and future directions

In recognition of the threats, the following action has been initiated:

1. IBAs.The need to ensure habitat / ecosystem protection as the principle pathway for conservation of the wild populations, the Important Bird Areas(IBA) programme to recognize habitat/ ecosystems was launched in 2001 by FOGSL. This exercise resulted in the identification from literature and limited field verification of 77 potential IBA's for Sri Lanka. An extensive education programme island wide (except north and east) was also conducted. The follow up will involve a detailed survey of these potential IBA s in the coming years and establishing Site Support Groups (SSG s) to assist in their management with the assistance of the relevant state agency.

2. Research into species. The absence of information on the biology and ecology of the avifauna of Sri Lanka is appalling. It is not surprising, as scientific interest in the subject did not commence till 1976. We now have some reliable information on avian communities but lack species specific information. The initial work commenced with the study on the endemic Spot winged Thrush (Chandralal & Weerakoon in press), and presently a study on the flagship species Blue Magpie (Ratnayake 2004), Ashy headed Babbler (Siriwardena 2004) and the Spot billed Pelican (eco-V 2000 – 2004) is ongoing. More are planned for the future.
3. Database. Sri Lanka can be proud of having the largest database of continuous flock studies in the world at Sinharaja, (Since 1980). Similarly, detailed studies on communication and habitat needs have been pursued in the present flock studies (Goodale et al 2003).
4. Species Recovery Plan. Under the Protected Area Management and Wildlife Conservation Project, plans for species recovery are expected to be initiated. This will enhance the required conservation action for some of the species.
5. Annual Waterfowl Counts. The Ceylon Bird Club has been conducting the Annual Waterfowl Count in Sri Lanka on behalf of Wetlands International. These counts provide data for “estimates and trend analysis” of the use of wetlands by waterfowl. The data however, does not stand the rigor of scientific analysis for “good estimates or census” due to constraints in the data collection methodology. This however does not make the survey redundant for macro level assessments of the waterfowl. It is useful for conservation especially for the identification of wetland sites for designation under the Ramsar criteria.

At least in the case of birds, we do not usually need to collect specimens for identification, but we need to initiate a serious survey to undertake some molecular biological analysis using modern methodologies for taxonomic and phylogenetic studies. We hope that funding for such an activity will be forthcoming in the future.

The taxonomy keeps changing, so does the status of the species in each country, new threats emerge as we go along - monitoring and evaluation is a constant necessity. This exercise repeated at least every five years, will be a major step to put science into its correct perspective and to enable the proper conservation of species.

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Appendix 1: Checklist of avifauna in Sri Lanka

Legends:

(L1) List I. Includes species whose presence is confirmed by one or more specimens in Legge (1983), Waite (1931), Whistler (1944), Phillips (1978) and other confirmed publications and sight records within the last 25 years.

(L2) List II. Includes species for which there are three or more sight records. Sightings should be confirmed by more than one observer or documented by valid description in a recognized refereed ornithological or scientific publication. Species with specimens but not recorded (sighted) within last 25 years are also included here.

(L3) List III. Includes species for which there are one or two sight- records. [Observers are encouraged to pay particular attention to species in this list, some of which may be more common than the records indicate].

BrR	-	Breeding Resident
WV	-	Winter Visitor
WVa	-	Winter Vagrant
Va	-	Vagrant
SU	-	Status Unknown
SV	-	Summer Visitor
PM	-	Passage Migrant
BrR & WV	-	Breeding Resident and Winter Visitor
BrR & SV	-	Breeding Resident and Summer Visitor
BrR/UWV	-	Breeding Resident/ Uncertain Winter Visitor
WV/UBr	-	Winter Visitor/ Uncertain Breeding Resident

Availability of specimens confirmed in..

d – Specimen lodged in Department of Wildlife Conservation, Sri Lanka

w – Whistler. H (1944)

g – Legge. W.V. (1983)

t – Wait. W.E. (1931)

p – Phillips W.W.A. (1978)

GALLIFORMES

PHASIANIDAE

1.	*Francolinus pictus* (Jardine & Selby) 1828 (E: Painted Francolin. S: Tith Watu-kukula)	BrR	L1 [w g]
2.	*Francolinus pondicerianus* (Gmelin) 1789 (E: Grey Francolin. S: Alu Watu-kukula)	BrR	L1 [w g]
3.	*Coturnix coromandelica* (Gmelin) 1789 (E: Rain Quail. S: Wahi Piriwatuwa)	SU	L1 [w g t p]

4. *Coturnix coturnix* (Linnaeus) 1758 WVa L2 [g]
(E: Common Quail. S: Podu Piriwatuwa)
5. *Coturnix chinensis* (Linnaeus) 1766 BrR L1 [w g]
(E: Blue-breasted Quail. S: Laya-nil Piriwatuwa)
6. *Perdicula asiatica* (Latham) 1790 BrR L1 [g]
(E: Jungle Bush-quail. S: Wana Panduru-watuwa)
7. ***Galloperdix bicalcarata*** (Forster, JR) 1781 **END** BrR L1 [w g]
(E: Sri Lanka Spurfowl. S: Sri Lanka Haban-kukula)
8. ***Gallus lafayetii*** Lesson 1831 **END** BrR L1 [g]
(E: Sri Lanka Junglefowl. S: Sri Lanka Wali-kukula)
9. *Pavo cristatus* Linnaeus 1758 BrR L1 [w g]
(E: Indian Peafowl. S: Monora/ Sebeda)

ANSERIFORMES

Dendrocygnidae

10. *Dendrocygna bicolor* (Vieillot) 1816 WV L1 [w g t p]
(E: Fulvous Whistling-duck. S: Maha Thamba-seruwa)
11. *Dendrocygna javanica* (Horsfield) 1821 BrR L1 [g]
(E: Lesser Whistling-duck. S: Heen Thamba-seruwa)

Anatidae

12. *Anser anser* (Linnaeus) 1758 WVa L2 [w g p]
(E: Greylag Goose. S: Karalu Paththaya)
13. *Tadorna ferruginea* (Pallas) 1764 WV L1 [g]
(E: Ruddy Shelduck. S: Rath Sakwalaya)
14. *Sarkidiornis melanotos* (Pennant) 1769 SU L1 [g]
(E: Comb duck. S: Kabaliththiya)
15. *Nettapus coromandelianus* (Gmelin) 1789 BrR L1 [g]
(E: Cotton Pygmy-goose. S: Mal-seruwa)
16. *Anas strepera* Linnaeus 1758 WV L1 [w g t p]
(E: Gadwall. S: Gadwal Seruwa)
17. *Anas penelope* Linnaeus 1758 WV L1 [g t p]
(E: Eurasian Wigeon. S: Eurasiya Wijana Seruwa)
18. *Anas platyrhynchos* Linnaeus 1758 WVa L3
(E: Mallard. S: Mallard Seruwa)
19. *Anas poecilorhyncha* Forster, JR 1781 WV L1 [g p]
(E: Spot-billed Duck S: Thith-hota Seruwa)
20. *Anas clypeata* Linnaeus 1758 WV L1 [g]
(E: Northern Shoveler S: Uthuru Saval Seruwa)
21. *Anas acuta* Linnaeus 1758 WV L1 [g]
(E: Northern Pintail S: Uthuru Ulpenda Seruwa)
22. *Anas querquedula* Linnaeus 1758 WV L1 [g]
(E: Garganey S: Garganey Seruwa)

23. *Anas crecca* Linnaeus 1758 WV L1 [g]
(E: Common Teal S: Podu Seruwa)
24. *Marmaronetta angustirostris* (Menetries) 1832 WVa L3
(E: Marbled Duck S: Garandu-sera)
25. *Rhodonessa rufina* WVa L3
(E: Red-crested Pochard S: Rathu Kudumbi-seruwa)
26. *Aythya ferina* (Linnaeus) 1758 WVa L3
(E: Common Pochard S: Podu Mada-sera)
27. *Aythya fuligula* (Linnaeus) 1758 WV L2 [g p]
(E: Tufted Duck S: Kudumbi Mada-sera)

TURNICIFORMES

TURNICIDAE

28. *Turnix sylvatica* (Desfontaines) 1789 WVa L3
(E: Little Button-quail S: Punchi Bola-watuwa)
29. *Turnix suscitator* (Gmelin) 1789 BrR L1 [w g]
(E: Barred Button-quail S: Bola Watuwa)

PICIFORMES

PICIDAE

30. *Jynx torquilla* Linnaeus 1758 WVa L2
(E: Eurasian Wryneck S: Eurasiya Gelanamiya
31. *Dendrocopus nanus* [*Dendrocopos moluccensis*] (Gmelin) 1788 BrR L1 [w g]
(E: Brown-capped Pygmy Woodpecker S: Bora Esasi Gomara-karela)
32. *Dendrocopos mahrattensis* (Latham) 1802 BrR L1 [w g]
(E: Yellow-crowned Woodpecker S: Kaha-silu Gomara-karela)
33. *Celeus brachyurus* (Vieillot) 1818 BrR L1 [w g]
(E: Rufous Woodpecker S: Borath Koda-karela)
34. *Picus chlorolophus* (Vieillot) 1818 BrR L1 [w g]
(E: Lesser Yellow-naped Woodpecker S: Heen Kaha-gelasi Karela)
35. *Picus xanthopygaeus* (Gray, JE & Gray, GR) 1846 BrR L1 [w]
(E: Streaked-throated Woodpecker S: Punchi Kawuru Karela)
36. *Dinopium benghalense* (Linnaeus) 1758 BrR L1 [w g]
(E: Black-rumped Flameback S: Rath-karela)
37. *Chrysocolaptes lucidus* (Scopoli) 1786 BrR L1 [w g 1]
(E: Greater Flameback S: Lepita Maha-karela)
38. *Chrysocolaptes festivus* (Boddaert) 1783 BrR L1 [w g]
(E: White-naped Woodpecker S: Kahapita Maha-karela)

[1] Rasmussen and Anderton 2005 - *Chrysocolaptes lucidus stricklandi* upgraded to endemic species level under "taxonomic dependent" as *Chrysocolaptes stricklandi*

MEGALAIMIDAE

39. *Megalaima zeylanica* (Gmelin) 1788 — BrR L1[w g]
    (E: Brown-headed Barbet S: Polos Kottoruwa)
40. ***Megalaima flavifrons*** (Cuvier) 1816 **END** — BrR L1[w g]
    (E: Sri Lanka Yellow-fronted Barbet S: Sri Lanka Ranmunatha Kottoruwa)
41. ***Megalaima rubricapilla*** (Gmelin) 1788 — BrR L1[w g 2]
    (E: Crimson-fronted Barbet S: Rathmunath Kottoruwa)
42. *Megalaima haemacephala* (Muller) 1776 — BrR L1[w g]
    (E: Coppersmith Barbet S: Rathlaye Kottoruwa)

BUCEROTIFORMES

Bucerotidae

43. ***Ocyceros gingalensis*** (Shaw) 1811 — BrR L1[w g]
    (E: Sri Lanka Grey Hornbill S: Sri Lanka Alu Kandaththa)
44. *Anthracoceros coronatus* (Boddaert) 1783 — BrR L1[g]
    (E: Malabar Pied Hornbill S: Poru-Kandaththa)

UPUPIFORMES

Upupidae

45. *Upupa epops* Linnaeus 1758 — BrR L1[w g]
    (E: Common Hoopoe S: Podu Poroluwa)

TROGONIFORMES

Trogonidae

46. *Harpactes fasciatus* (Pennant) 1769 — BrR L1[w g]
    (E: Malabar Trogon S: Lohawannichchiya)

CORACIIFORMES

Coraciidae

47. *Coracias benghalensis* (Linnaeus) 1758 — BrR L1[w g]
    (E: Indian Roller S: Dumbonna)
48. *Eurystomus orientalis* (Linnaeus) 1766 — BrR L1[w g t]
    (E: Dollarbird S: Dumkawa)

Alcedinidae

49. *Alcedo atthis* (Linnaeus) 1758 — BrR L1[w g]
    (E: Common Kingfisher S: Mal Pilihuduwa)
50. *Alcedo meninting* Horsfield 1821 — BrR L1[w g]
    (E: Blue-eared Kingfisher S: Nilkan Pilihuduwa)
51. *Ceyx erithacus* (Linnaeus) 1758 — BrR L1[g]
    (E: Oriental Dwarf Kingfisher S: Peradiga Ran-pilihuduwa)

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[2] Rasmussen and Anderton 2005 - Confirms endemic species status

HALCYONIDAE

52. *Halcyon capensis* BrR L1 $^{w g}$
(E: Stork-billed Kingfisher S: Manathudu Madi-pilihuduwa)
53. *Halcyon smyrnensis* (Linnaeus) 1758 BrR L1 $^{w g}$
(E: White-throated Kingfisher S: Layasudu Madi-pilihuduwa)
54. *Halcyon pileata* (Boddaert) 1783 WV L1 $^{w g t}$
(E: Black-capped Kingfisher S: Kalu Esasi Madi-pilihuduwa)

CERYLIDAE

55. *Ceryle rudis* (Linnaeus) 1758 BrR L1 $^{w g}$
(E: Pied Kingfisher S: Gomara-pilihuduwa)

MEROPIDAE

56. *Merops orientalis* Latham 1802 BrR L1 $^{w g}$
(E: Green Bee-eater S: Punchi Binguharaya)
57. *Merops philippinus* Linnaeus 1766 WV L1 $^{w g}$
(E: Blue-tailed Bee-eater S: Nilpenda Binguharaya)
58. *Merops apiaster* Linnaeus 1758 WV L2
(E: European Bee-eater S: Europeeya Binguharaya)
59. *Merops leschenaulti* Vieillot 1817 rR L1 $^{w g}$
(E: Chestnut-headed Bee-eater S: Thambala-hisa Binguharaya)

CUCULIFORMES

CUCULIDAE

60. *Clamator jacobinus* (Boddaert) 1783 BrR L1 $^{w g}$
(E: Pied Cuckoo S: Gomara Kondakoha)
61. *Clamator coromandus* (Linnaeus) 1766 WV L1 $^{w g t}$
(E: Chestnut-winged Cuckoo S: Thambala-piya Kondakoha)
62. *Hierococcyx varius* BrR /UWV L1 ^{g}
(E: Common Hawk Cuckoo S: Ukusukoha)
{*Cuculus varius* Vahl 1797
63. *Cuculus micropterus* Gould 1838 SU L1 $^{w g t}$
(E: Indian Cuckoo S: Indu Kookilaya)
64. *Cuculus canorus* Linnaeus 1758 WV L1 $^{w t}$
(E: Eurasian Cuckoo S: Podu Kookilaya)
65. *Cuculus poliocephalus* Latham 1790 WV L1 $^{w g}$
(E: Lesser Cuckoo S: Punchi Kookilaya)
66. *Cacomantis sonneratii* (Latham) 1790 BrR L1 ^{g}
(E: Banded Bay Cuckoo S: Vayira Gurukoha)
67. *Cacomantis passerinus* (Vahl) 1797 WV L1 $^{w g}$
(E: Grey-bellied Cuckoo S : Kusalu Gurukoha)
68. *Chrysococcyx maculatus* (Gmelin) 1788 Wva L1 $^{w g t}$
(E: Asian Emerald Cuckoo S: Asia Marakoha)

69. *Surniculus lugubris* (Horsfield) 1821 BrR L1$^{w g}$
(E: Drongo Cuckoo S: Kawudukoha)

70. *Eudynamys scolopacea* (Linnaeus) 1758 BrR L1$^{w g}$
(E: Asian Koel S: Kowula)

71. *Phaenicophaeus viridirostris* (Jerdon) 1840 BrR L1$^{w g}$
(E: Blue-faced Malkoha S: Wathanil Malkoha)

72. *Phaenicophaeus leschenaultii* (Lesson) 1830 BrR L1$^{w g}$
(E: Sirkeer Malkoha S: Pathan Malkoha / Atikukula)

73. ***Phaenicophaeus pyrrhocephalus*** (Pennant) 1769 BrR L1$^{w g}$
(E: Sri Lanka Red-faced Malkoha S: Sri Lanka Watha-rathu Malkoha)

Centropodidae

74. *Centropus sinensis* (Stephens) 1815 BrR L1$^{w g}$
(E: Greater Coucal S: Ati-kukula)

75. *Centropus bengalensis* (Gmelin) 1788 Va L2$^{w g t p}$
(E: Lesser Coucal S: Heen Ati-kukula)

76. ***Centropus chlororhynchus*** Blyth 1849 **END** BrR L1$^{w g}$
(E : Sri Lanka Green-billed Coucal S: Sri Lanka Bata Ati-kukula)

PSITTACIFORMES

Psittacidae

77. *Loriculus beryllinus* (Forster, JR) 1781 **END** BrR L1$^{w g}$
(E: Sri Lanka Hanging Parakeet S: Sri Lanka Giramaliththa)

78. *Psittacula eupatria* (Linnaeus) 1766 BrR L1$^{w g}$
(E: Alexandrine Parakeet S: Labu Girawa)

79. *Psittacula krameri* (Scopoli) 1769 BrR L1$^{w g}$
(E: Rose-ringed Parakeet S: Rana Girawa)

80. *Psittacula cyanocephala* (Linnaeus) 1766 BrR L1$^{w g}$
(E: Plum-headed Parakeet S: Pandu Girawa)

81. *Psittacula calthropae* (Blyth) 1849 **END** BrR L1$^{w g}$
(E: Sri Lanka Layard's Parakeet S: Sri Lanka Alu Girawa)

APODIFORMES

Apodidae

82. *Collocalia unicolor* (Jerdon) 1840 BrR L1$^{w g}$
(E: Indian Swiftlet S: Indu Upa-thurithaya)

83. *Hirundapus giganteus* (Temminck) 1825 BrR L1^{g}
(E: Brown-backed Needletail S: Pitabora Katupenda-thurithaya)

84. *Cypsiurus balasiensis* (Gray, JE) 1829 BrR L1$^{w g}$
(E: Asian Palm Swift S: Asiaa Thal-thurithaya)

85. *Tachymarptis melba* (Linnaeus) 1758 BrR L1^{w}
(E: Alpine Swift S: Alpine-thurithaya)

86. *Apus pacificus* (Latham) 1802 WVa L3
(E: Fork-tailed Swift S: Debal –waliga Thurithaya
87. *Apus affinis* (Gray, JE) 1830 BrR L1 [w g]
(E: House Swift S: Punchi Thurithaya)
88. *Apus acuticauda* (Jerdon) WVa L3
(E: Dark-rumped Swift S: Nithamba-anduru Thurithaya)

HEMIPROCNIDAE

89. *Hemiprocne coronata* (Tickell) 1833 BrR L1 [w g]
(E: Crested Treeswift S: Silu Ruk-thurithaya)

STRIGIFORMES

TYTONIDAE

90. *Tyto alba* (Scopoli) 1769 BrR L1 [g t]
(E: Barn Owl S: Atu Wesbassa)

PHODILINAE

91. *Phodilus badius* (Horsfield) 1821 BrR L1 [w g t 3]
(E: Oriental Bay Owl S: Peradigu Gurubassa)

STRIGIDAE

92. *Otus sunia* (Hodgson) 1836 BrR L1 [g]
(E: Oriental Scops Owl S: Peradigu Kanbassa)
93. *Otus bakkamoena* Pennant 1769 BrR L1 [w g]
(E: Collard Scops Owl S: Karapati Kanbassa)
94. ***Otus thilohofmanni*** Warakagoda & Rassmusan 2004 **END** BrR L1 [d]
(E: Serendib Scops Owl S: Panduwan Kanbassa)
95. *Bubo nipalensis* Hodgson 1836 BrR L1 [w g t]
(E: Spot-bellied Eagle Owl S: Ukusu Bakamoona / Ulama)
96. *Ketupa zeylonensis* (Gmelin) 1788 BrR L1 [g]
(E: Brown Fish Owl S: Bora Kewul-bakamoona)
97. *Strix leptogrammica* Temminck 1832 BrR L1 [w g]
(E: Brown Wood Owl S: Bora Wana-bakamoona)
98. *Glaucidium radiatum* (Tickell) 1833 BrR L1 [w g]
(E: Jungle Owlet S: Wana Upabassa)
99. ***Glaucidium castanonotum*** (Blyth) 185 **END** BrR L1 [g]
(E: Sri Lanka Chestnut-backed Owlet S: Sri Lanka Pit-a June thambala Upabassa))
100. *Ninox scutulata* (Raffles) 1822 BrR L1 [g]
(E: Brown Hawk Owl S: Bora Ukusu-bassa)
101. *Asio flammeus* (Pontoppidan) 1763 WV L1 [w g t]
(E: Short-eared Owl S: Keti Kan-Bakamoona)

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[3] Rasmussen and Anderton 2005 - *Phodilus badius assimilis* upgraded to species level *Phodilus assimilis*

Batrachostomidae

102. *Batrachostomus moniliger* Blyth 1849 BrR L1 [w g t]
(E: Frogmouth S: Madi-muhuna)

Caprimulgidae

103. *Caprimulgus indicus* Latham 1790 BrR L1 [g]
(E: Grey Nightjar S: Alu Bimbassa)
104. *Caprimulgus atripennis* Jerdon 1845 BrR L1 [w g]
(E: Jerdon's Nightjar S: Jerdon Bimbassa)
105. *Caprimulgus asiaticus* Latham 1790 BrR L1 [w g]
(E: Common Nightjar S: Indu Bimbassa)

COLUMBIFORMES

Columbidae

106. *Columba livia* Gmelin 1789 BrR L1 [w g]
(E: Rock Pigeon S: Podu Paraviya)
107. ***Columba torringtoni*** Bonaparte 1854 **END** BrR L1 [w g t]
(E: Sri Lanka Wood Pigeon S: Sri Lanka Mayila Paraviya)
108. *Columba punicea* Blyth 1842 WV L2 [w t p]
(E: Pale-capped Pigeon S: La-esasi Paraviya)
109. *Streptopelia orientalis* (Latham) 1790 WV L1 [w g]
(E: Oriental Turtle Dove S: Peradigu Kayuru Kobeiyya)
110. *Streptopelia chinensis* (Scopoli) 1786 BrR L1 [w g]
(E: Spotted Dove S: Alu Kobeiyya)
111. *Streptopelia tranquebarica* (Hermann) 1804 WV L1 [w g p]
(E: Red Collared Dove S: Rathmala Kobeiyya)
112. *Streptopelia decaocto* (Frivaldszky) 1838 BrR L1 [w g]
(E : Eurasian Collard Dove S: Mala Kobeiyya)
113. *Chalcophaps indica* (Linnaeus) 1758 BrR L1 [w g]
(E: Emerald Dove S: Neela-Kobeiyya)
114. *Treron bicincta* (Jerdon) 1840 BrR L1 [w g]
(E: Orange-breasted Green-pigeon S: Laya-ran Batagoya)
115. *Treron pompadora* (Gmelin) 1789 BrR L1 [w g 4]
(E: Pompadour Green-pigeon S: Pompadoru Batagoya)
116. *Treron phoenicoptera* (Latham) 1790 BrR/UWV L1 [g t]
(E: Yellow-footed Green-pigeon S: Seepadu Batagoya)
117. *Ducula aenea* (Linnaeus) 1766 BrR L1 [w g]
(E: Green Imperial Pigeon S: Neela Mahagoya)

[4] Rasmussen and Anderton 2005 - *Treron pompadora pompadora* upgraded to endemic species level under "taxonomy dependent" as *Treron pompadora*

GRUIFORMES

RALLIDAE

118. *Rallina eurizonoides* (Lafresnaye) 1845	WV	L1[w g t]
(E: Slaty-legged Crake S: Alu-pa Keraliya)		
119. *Gallirallus striatus* (Linnaeus) 1766	BrR	L1[w g]
(E: Slaty-breasted Rail S: Layaalu Pati-reluwa)		
120. *Rallus aquaticus* Linnaeus 1758	WV	L2[w g p][5]
(E: Water rail S: Diya Reluwa)		
121. *Crex crex* (Linnaeus) 1758	WV	L2[g p]
(E: Corn Crake S: Goda-keraliya)		
122. *Amaurornis phoenicurus* (Pennant) 1769	BrR	L1[w g t]
(E: White-breasted Waterhen S: Laya-sudu Korawakka)		
123. *Porzana pusilla* (Pallas) 1776	WV	L1[g]
(E: Baillon’s Crake S: Baillon Wil-keraliya)		
124. *Porzana fusca* (Linnaeus) 1766	BrR	L1[w g]
(E: Ruddy-breasted Crake S: Laya-rathu Wil-keraliya)		
125. *Gallicrex cinerea* (Gmelin) 1789	BrR	L1[g]
(E: Watercock S: Kora)		
126. *Porphyrio porphyrio* (Linnaeus) 1758	BrR	L1[w g]
(E: Purple Swamphen S: Podu Dam-kithala)		
127. *Gallinula chloropus* (Linnaeus) 1758	BrR	L1[g]
(E: Common Moorhen S: Podu Gallinuwa)		
128. *Fulica atra* Linnaeus 1758	BrR	L1[w g t]
(E: Common Coot S: Podu Kalu-kithala)		

CICONIIFORMES

SCOLOPACIDAE

129. *Scolopax rusticola* Linnaeus 1758	WV	L1[g]
(E: Eurasian Woodcock S: Eurasiya Arathuduwa)		
130. *Gallinago nemoricola* Hodgson 1836	WVa	L3
(E: Wood Snipe S: Wana Kaswatuwa)		
131. *Gallinago stenura* (Bonaparte) 1831	WV	L1[w g]
(E: Pintail Snipe S: Ulpenda Kaswatuwa)		
132. *Gallinago megala* Swinhoe 1861	WV	L2[w g p]
(E: Swinhoe’s Snipe S: Swainhoo Kaswatuwa)		
133. *Gallinago media* (Latham) 1787	WV	L1[w g p]
(E: Great Snipe S: Maha Kaswatuwa)		
134. *Gallinago gallinago* (Linnaeus) 1758	WV	L1[g t]
(E: Common Snipe S: Podu Kaswatuwa)		
135. *Lymnocryptes minimus* (Brunnich) 1764	WV	L1[g p]
(E: Jack Snipe S: Heen-kaswatuwa)		

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[5] Rasmussen and Anderton 2005 - *Rallus aquaticus indicus* upgraded to species level Rallus indicus

136. *Limosa limosa* (Linnaeus) 1758 (E: Black-tailed Godwit S: Kalu-penda Gohuduwiththa)	WV	L1$^{w\,g}$
137. *Limosa lapponica* (Linnaeus) 1758 (E: Bar-tailed Godwit S: Waira-penda Gohuduwiththa)	WV	L1$^{w\,g}$
138. *Numenius minutus* (Gould) 1841 (E: Little Curlew S: Heen Kalikaya)	WVa	L3
139. *Numenius phaeopus* (Linnaeus) 1758 (E: Whimbrel S: Wimburali Kalikaya)	WV	L1$^{w\,g}$
140. *Numenius tenuirostris* Vieillot 1817 (E: Slender-billed Curlew S: Heen-thudu Kalikaya)	WVa	L3
141. *Numenius arquata* (Linnaeus) 1758 (E: Eurasian Curlew S: Eurasiya Kalikaya)	WV	L1^{w}
142. *Tringa erythropus* (Pallas) 1764 (E: Spotted Redshank S: Tith Rathpa Silibilla)	WV	L1$^{w\,g\,p}$
143. *Tringa totanus* (Linnaeus) 1758 (E: Common Redshank S: Podu Rathpa Silibilla)	WV	L1$^{w\,g}$
144. *Tringa stagnatilis* (Bechstein) 1803 (E: Marsh Sandpiper S: Waguru Silibilla)	WV	L1^{g}
145. *Tringa nebularia* (Gunnerus) 1767 (E: Common Greenshank S: Podu Palapa Silibilla)	WV	L1$^{w\,g}$
146. *Tringa guttifer* (Nordmann) 1835 (E: Nordmann's Greenshank S: Thith Palalpa Silibilla)	WVa	L3
147. *Tringa solitaria* Wilson, A 1813 (E: Solitary Sandpiper S: Thanikada Silibilla *)*	WVa	L3
148. *Tringa ochropus* Linnaeus 1758 (E: Green Sandpiper S: Kola Silibilla)	WV	L1^{g}
149. *Tringa glareola* Linnaeus 1758 (E: Wood Sandpiper S: Wana Silibilla)	WV	L1$^{w\,g}$
150. *Xenus cinereus* (Guldenstadt) 1775 (E: Terek Sandpiper S: Terek Silinna)	WV	L1^{g}
151. *Actitis hypoleucos* (Linnaeus) 1758 (E: Common Sandpiper S: Podu Siliththa)	WV	L1$^{w\,g}$
152. *Tringa macularia* (Linnaeus) 1766 (E: Spotted Sandpiper S: Pulli Silibilla)	WVa	L3
153. *Arenaria interpres* (Linnaeus) 1758 (E: Ruddy Turnstone S: Rath Galperaliya)	WV	L1^{g}
154. *Limnodromus semipalmatus* (Blyth) 1848 (E: Asiatic Dowitcher S: Asiya Siliwatuwa)	WVa	L3
155. *Calidris tenuirostris* (Horsfield) 1821 (E: Great Knot S: Mahanott Hinna)	WVa	L3
156. *Calidris canutus* (Linnaeus) 1758 (E: Red Knot S: Rathu Not Hinna)	WV	L1$^{w\,g\,p}$

157. *Calidris alba* (Pallas) 1764 — WV L1[w g]
(E: Sanderling S: Wali Hinna)

158. *Calidris pygmeus* — WV L2
(E: Spoon-billed Sandpiper S: Handi Hinna)

159. *Calidris minuta* (Leisler) 1812 — WV L1[w g]
(E: Little Stint S: Punchi Hinna)

160. *Calidris ruficollis* (Pallas) 1776 — WV L2
(E: Rufous-necked Stint S: Dumburu-gela Hinna)

161. *Calidris temminckii* (Leisler) 1812 — WV L1[w g]
(E: Temminck's Stint S: Temminck Hinna)

162. *Calidris subminuta* (Middendorff) 1853 — WV L1[g]
(E: Long-toed Stint S: Digaangili Hinna)

163. *Calidris fuscicollis* (Vieillot) 1819 — WVa L3
(E: White-rumped Sandpiper S: Nithamba-sudu Hinna)

164. *Calidris acuminata* (Horsfield) 1821 — WV L1[g p]
(E: Sharp-tailed Sandpiper S: Ul-penda Hinna)

165. *Calidris alpina* (Linnaeus) 1758 — WV L2
(E: Dunlin S: Dumbulu Hinna)

166. *Calidris ferruginea* (Pontoppidan) 1763 — WV L1[w g]
(E: Curlew Sandpiper S: Kalika Hinna)

167. *Tryngites subruficollis* (Vieillot) 1819 — WV L2[g p]
(E: Buff-breasted Sandpiper S: Layapandu Sili-hinna)

168. *Limicola falcinellus* (Pontoppidan) 1763 — WV L1[w g]
(E: Broad-billed Sandpiper S: Mathudu-hinna)

169. *Philomachus pugnax* (Linnaeus) 1758 — WV L1[w g]
(E: Ruff S: Lowichchiya)

170. *Steganopus tricolor* Vieillot 1819 — SU L3
(E: Wilson's Phalarope S: Wilsonge Diyawatuwa)

171. *Phalaropus lobatus* (Linnaeus) 1758 — WV L2
(E: Red-necked Phalarope S: Rathgela Diyawatuwa)

172. *Phalaropus fulicaria* (Linnaeus) 1758 — WVa L3
(E: Red Phalarope S: Rathu Diyawatuwa)

ROSTRATULIDAE

173. *Rostratula benghalensis* (Linnaeus) 1758 — BrR L1[w g]
(E: Greater Painted-snipe S: Raja Ulu-kaswatuwa)

JACANIDAE

174. *Hydrophasianus chirurgus* (Scopoli) 1786 — BrR L1[g]
(E: Pheasant-tailed Jacana S: Savul-penda Diyasaana)

Burhinidae

175. *Burhinus oedicnemus* (Linnaeus) 1758 BrR L1[w g]
(E: Eurasian Thick-knee S: Eurasia Golukiraluwa)

176. *Esacus recurvirostris* (Cuvier) 1829 BrR L1[g]
(E: Great Thick-knee S: Maha-Golukiraluwa)

Charadriidae

177. *Haematopus ostralegus* Linnaeus 1758 WV L2
(E: Eurasian Oystercatcher S: Eurasia Bolugulla)

178. *Himantopus himantopus* (Linnaeus) 1758 BrR L1[w g]
(E: Black-winged Stilt S: Kalupiya Ipalpawa)

179. *Himantopus leucocephalus* Gould 1837 WV L2
(E: Australian Stilt S: Australiyanu Ipalpawa)

180. *Recurvirostra avosetta* Linnaeus 1758 WV L1[w g]
(E: Pied Avocet S: Gomara Avasatha)

181. *Pluvialis fulva* (Gmelin) 1789 WV L1[w g]
(E: Pacific Golden Plover S: Sethkara Ran Maha-oleviya)

182. *Pluvialis squatarola* (Linnaeus) 1758 W V L1[w g]
(E: Grey Plover S: Alu Maha-oleviya)

183. *Charadrius hiaticula* Linnaeus 1758 WV L2
(E: Common Ringed Plover S: Loku Mala Oleviya)

184. *Charadrius placidus* Gray, JE & Gray, GR 1863 WVa L3
(E: Long-billed Plover S: Dick-thuda Oleviya)

185. *Charadrius dubius* Scopoli 1786 BrR & WV L1[w g]
(E: Little Ringed Plover S: Punchi Mala Oleviya)

186. *Charadrius alexandrinus* Linnaeus 1758 BrR & WV L1[w g]

187. (E: Kentish Plover S: Kenti Oleviya) WV L1[w]
(E: Lesser Sand Plover S: Heen Wali Oleviya)

188. *Charadrius leschenaultii* Lesson 1826 WV L1[g]
(E: Greater Sand Plover S: Raja Wali Oleviya)

189. *Charadrius asiaticus* Pallas 1773 WV L1[g p]
(E : Caspian Plover S: Caspia Oleviya)

190. *Charadrius veredus* Gould 1848 WVa L3
(E: Oriental Plover S: Peradigu Oleviya)

191. *Vanellus malabaricus* (Boddaert) 1783 BrR L1[w g]
(E: Yellow-wattled Lapwing S: Kaha-yatimal Kirella)

192. *Vanellus cinereus* (Blyth) 1842 WVa L3
(E: Grey-headed Lapwing S: Hisa-alu Kirella)

193. *Vanellus indicus* (Boddaert) 1783 BrR L1[w g]
(E: Red-wattled Lapwing S: Rath-yatimal Kirella)

194. *Vanellus gregarius* (Pallas) 1771 WV L2[g]
(E: Sociable Lapwing S: Ranchu Kirella)

Glareolidae

195. *Dromas ardeola* Paykull 1805 SU L1[w g]
(E: Crab-plover S: Kakulu-oleviya)

196. *Cursorius coromandelicus* (Gmelin) 1789 BrR L1[w g]
(E: Indian Courser E: Indu Javalihiniya)

197. *Glareola pratincola* (Linnaeus) 1766 WV L1[g p]
(E: Collared Pratincole S: Karapati Javasariya)

198. *Glareola maldivarum* Forster, JR 1795 BrR L1[g]
(E: Oriental Pratincole E: Peradigu Javasariya)

199. *Glareola lactea* Temminck 1820 BrR L1[g]
(E: Small Pratincole S: Punchi Javasariya)

Laridae

200. *Catharacta lonnbergi* Mathews 1831 SV L2[g t 6]
(E: Brown Skua S: Dumburu Piri-vilumbuwa)

201. *Catharacta maccormicki* (Saunders) 1893 SU L3[t 7]
(E: South Polar Skua S: Dakunu-drava Piri-vilumbuwa)

202. *Stercorarius pomarinus* (Temminck) 1815 SV L1[w g t p]
(E: Pomarine Jaeger S :Pomarine Vilumbuwa)

203. *Stercorarius parasiticus* (Linnaeus) 1758 SU L3
(E: Parasitic Jaeger S: Paraputu Vilumbuwa)

204. *Larus hemprichii (Bruch) 1853* SU L3
(E: Sooty Gull S: Dumbutu Galuviya)

205. *Larus argentatus* Pontoppidan 1763 WV L3
(E: Herring Gull S: Herring Galuviya)

206. *Larus heuglini* Bree 1876 WV L1[w g t]
(E: Heuglin's Gull S: Heuglin Galuviya)

207. *Larus cachinnans* Pallas 1811 SU L2
(E: Yellow-legged Gull S: Kahapa Galuviya)

208. *Larus fuscus* Linnaeus 1758 WV L3
(E: Lesser Black-backed Gull S: Heen Pita-kalu Galuviya)

209. *Larus ichthyaetus* Pallas 1773 WV L1[g]
(E: Pallas's Gull S: Maha Kalu-hisa Galuviya)

210. *Larus brunnicephalus* Jerdon 1840 WV L1[w g]
(E: Brown-headed Gull S: Bora-hisa Galuviya)

211. *Larus ridibundus* Linnaeus 1766 WV L3
(E: Black-headed Gull S: Kalu-his Galuviya)

212. *Larus genei* Breme 1839 SU L3
(E: Slender-billed Gull S: Heen-thudu Galuviya)

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[6] Originally identified as *C.antarctica* (Legge 1983 and Wait 1931). Error corrected by De Silva (1989d)

[7] Specimen originally identified by Wait (1931) was an error, corrected by De Silva (1989)

213. *Gelochelidon nilotica* SU L1[g]
(E: Gull-billed Tern S: Galuthudu Sayurulihiniya)

214. *Sterna caspia* Pallas 1770 WV L1[g t]
(E: Caspian Tern S: Caspia Muhudulihiniya)

215. *Sterna bengalensis* Lesson 1831 WV L1[w g]
(E: Lesser Crested Tern S: Heen Konda Muhudulihiniya)

216. *Sterna bergii* Lichtenstein 1823 BrR L1[w g]
(E: Great Crested Tern S: Maha Konda Muhudulihiniya)

217. *Sterna sandvicensis* Latham 1787 WV L1[g]
(E: Sandwich Tern S : Sandwich Muhudulihiniya)

218. *Sterna dougallii* Montagu 1813 SV/BrR L1[w g]
(E: Roseate Tern S: Arunu Muhudulihiniya)

219. *Sterna sumatrana* Raffles 1822 SU L3
(E: Black-naped Tern S: Kalu-gelasi Muhudulihiniya)

220. *Sterna hirundo* Linnaeus 1758 WV/UBrR L1[w g t]
(E: Common Tern S: Podu Muhudulihiniya)

221. *Sterna albifrons* Pallas 1764 BrR L1[w g]
(E: Little Tern S: Punchi Muhudulihiniya)

222. *Sterna saundersi* Hume 1877 BrR L1[g]
(E: Saunders’s Tern S: Saunders Muhudulihiniya)

223. *Sterna repressa* Hartert 1916 Va L3
(E: White-cheeked Tern S: Kopula-sudu Muhudulihiniya)

224. *Sterna anaethetus* Scopoli 1786 SU L1[g t]
(E: Bridled Tern S: Kadiyalam Muhudulihiniya)

225. *Sterna fuscata* Linnaeus 1766 PM L1[g t p]
(E: Sooty Tern S: Dumbutu Muhudulihiniya)

226. *Chlidoniasus* (Pallas) 1811 WV L1[w g]
(E: Whiskered Tern S: Alupiya Kangul-lihiniya)

227. *Chlidonias leucopterus* (Temminck) 1815 WV L1[w g t]
(E: White-winged Tern S: Sudupiya Kangul-lihiniya)

228. *Chlidonias niger* (Linnaeus) 1758 WV L3
(E: Black Tern S: Kalu Kangul-lihiniya)

229. *Anous stolidus* (Linnaeus) 1758 Va L1[g t]
(E: Brown Noddy S: Bora Nidilihiniya)

230. *Anous minutus* Boie 1844 SU L3
(E: Black Noddy S: Kalu Nidilihiniya)

231. *Anous tenuirostris* (Temminck) 1823 Va L1[g]
(E: Lesser Noddy S: Heen Nidilihiniya)

ACCIPITRIDAE

232. *Pandion haliaetus* (Linnaeus) 1758 WV L2
(E: Osprey S: Kuralaya)

233. *Aviceda jerdoni* (Blyth) 1842 BrR L1[g]
(E: Jerdon's Baza S: Jerdon Saratakussa)

234. *Aviceda leuphotes* (Dumont) 1820 WV L1[g]
(E: Black Baza S: Kalu Saratakussa)

235. *Pernis ptilorhyncus* (Temminck) 1821 BrR & WV L1[g]
(E: Oriental Honey-buzzard S: Silu Bambarakussa)

236. *Elanus caeruleus* (Desfontaines) 1789 BrR L1[g]
(E: Black-shouldered Kite S: Uris-kalu Pathannkussa)

237. *Milvus migrans* (Bonddaert) 1783 BrR L1[w g]
(E: Black Kite S: Bora Parakussa)

238. *Haliastur indus* (Boddaert) 1783 BrR L1[w g]
(E: Brahminy Kite S: Bamunu Piyakussa)

239. *Haliaeetus leucogaster* (Gmelin) 1788 BrR L1[w g]
(E: White-bellied Sea-eagle S: Kusa-ali Sayurukussa)

240. *Ichthyophaga ichthyaetus* (Horsfield) 1821 BrR L1[g]
(E: Grey-headed Fish-eagle S: Raja Alu-his Masukussa)

241. *Neophron percnopterus* (Linnaeus) 1758 WVa L1[w g t p]
(E: Egyptian Vulture S: Ejupthu Gijulihiniya)

242. *Spilornis cheela* (Latham) 1790 BrR L1[w g]
(E: Crested Serpent Eagle S: Silu Sarapakussa)

243. *Circus aeruginosus* (Linnaeus) 1758 WV L1[w g]
(E: Western Marsh Harrier S: Batahira Waguru Harikussa)

244. *Circus macrourus* (Gmelin, SG) 1770 WV L1[w g]
(E: Pallid Harrier S: Sudumali Harikussa)

245. *Circus melanoleucos* (Pennant) 1769 WV L1[w g]
(E: Pied Harrier S: Gomara Harikussa)

246. *Circus pygargus* (Linnaeus) 1758 WV L1[w g]
(E: Montagu's Harrier S: Montegu Harikussa)

247. *Accipiter trivirgatus* (Temminck) 1824 BrR L1[w g]
(E: Crested Goshawk S: Silu Ukussa)

248. *Accipiter badius* (Gmelin) 1788 BrR L1[w g]
(E: Shikra S: Ukussa)

249. *Accipiter virgatus* (Temminck) 1822 BrR L1[g]
(E: Besra S: Besra Ukussa)

250. *Accipiter nisus* (Linnaeus) 1758 WVa L3
(E: Eurasian Sparowhawk S: Eurasiya Ukussa)

251. *Buteo buteo* (Linnaeus) 1758 WV L1[w g][8]
(E: Common Buzzard S: Urasiya Lasikussa)

252. *Buteo rufinus* (Cretzschmar) 1829 WVa L3
(E: Long-legged Buzzard S: Dikpa Lasikussa)

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[8] Rasmussen and Anderton 2005 - *Buteo buteo burmanicus* upgraded to species level *Buteo burmanicus*

253. *Ictinaetus malayensis* (Temminck) 1822 — BrR L1[g]
(E: Black Eagle S: Kalukussa)

254. *Hieraaetus fasciatus* (Vieillot) 1822 — SU L1[w g p]
(E: Bonnelli's Eagle S: Bonelli Rajaaliya)

255. *Hieraaetus pennatus* (Gmelin) 1788 — WV L1[w g t p]
(E: Booted Eagle S: Kesarupa Rajaaliya)

256. *Hieraaetus kienerii* (Geoffroy Saint-Hilaire, I) 1835 — BrR L1[w g t]
(E: Rufous-bellied Eagle S: Kusarath Rajaaliya)

257. *Spizaetus cirrhatus* (Gmelin) 1788 — BrR L1[w g]
(E: Changeable Hawk Eagle S: Perali Kondakussa)

258. *Spizaetus nipalensis* (Hodgson) 1836 — BrR L1[g]
(E: Mountain Hawk Eagle S: Hela Kondakussa)

FALCONIDAE

259. *Falco naumanni* Fleischer 1818 — WVa L3
(E: Lesser Kestrel S: Heen Kurulugoya)

260. *Falco tinnunculus* Linnaeus 1758 — BrR/UWV L1[w g t]
(E: Common Kestrel S: Podu Kurulugoya)

261. *Falco chicquera* Daudin 1800 — WVa L3
(E: Red-necked Falcon S: Rathuhis Kurulugoya)

262. *Falco amurensis* Radde 1863 — WVa L1[w g t p]
(E: Amur Falcon S: Amur Kurulugoya)

263. *Falco severus* Horsfield 1821 — WV L2[w g p]
(E: Oriental Hobby S: Peradigu Hobby Kurulugoya)

264. *Falco peregrinus* Tunstall 1771 — BrR/UWV L1[w g]
(E: Peregrine/ Shaheen Falcon S: Peri/shahin Kurulugoya)

265. *Microhierax fringilarius* — Va L3
(E: Black-thighed Falconet S: Kalu-kalawa Kurulaya)

PODICIPEDIDAE

266. *Tachybaptus ruficollis* (Pallas) 1764 — BrR L1[w g]
(E: Little Grebe S: Punchi Gembithuruwa)

PHAETHONTIDAE

267. *Phaethon aethereus* Linnaeus 1758 — SV L1[g p]
(E: Red-billed Tropicbird S: Raththudu Gimwalaya)

268. *Phaethon lepturus* Daudin 1802 — SU L1[w g t p]
(E: White-tailed Tropicbird S: Kahathudu Gimwalaya)

SULIDAE

269. *Sula dactylatra* Lesson 1831 — SU L1[w g t p]
(E: Masked Booby S: Wes Sulaviya)

270. *Sula sula* (Linnaeus) 1766 — SU L1[g p]
(E: Red-footed Booby S: Rathpa Sulaviya)
271. *Sula leucogaster* (Boddaert) 1783 — Va L1[g p]
(E: Brown Booby S: Bora Sulaviya)

ANHINGIDAE

272. *Anhinga melanogaster* Pennant 1769 — BrR L1[w g]
(E: Darter S: Peradigu Ahikava)

PHALACROCORACIDAE

273. *Phalacrocorax niger* (Vieillot) 1817 — BrR L1[w g]
(E: Little Cormorant S: Punchi Diyakava)
274. *Phalacrocorax fuscicollis* Stephens 1826 — BrR L1[w g t]
(E: Indian Cormorant S: Indu Diyakava)
275. *Phalacrocorax carbo* (Linnaeus) 1758 — BrR L1[g]
(E: Great Cormorant S: Maha Diyakava)

ARDEIDAE

276. *Egretta garzetta* (Linnaeus) 1766 — BrR L1[g]
(E: Little Egret S: Punchi Ali-koka)
277. *Egretta gularis* (Bosc) 1792 — BrR L1[g]
(E: Western Reef Heron S: Batahira Pera Ali-koka)
278. *Ardea cinerea* Linnaeus 1758 — BrR L1[g p]
(E: Grey Heron S: Alu Koka)
279. *Ardea goliath* Cretzschmar 1829 — WVa L1[w g t]
(E: Goliath Heron S: Yoda Koka)
280. *Ardea purpurea* Linnaeus 1766 — BrR L1[g]
(E: Purple Heron S: Karawal Koka)
281. *Casmerodius albus* (Linnaeus) 1758 — BrR L1[w g]
(E: Great Egret S: Maha Sudu-koka)
282. *Mesophoyx intermedia* Wagler 1829 — BrR L1[w g]
(E: Intermediate Egret S: Sudu Madi-koka)
283. *Bubulcus ibis* (Linnaeus) 1758 — BrR L1[w g]
(E: Cattle Egret S: Gava-koka)
284. *Ardeola grayii* (Sykes) 1832 — BrR L1[w g]
(E: Pond Heron S: Kana-koka)
285. *Ardeola bacchus* (Bonaparte) 1855 — WVa L3
(E: Chinese Pond Heron S: Cheena Kana-koka)
286. *Butorides striatus* (Linnaeus) 1758 — BrR L1[w g]
(E: Little Heron S: Pala-koka)
287. *Nycticorax nycticorax* (Linnaeus) 1758 — BrR L1[w g]
(E: Black-crowned Night Heron S: Ra-koka)

288. *Gorsachius melanolophus* (Raffles) 1822 WV L1 [w g]
(E: Malayan Night Heron S: Malaya Thambala-koka)
289. *Ixobrychus sinensis* (Gmelin) 1789 BrR L1 [w g]
(E: Yellow Bittern S: Kaha Mati-koka)
290. *Ixobrychus cinnamomeus* (Gmelin) 1789 BrR L1 [w g]
(E: Cinnamon Bittern S: Kahabora Mati-koka)
291. *Dupetor flavicollis* (Latham) 1790 BrR L1 [w g]
(E: Black Bittern S: Kalu Pili-koka)
292. *Botaurus stellaris* (Linnaeus) 1758 WVa L2
(E: Great Bittern S: Eurasiya Pan-koka)

PHOENICOPTERIDAE

293. *Phoenicopterus ruber* Linnaeus 1758 WV L1 [g]
(E: Greater Flamingo S: Raja Siyakkaraya)
294. *Phoenicopterus minor* Geoffroy Saint-Hilaire, E 1798 WVa L3
(E: Lesser Flamingo S: Heen Siyakkaraya)

THRESKIORNITHIDAE

295. *Plegadis falcinellus* (Linnaeus) 1766 WV L1 [g]
(E: Glossy Ibis S: Silutu Dathuduwa)
296. *Threskiornis melanocephalus* (Latham) 1790 BrR L1 [g]
(E: Black-headed Ibis S: Indu Sudu Dakaththa)
297. *Platalea leucorodia* Linnaeus 1758 BrR L1 [g]
(E: Eurasian Spoonbill S: Eurasiya Handialawa)

PELECANIDAE

298. *Pelecanus onocrotalus* Linnaeus 1758 SU L3
(E: Great White Pelican S: Maha Sudu Pasthuduwa)
299. *Pelecanus crispus* Bruch 1832 SU L3
(E: Dalmatian Pelican S: Dalmatian Pasthuduwa)
300. *Pelecanus philippensis* Gmelin 1789 BrR L1 [g]
(E: Spot-billed Pelican S: Thithhota Pasthuduwa)

CICONIIDAE

301. *Mycteria leucocephala* (Pennant) 1769 BrR L1 [g]
(E: Painted Stork S: Lathuwakiya)
302. *Anastomus oscitans* (Boddaert) 1783 BrR L1 [g]
(E: Asian Openbill S: Asia Vivarathuduwa)
303. *Ciconia nigra* (Linnaeus) 1758 SU L3
(E: Black Stork S: Kalu Manawa)
304. *Ciconia episcopus* (Boddaert) 1783 BrR L1 [g]
(E: Woolly-necked Stork S: Padili Manawa)

305. *Ciconia ciconia* (Linnaeus) 1758 — SU — L2 [w]
(E: White Stork   S: Sudu Manawa)

306. *Ephippiorhynchus asiaticus* (Latham) 1790 — BrR — L1 [g]
(E: Black-necked Stork   S: Ali-manawa)

307. *Leptoptilos javanicus* (Horsfield) 1821 — BrR — L1 [g]
(E: Lesser Adjutant   S: Heen Bahuru-manawa)

FREGATIDAE

308. *Fregata minor* (Gmelin) 1789 — Va — L2 [w t p]
(E: Great Frigatebird S: Maha Sahasiya)

309. *Fregata ariel* (Gray, GR) 1845 — Va — L1 [p]
(E: Lesser Frigatebird   S: Singithi Sahasiya)

310. *Fregata andrewsi* Mathews 1914 — SU — L2 [t]
(E: Christmas Island Frigatebird   S: Naththal Diw Sahasiya)

PROCELLARIIDAE

311. *Daption capense* (Linnaeus) 1758 — SU — L2 [w g t p]
(E: Cape Petrel   S: Keppa Pita-raleya)

312. *Pterodroma baraui* (Jouanin) 1964 — SU — L3
(E: Barau's Petrel   S: Barau Raleya)

313. *Pterodroma lessonii* (Garnot) 1826 — SU — L3
(E: White-headed Petrel   S: Hisa-sudu Raleya)

314. *Pterodroma mollis* (Gould) 1844 — SU — L3
(E: Soft-plumaged Petrel   S: Sumudu Pill Raleya)

315. *Bulweria bulwerii* (Jardine & Selby) 1828 — SU — L3
(E: Bulwer's Petrel   S: Bulwer Heen-raleya)

316. *Bulweria fallax* Jouanin 1955 — SU — L1 [g]
(E: Jouanin's Petrel   S: Jouanin Heen-raleya)

317. *Calonectris leucomelas* (Temminck) 1835 — SU — L1 [w t p]
(E: Streaked Shearwater   S: Kadiiri Pirilavakaya)

318. *Puffinus pacificus* (Gmelin) 1789 — Va — L2 [w g t p]
(E: Wedge-tailed Shearwater   S: Kungnapenda Diyalavakaya)

319. *Puffinus carneipes* Gould 1844 — PM — L1 [w g t p]
(E: Flesh-footed Shearwater   S: Palolpa Diyalavakaya)

320. *Puffinus griseus* (Gmelin) 1789 — SU — L3
(E: Sooty Shearwater   S: Dumbutu Diyalavakaya)

321. *Puffinus tenuirostris* (Temminck) 1835 — SU — L1 [g p]
(E: Short-tailed Shearwater   S: Ketipenda Diyalavakaya)

322. *Puffinus lherminieri* Lesson 1839 — SU — L3
(E: Audubon's Shearwater   S: Audubon Diyalavakaya)

323. *Oceanites oceanicus* (Kuhl) 1820 — SV — L1 [w g t]
(E: Wilson's Storm-petrel   S: Wilson Sadawasuruwa)

324. *Pelagodroma marina* (Latham) 1790 WV L3
(E: White-faced Storm-petrel S:Watha Sudu Sadawasuruwa)

325. *Oceanodroma monorhis* (Swinhoe) 1867 SU L1 w g p
(E: Swinhoe's Storm-petrel S: Swinhoe Kunatusuruwa)

PASSERIFORMES

Pittidae

326. *Pitta brachyura* (Linnaeus) 1766 WV L1 w g
(E: Indian Pitta S: Avichchiya)

Irenidae

327. *Irena puella* (Latham) 1790 WV L2 w g p
(E: Asian Fairy Bluebird S: Asia Neelarajaya)

328. *Chloropsis cochinchinensis* (Gmelin) 1789 BrR L1 w g
(E: Blue-winged Leafbird S: Nilpiya Kolarisiya)

329. *Chloropsis aurifrons* (Temminck) 1829 BrR L1 w g
(E: Golden-fronted Leafbird S: Rannalala Kolarisiya)

Laniidae

330. *Lanius cristatus* Linnaeus 1758 WV L1 w g t
(E: Brown Shrike S: Bora Sabariththa)

331. *Lanius vittatus* Valenciennes 1826 WV L2
(E: Bay-backed Shrike S: Pita-alu Sabariththa)

332. *Lanius schach* Linnaeus 1758 BrR L1 w g
(E: Long-tailed Shrike S: Dikpenda Sabariththa)

333. *Lanius meridionalis* Temminck 1820 WVa L3
(E: Southern Grey Shrike S: Alu Sabariththa)

Corvidae

334. *Urocissa ornata* (Wagler) 1829 END BrR L1 g
(E: Sri Lanka Blue Magpie S: Sri Lanka Kahibella)

335. *Corvus splendens* Vieillot 1817 BrR L1 w g
(E: House Crow S: Kolamba Kaputa)

336. *Corvus macrorhynchos* Wagler 1827 BrR L1 w g
(E: Large-billed Crow S: Kalu Kaputa)

337. *Artamus fuscus* Vieillot 1817 BrR L1 w g
(E: Ashy Woodswallow S: Alu Wanalihiniya)

338. *Oriolus oriolus* (Linnaeus) 1758 WV L1 g p [9]
(E: Eurasian Golden Oriole S: Eurasiya Ran Kahakurulla)

[9] Rassmussen and Anderton 2005 - *Oriolus oriolus kundoo* upgraded to speciel level *Oriolus kundoo*, both *Oriolus oriolus* and *Oriolus kundoo* present in Sri Lanka

339. *Oriolus chinensis* Linnaeus 1766 WV L1[w g t p]
(E: Black-naped Oriole S: Kalu-gelasi Kahakurulla)

340. *Oriolus tenuirostris* Blyth 1846 WVa L3
(E: Slender-billed Oriole S: Heen Thudu Kahakurulla)

341. *Oriolus xanthornus* (Linnaeus) 1758 BrR L1[w g]
(E: Black-hooded Oriole S: Kahakurulla)

342. *Coracina macei* (Lesson) 1830 BrR L1[w g]
(E: Large Cuckooshrike S: Maha Kovul-saratiththa)

343. *Coracina polioptera* (Sharpe) 1879 WVa L3
(E: Indochinese Cuckooshrike S: Induchina Kovul-saratiththa)

344. *Coracina melanoptera* (Ruppell) 1839 BrR L1[w g]
(E: Black-headed Cuckooshrike S: Kalu-his Kovul-saratiththa)

345. *Pericrocotus cinnamomeus* (Linnaeus) 1766 BrR L1[w g]
(E: Small Minivet S: Punchi Miniviththa)

346. *Pericrocotus flammeus* (Forster, JR) 1781 BrR L1[w g]
(E: Scarlet Minivet S: Dilirath Miniviththa)

347. *Hemipus picatus* (Sykes) 1832 BrR L1[w g t]
(E: Bar-winged Flycatcher-shrike S: Wairapiya Masi-saratiththa)

348. *Rhipidura aureola* Lesson 1830 BrR L1[w g]
(E: White-browed Fantail S: Bama-sudu Pawanpenda)

349. *Rhipidura javanica* (Sparrman) 1788 WVa L3
(E: Pied Fantail S: Gomara Pawanpenda)

350. *Dicrurus macrocercus* Vieillot 1817 BrR L1[w g t]
(E: Black Drongo S: Kalu Kawuda)

351. *Dicrurus leucophaeus* Vieillot 1817 WV L1[g t]
(E: Ashy Drongo S: Alu Kawuda)

352. *Dicrurus caerulescens* (Linnaeus) 1758 BrR L1[w g]
(E: White-bellied Drongo S: Kawuda)

353. *Dicrurus paradiseus* (Linnaeus) 1766 BrR L1[w g][10]
(E: Great Racket-tailed Drongo S: Maha Kawuda)

354. *Hypothymis azurea* (Boddaert) 1783 BrR L1[w g]
(E: Black-naped Monarch S: Kalu-gelasi Radamara)

355. *Terpsiphone paradisi* (Linnaeus) 1758 BrR & WV L1[w g]
(E: Asian Paradise- flycatcher S: Asia Rahanmara)

356. *Aegithina tiphia* (Linnaeus) 1758 BrR L1[w g]
(E: Common Iora S: Podu Iorawa)

357. *Aegithina nigrolutea* (Marshall, GFL) 1876 SU L 2[11]
(E: Marshall's Iora S: Marshallge Iorawa)

[10] Rassmussen and Anderton 2005 - *Dicrurus paradiseus lophorinus*, upgraded to endemic species level as *Dicrurus lophorinus* under "taxonomy dependent". Both *Dicrurus lophorinus* and *Dicrurus paradiseus* occur in Sri Lanka

[11] Rassmussen and Anderton 2005 - A male specimen (BMNH; previously considered an abberent common) from Uva (SE Sri Lanka) is this species but shows slight tendency towards tiphia

358. *Tephrodornis pondicerianus* (Gmelin) 1789 BrR L1 [w g t 12]
(E: Common Woodshrike S: Podu Wana-saratiththa)

MUSCICAPIDAE

359. *Monticola solitarius* (Linnaeus) 1758 WV L1 [g]
(E: Blue Rock Thrush S: Nil Gal-thirasikaya)
360. ***Myophonus blighi*** (Holdsworth) 1872 **END** BrR L1 [w g]
(E: Sri Lanka Whistling Thrush S: Sri Lanka Uruwan-thirasikaya)
361. *Zoothera wardii* (Blyth) 1842 WV L1 [w g]
(E: Pied Thrush S: Gomara Thirasikaya)
362. *Zoothera citrina* (Latham) 1790 WV L1 [w g]
(E: Orange-headed Thrush S: Hisaran Thirasikaya)
363. ***Zoothera spiloptera*** (Blyth) 1847 **END** BrR L1 [w g]
(E: Sri Lanka Spot-winged Thrush S: Sri Lanka Thithpiya Thirasikaya)
364. *Zoothera dauma* (Latham) 1790 BrR L1 [g 13]
(E: Scaly Thrush S: Kayuru Thirasikaya)
365. *Turdus merula* Linnaeus 1758 BrR L1 [w g]
(E: Eurasian Blackbird S: Urasia Kalu Bimsariya)
366. *Turdus obscurus* Gmelin 1789 WV L2
(E: Eyebrowed Thrush S; Ahibami Bimsariya)
367. *Muscicapa striata* (Pallas) 1764 WVa L3
(E: Spotted Flycatcher S: Pulli Masimara)
368. *Muscicapa daurica* Pallas 1811 WV L1 [g]
(E: Asian Brown Flycatcher S: Asia Bora Masimara)
369. *Muscicapa muttui* (Layard, EL) 1854 WV L1 [w g t]
(E: Brown-breasted Flycatcher S: Layabora Masimara)
370. *Ficedula zanthopygia* (Hay) 1845 WVa L3
(E: Yellow-rumped Flycatcher S: Nithamba-kaha Rath-masimara)
371. *Ficedula parva* (Bechstein) 1792 Va L3
(E: Red-throated Flycatcher S: Rathu-gela Rath-masimara)
372. *Ficedula subrubra* (Hartert & Steinbacher) 1934 WV L1 [w]
(E: Kashmir Flycatcher S: Kashmira Rath-masimara)
373. *Ficedula tricolor* (Hodgson) 1845 WVa L3
(E: Slaty-blue Flycatcher S: Neelawan Rath-masimara)
374. *Ficedula nigrorufa* (Jerdon) 1839 WVa L2
(E: Black-and-Orange Flycatcher S: Kalu-thambili Rath-masimara)
375. ***Eumyias sordida*** (Walden) 1870 **END** BrR L1 [w g]
(E: Sri Lanka Dull Blue Flycatcher S: Sri Lanka Neelan-masimara)

[12] Rasmussen and Anderton 2005 - *Tephrodornis pondicerianus affinis* upgraded to endemic species level as *Tephrodornis affinis* under "taxonomy dependent"

[13] Rasmussen and Anderton 2005 - *Zoothera dauma imbricata* upgraded to endemic species level *Zoothera imbricata*, under "taxonomy dependent"

376. *Cyornis pallipes* (Jerdon) 1840 WVa L3
(E: White-bellied Blue Flycatcher S: Sudu-udara Nil-masimara)

377. *Cyornis rubeculoides* (Vigors) 1831 WV L1[g]
(E: Blue-throated Flycatcher S: Neelagela Nil-masimara)

378. *Cyornis banyumas* (Horsfield) 1821 WVa L3
(E: Hill Blue Flycatcher S: Kandukara-neela Nil-masimara)

379. *Cyornis tickelliae* Blyth 1843 BrR L1[w g]
(E: Tickell's Blue Flycatcher S: Tickel Nil-masimara)

380. *Culicicapa ceylonensis* (Swainson) 1820 BrR L1[w g]
(E: Grey-headed Canary Flycatcher S: Aluhis Kaha-masimara)

381. *Luscinia svecica* (Linnaeus) 1758 WV L1[g t p]
(E: Bluethroat S: Nilgela Sitikichcha)

382. *Luscinia brunnea* (Hodgson) 1837 WV L1[w g]
(E: Indian Blue Robin S: Indu Nil Sitikichcha)

383. *Cercotrichas galactotes* (Temminck) 1820 WVa L2
(E: Rufous-tailed Scrub Robin S: Rathpenda Chatasikaya)

384. *Copsychus saularis* (Linnaeus) 1758 BrR L1[w g]
(E: Oriental Magpie Robin S: Polkichcha)

385. *Copsychus malabaricus* (Scopoli) 1786 BrR L1[w]
(E: White-rumped Shama S: Wana Polkichcha)

386. *Saxicoloides fulicata* (Linnaeus) 1766 BrR L1[w]
(E: Indian Robin S: Indu Kalukichcha)

387. *Saxicola caprata* (Linnaeus) 1766 BrR L1[w g]
(E: Pied Bushchat S: Gomara Sitibichcha)

388. *Oenanthe pleschanka* (Lepechin) 1770 WVa L3
(E: Pied Wheatear S: Gomara Kateesithaya)

389. *Oenanthe deserti* (Temminck) 1825 WVa L3
(E: Desert Wheatear S; Kathara Kateesithaya)

390. *Oenanthe isabellina* (Temminck) 1829 WVa L3
(E: Isabelline Wheatear S: Isabelline Kateesithaya)

STURNIDAE

391. ***Sturnus albofrontatus* END** BrR L1[g]
(E: Sri Lanka White-faced Starling S: Sri Lanka Wathasudu Sharikawa)

392. *Sturnus malabaricus* (Gmelin) 1789 WVa L3
(E: Chestnut-tailed Starling S: Thambala penda Sharikawa)

393. *Sturnus pagodarum* (Gmelin) 1789 BrR L1[w g]
(E: Brahminy Starling S: Bamunu Sharikawa)

394. *Sturnus sturninus* (Pallas) 1776 WVa L3
(E: Purple-backed Starling S: Dampita Sharikawa)

395. *Sturnus roseus* (Linnaeus) 1758 WV L1[g]
(E: Rosy Starling S: Rosa Sharikawa)

396. *Sturnus contra* Linnaeus 1758 WVa L3
(E: Asian Pied Starling S: Asia Gomara Sharikawa)
397. *Acridotheres tristis* (Linnaeus) 1766 BrR L1 w g
(E: Common Myna S: Mayna)
398. ***Gracula ptilogenys*** Blyth 1846 **END** BrR L1 w g
(E: Sri Lanka Myna S: Sri Lanka Salalihiniya)
399. *Gracula religiosa* Linnaeus 1758 BrR L1 w g
(E: Hill Myna S: Salalihiniya)

SITTIDAE

400. *Sitta frontalis* Swainson 1820 BrR L1 w g
(E: Velvet-fronted Nuthatch S: Villuda Nalal Yatikuriththa)

PARIDAE

401. *Parus major* Linnaeus 1758 BrR L1 w g
(E: Great Tit S: Maha Tikiriththa)

HIRUNDINIDAE

402. *Riparia riparia* (Linnaeus) 1758 WV L2
(E: Sand Martin S: Karapati Ivurilihiniya)
403. *Hirundo fuligula* Lichtenstein 1842 WVa L3
(E: Rock Martin S: Gal Wahilihiniya)
404. *Hirundo concolor* Sykes 1832 WV L2
(E: Dusky Crag Martin S: Anduru Wahilihiniya)
405. *Hirundo rustica* Linnaeus 1758 BrR L1 w g p
(E: Barn Swallow S: Atu Wahilihiniya)
406. *Hirundo tahitica* Gmelin 1789 BrR L1 g
(E: Pacific Swallow S: Sethkara Wahilihiniya)
407. *Hirundo smithii* Leach 1818 WVa L3
(E: Wire-tailed Swallow S: Kurupenda Wahilihiniya)
408. *Hirundo daurica* Linnaeus 1771 BrR L1 w g [14]
(E: Red-rumped Swallow S: Nithamba rathu Wahilihiniya)
409. *Hirundo fluvicola* Blyth 1855 WVa L3
(E: Streak-throated Swallow S: Irigela Wahilihiniya)

PYCNONOTIDAE

410. *Pycnonotus melanicterus* (Gmelin) 1789 BrR L1 w g [15]
(E: Black-crested Bulbul S: Kalu Hisasi Kondaya)

[14] Rasmussen and Anderton 2005 - *Hirundo daurica hyperythra* upgraded to endemic species level as *Hirundo hyperythra*, under “taxonomy dependent”. Both *Hirundo hyperythra* and *Hirundo daurica* occur in Sri Lanka.

[15] Rasmussen and Anderton 2005 - *Pycnonotus melenecturus melenecturus* upgraded as an endemic species *Pycnonotus melenicturus* under “taxonomy depemdent”

411. *Pycnonotus cafer* (Linnaeus) 1766 BrR L1 [w g]
(E: Red-vented Bulbul S: Kondaya)

412. ***Pycnonotus penicillatus*** Blyth 1851 **END** BrR L1 [w g]
(E: Sri Lanka Yellow-eared Bulbul S: Sri Lanka Kahakan Kondaya)

413. *Pycnonotus luteolus* (Lesson) 1841 BrR L1 [w g]
(E: White-browed Bulbul S: Bamasudu Kondaya)

414. *Iole indica* (Jerdon) 1839 BrR L1 [w g]
(E: Yellow-browed Bulbul S: Bamakaha Guluguduwa)

415. *Hypsipetes leucocephalus* (Gmelin) 1789 rR L1 [w g]
(E: Black Bulbul S: Kalu-kondaya)

Cisticolidae

416. *Cisticola juncidis* (Rafinesque) 1810 BrR L1 [w]
(E: Zitting Cisticola S: Iri Pawansariya)

417. *Prinia rufescens* Blyth 1847 WVa L3
(E: Rufescent Prinia S: Rath Priniya)

418. *Prinia hodgsonii* Blyth 1844 BrR L1 [w g]
(E: Grey-breasted Prinia S: Laya-alu Priniya)

419. *Prinia sylvatica* Jerdon 1840 BrR L1 [w g]
(E: Jungle Prinia S: Wana Priniya)

420. *Prinia socialis* Sykes 1832 BrR L1 [w g]
(E: Ashy Prinia S: Alu Priniya)

421. *Prinia inornata* Sykes 1832 BrR L1 [w g]
(E: Plain Prinia S: Sarala Priniya)

Zosteropidae

422. ***Zosterops ceylonensis*** Holdsworth 1872 **END** BrR L1 [w g]
(E: Sri Lanka White-eye S: Sri Lanka Sithasiya)

423. *Zosterops palpebrosus* (Temminck) 1824 BrR L1 [w g]
(E: Oriental White-eye S: Peradigu Sithasiya)

Sylviidae

424. *Cettia pallidipes* (Blanford) 1872 WVa L3
(E: Pale-footed Bush Warbler S: Lapaya Pandururaviya)

425. ***Bradypterus palliseri*** (Blyth) 1851 **END** BrR L1 [w g]
(E: Sri Lanka Bush Warbler S: Sri Lanka Wanaraviya)

426. *Locustella lanceolata* (Temminck) 1840 WVa L3
(E: Lanceolated Warbler S: Lansa Piliraviya)

427. *Locustella naevia* (Boddaert) 1783 WVa L3
(E: Grasshopper Warbler S: Palangati Piliraviya)

428. *Locustella certhiola* (Pallas) 1811 WVa L1 [p]
(E: Rusty-rumped Warbler S; Nithamba Rathbora Piliraviya)

429. *Acrocephalus dumetorum* Blyth 1849 WV L1 [g]
(E: Blyth's Reed Warbler S: Blyths Panraviya)

430. *Acrocephalus stentoreus* (Hemprich & Ehrenberg) 1833 BrR/UWV L1 [w g t p]
(E: Clamorous Reed Warbler S: Gosa Panraviya)

431. *Hippolais caligata* (Lichtenstein) 1823 WV L1 [w g t 16]
(E: Booted Warbler S: Kesarupa Rukraviya)

432. *Orthotomus sutorius* (Pennant) 1769 BrR L1 [w g]
(E: Common Tailorbird S: Battichcha)

433. *Phylloscopus fuscatus* (Blyth) 1842 WVa L3
(E: Dusky Warbler S: Anduru Gassraviya)

434. *Phylloscopus trochiloides* (Sundevall) 1837 WV L1 [w g 17]
(E: Greenish Warbler S: Kola Gassraviya)

435. *Phylloscopus magnirostris* (Blyth) 1843 WV L1 [w g]
(E: Large-billed Leaf Warbler S: Mathusu Gassraviya)

436. *Seicercus burkii* (Burton) 1836 WVa L3
(E: Golden-spectacled Warbler S: Ran Upasraviya)

437. *Schoenicola platyura* (Jerdon) 1844 WVa L2 [w g t p]
(E: Broad-tailed Grassbird S: Mapenda Thanaraviya)

438. ***Garrulax cinereifrons*** Blyth 1851 **END** BrR L1 [g]
(E: Sri Lanka Ashy-headed Laughing –thrush S; Sri Lanka Alu-demalichcha)

439. ***Pellorneum fuscocapillum*** (Blyth) 1849 **END** BrR L1 [w g t]
(E: Sri Lanka Brown-capped Babbler S: Sri Lanka Boraga-demalichcha)

440. *Pomatorhinus horsfieldii* Sykes 1832 BrR L1 [w g 18]
(E: Scimitar Babbler S: Da-demalichcha)

441. *Dumetia hyperythra* (Franklin) 1831 BrR L1 [w g]
(E: Tawny-bellied Babbler S: Kusakaha Landu-demalichcha)

442. *Rhopocichla atriceps* (Jerdon) 1839 BrR L1 [w g]
(E: Dark-fronted Babbler S: Wathanduru Panduru-demalichcha)

443. *Chrysomma sinense* (Gmelin) 1789 BrR L1 [w g]
(E: Yellow-eyed Babbler S: Nethkaha Thana-demalichcha)

444. ***Turdoides rufescens*** (Blyth) 1847 **END** BrR L1 [w g]
(E: Sri Lanka Orange-billed Babbler S: Sri Lanka Rathu Demalichcha)

445. *Turdoides affinis* (Jerdon) 1845 BrR L1 [w g]
(E: Yellow-billed Babbler S: Demalichcha)

446. *Sylvia curruca* (Linnaeus) 1758 WV L1 [w t 19]
(E: Lesser Whitethroat S: Heen Gelasudu Rusiraviya)

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[16] Rasmussen and Anderton 2005 - *Hippolais caligata rama* upgraded to species level *Hippolais rama*. *Hippolais caligata* and *Hippolais rama* both occur in Sri Lanka.

[17] Rasmussen and Anderton 2005 - *Phylloscopus trochiloides nitidus* upgraded to species level *Pylloscopus nitidus*, both species *Phylloscopu trociloides* and *Phylloscopus nitidus* occur in Sri Lanka

[18] Rasmussen and Anderton 2005 - *Pomatorhinus schisticeps horsfieldii* upgraded to endemic species level *Pomatorhinus horsfieldii*, under "taxonomy dependent"

[19] Rasmussen and Anderton 2005 - *Sylvia curruca althaea* upgraded to *Sylvia althaea* species level. Both *Sylvia curruca halimodendri* and *Sylvia* althaea occur in Sri Lanka

ALAUDIDAE

447. *Mirafra assamica* Horsfield 1840 BrR L1 [w g]
(E: Rufous-winged Bushlark S: Rathpiya Akul-thulikawa)
448. *Eremopterix grisea* (Scopoli) 1786 BrR L1 [w g]
(E: Ashy-crowned Sparrow Lark S: Kirulalu Gekurulu-thulikawa)
449. *Alauda gulgula* Franklin 1831 BrR L1 [w g]
(E: Oriental Skylark S: Peradigu Ahas Thulikawa)

NECTARINIIDAE

450. *Dicaeum agile* (Tickell) 1833 BrR L1 [w g]
(E: Thick-billed Flowerpecker S: Mathudu Pililichcha)
451. ***Dicaeum vincens*** (Sclater, PL) 1872 **END** BrR L1 [w g]
(E: Sri Lanka Legge's Flowerpecker S: Sri Lanka Pililichcha)
452. *Dicaeum erythrorhynchos* (Latham) 1790 BrR L1 [w g]
(E: Pale-billed Flowerpecker S: Lathudu Pililichcha)
453. *Nectarina zeylonica* (Linnaeus) 1766 BrR L1 [w g]
(E: Purple-rumped Sunbird S: Nithamba Dam Sutikka)
454. *Nectarina minima* (Sykes) 1832 SU L3
(E: Crimson-backed Sunbird S: Rathpita Sutikka)
455. *Nectarina asiatica* (Latham) 1790 BrR L1 [w g]
(E: Purple Sunbird S: Dam Sutikka)
456. *Nectarina lotenia* (Linnaeus) 1766 BrR L1 [w g]
(E: Loten's Sunbird S: Lotenge Sutikka)

PASSERIDAE

457. *Passer domesticus* (Linnaeus) 1758 BrR L1 [w]
(E: House Sparrow S: Gekurulla)
458. *Petronia xanthocollis* (Burton) 1838 WVa L2 [t p]
(E: Chestnut-shouldered Petronia S: Pingu-uris Kuruliththa)
459. *Dendronanthus indicus* (Gmelin) 1789 WV L1 [g]
(E: Forest Wagtail S: Wana-halapenda)
460. *Motacilla alba* Linnaeus 1758 WV L1 [w g p]
(E: White Wagtail S: Sudu Halapenda)
461. *Motacilla maderaspatensis* Gmelin 1789 WV L1 [w g p]
(E: White-browed Wagtail S: Gomara Halapenda)
462. *Motacilla citreola* Pallas 1776 WVa L3
(E: Citine Wagtail S: Kaha-his Halapenda)
463. *Motacilla flava* Linnaeus 1758 WV L1 [g]
(E: Yellow Wagtail S: Kaha Halapenda)
464. *Motacilla cinerea* Tunstall 1771 WV L1 [w g]
(E: Grey Wagtail S: Alu Halapenda)
465. *Anthus richardi* Vieillot 1818 WV L1 [w g]
(E: Richard's Pipit S: Richard Varatichcha)

466. *Anthus rufulus* Vieillot 1818 BrR L1 w g
(E: Paddyfield Pipit S: Keth Varatichcha)
467. *Anthus campestris* (Linnaeus) 1758 WVa L3
(E:Tawny Pipit S: Thani Varatichcha)
468. *Anthus godlewskii* Taczanowski 1876 WV L1 w g p
(E: Blyth's Pipit S: Blyth Varatichcha)
469. *Anthus hodgsoni* Richmond 1907 WVa L3
(E: Olive-backed Pipit S: Olivepita Varatichcha)
470. *Anthus cervinus* (Pallas) 1811 WVa L3
(E:Red-throated Pipit S: Rathgela Varatichcha)
471. *Ploceus manyar* (Horsfield) 1821 BrR L1 g
(E: Streaked Weaver S: Pan Wadukurulla)
472. *Ploceus philippinus* (Linnaeus) 1766 BrR L1 w g
(E: Baya Weaver S: Ruk Wadukurulla)
473. *Amandava amandava (Linnaeus) 1758* SU L2 g
(E: Red Avandavat S; Rathu Amnadavatha)
474. *Lonchura malabarica* (Linnaeus) 1758 BrR L1 w g
(E: Silverbill S: Sarala Weekurulla)
475. *Lonchura striata* (Linnaeus) 1766 BrR L1 w g
(E: White-rumped Munia S: Nithamba Sudu Weekurulla)
476. *Lonchura kelaarti* (Jerdon) 1863 BrR L1 w g
(E: Black-throated Munia S: Gelakalu Weekurulla)
477. *Lonchura punctulata* (Linnaeus) 1758 BrR L1 w g
(E: Scaly-breasted Munia S: Laya Kayuru Weekurulla)
478. *Lonchura malacca* (Linnaeus) 1766 BrR L1 w g
(E: Black-headed Munia S: Hisakalu Weekurulla)
479. *Lonchura oryzivora* (Linnaeus) 1758 SU L2 g
(E: Java Sparrow S: Ja Weekurulla)

FRINGILIDAE

480. *Carpodacus erythrinus* (Pallas) 1770 WVa L3
(E : Common Rosefinch S: Podu Rosa Pincha)
481. *Emberiza melanocephala* Scopoli 1769 WVa L3
(E: Black-headed Bunting S: Kalu hisa Buntiya)
482. *Emberiza bruniceps* Brandt 1841 WVa L3
(E: Red-headed Bunting S: Rathu hisa Buntiya)

The Fauna of Sri Lanka (2006): 204-215

Status of Waterfowl in Sri Lanka

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Abstract

Based on the annual waterbird census conducted by the Ceylon Bird Club, approximately 155 species belonging to 21 families have been identified in Sri Lanka. These birds reside in a wide variety of wetlands ranging from sea level to c. 1,900m, with a large concentration found in the coastal and inland wetlands of the dry zone. Over the past century researches have documented significant changes to the actual and known status of several species. The continued survival of waterbirds is largely dependent on the maintenance of wetlands which provide the habitat niche. The paper also highlights the spatial and temporal trends of waterbird populations in Sri Lanka.

Keywords: *Waterbirds, Wetlands, Conservation, Distribution*

Background

Today the word 'waterbirds' has generally replaced 'waterfowl' used in the title above provided by IUCN. The Ramsar Convention defines 'waterbirds' as birds 'ecologically dependent upon wetlands'. Wetlands International (WI) uses a more precise working definition, viz., all species in 33 Families which are stated (WI 2002). Among these the 21 Families listed below are represented in Sri Lanka (Henry 1998). In general use today 'waterbirds' approximates to but does not exactly match this definition, referring to a few species not in the stated Families and leaving out a few species that are in them.

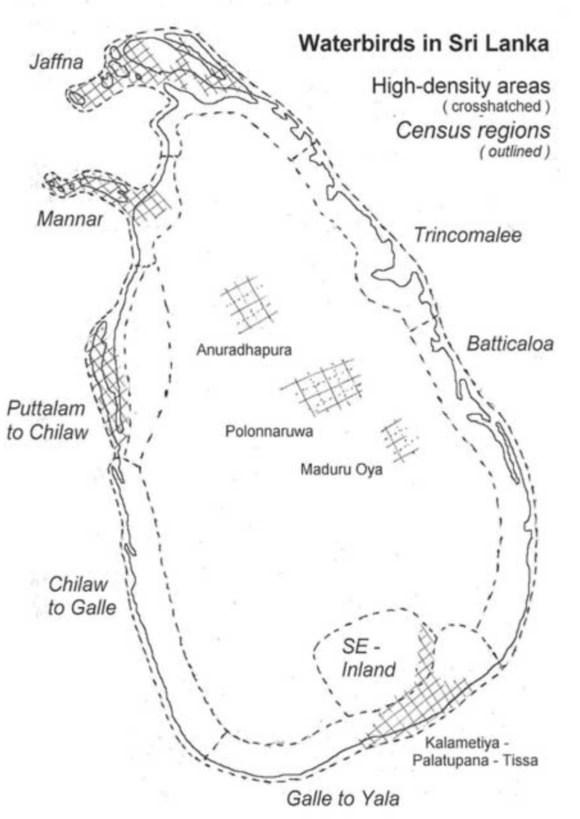

Figure 1: Areas of high waterbird density and regions for the annual census

A large part of the information in this paper is derived from the annual waterbird census in Sri Lanka conducted in January-February during the northern winter migrant season. This has been carried out every year since 1983 to date except one, by the Ceylon Bird Club (CBC) in association with WI and its predecessor. The data from this have been published in Hoffmann (1983 to 1998), Gunawardena (1999 to 2001), Sirivardana (2002, 2003a), and in further detail in a series of books by WI on the waterbird census in Asia from 1986 to 2001 including Li & Mundkur (2004).

As shown in Fig. 1, the island is divided into 10 regions for the census, demarcated for ecological or logistical reasons (Hoffmann 1992b). Eight lie along the coast and one is near the coast. The rest of the island is treated as one region because the number of waterbirds it yields is low.

The armed conflict has prevented the census in 1985 and coverage of certain areas in other years. A few rich sites have been excluded in many years for this reason. Most of the rich Jaffna region, though much affected, has been covered nearly every year.

Even if not for this limitation, the data from the census cannot be regarded as a perfect representation of the numbers of the various taxa of waterbirds in Sri Lanka at the time it is taken. Several factors can significantly affect the figures in a waterbird census. Four of these are: the extent of coverage of each region and site, weather conditions, movements of birds among sites, and the degree of visibility of the birds being sought. To expand on the last factor, rails and crakes (Family Rallidae), for example, are very elusive, hence greatly under-represented in the count; in this example, though, even the actual numbers are generally low.

The data from the census are extremely valuable but not the only source for information in this paper. The authors draw on wider experience in sightings and observations and other knowledge, their own and that available in Henry (1998) and Ceylon Bird Club Notes (1943 to 2004).

Waterbirds in Sri Lanka

As at April 2004 a total of 441 species of birds have been recorded in Sri Lanka by the CBC, which maintains the ornithological data and checklists for the country (Wijesinghe 1994; Ceylon Bird Club Notes 1998: 53, 59; 2004: 109). Following the definition of WI, 155, or 35%, of these species are waterbirds. The Appendix gives a complete and annotated list of waterbird species in Sri Lanka.

202 species of birds are migrants to the island, arriving as winter sets in at their breeding grounds and flying back as it ends. The great majority are from northern latitudes, visiting during winter in the northern hemisphere, while a small number of pelagic species visit from southern regions during their winter. Of the migrant species 92, or 46%, are waterbirds.

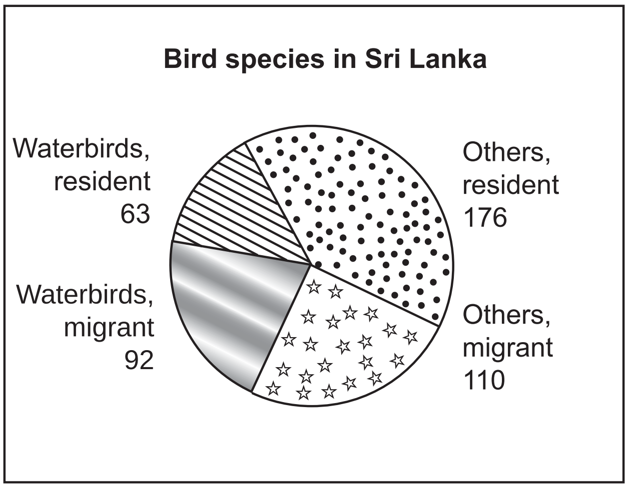

Figure 2: Species diversity correlations of resident, migrant and wetland birds in Sri Lanka

Waterbirds recorded in Sri Lanka belong to the following families: Podicipedidae (grebes), Phalacrocoracidae (cormorants), Anhingidae (darters), Pelecanidae (pelicans), Ardeidae (herons, egrets), Ciconiidae (storks), Threskiornithidae (ibises, spoonbills), Phoenicopteridae (flamingos), Anatidae (ducks), Rallidae (rails, crakes, coots), Jacanidae (jacanas), Rostratulidae (painted-snipes), Haematopodidae (oystercatchers), Recurvirostridae (stilts, avocets), Dromadidae (Crab Plover), Burhinidae (stone-curlews, stone-plovers), Glareolidae (coursers, pratincoles), Charadriidae (plovers, lapwings), Scolopacidae (stints, sandpipers, etc), Laridae (gulls) and Sternidae (terns) (Henry 1998).

In statistics from the census the Families are grouped as shown in Table 1. The words ‘shorebirds’ or ‘waders’ are used for all species in the Families Rostratulidae to Scolopacidae in the list above. The census figures over the 10 years 1994 to 2003 show that the most numerous waterbirds in Sri Lanka are ducks and shorebirds. (See Table 1 and Fig. 3). The majority of these belong to gregarious migrant species.

Table 1: **TOTALS OF GROUPS OF WATERBIRDS 1994 - 2003**

Year	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994
Grebes	712	235	410	632	229	232	236	1114	433	139
Pelicans	457	854	320	384	298	494	640	340	570	756
Cormorants, Darters	9056	10040	4071	8494	4764	7847	8521	7260	11372	8461
Herons	22019	13152	5148	21684	9368	16131	12365	11080	14415	13532
Storks	1958	1860	580	2862	1351	1585	1623	1837	2019	576
Ibises, Spoonbills	1239	1823	460	1248	533	1178	1341	1054	1200	1392
Flamingos	6410	4394	1409	2620	1357	964	2600	1177	188	138
Ducks	138417	35827	9487	25033	18495	72216	24697	17044	163272	18276
Rails, Coots	4689	673	513	1612	1123	1716	1650	1589	2755	940
Jacanas	1260	472	419	1306	1032	1443	1214	1071	1294	736
Waders	24472	132669	13080	33047	22583	38538	54707	17349	30774	20257
Gulls, Terns	51092	17578	15153	4940	10893	8896	10478	5915	7919	10561
Raptors	157	295	116	114	62	185	143	124	109	157
Total	261938	219872	51166	103976	72088	151425	120215	66954	236320	75,921

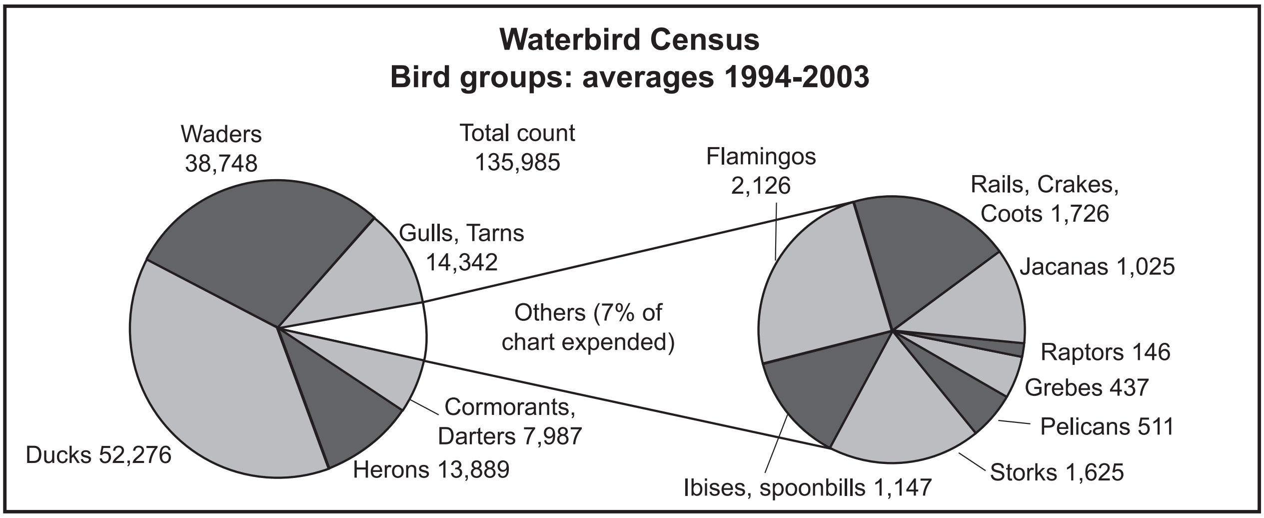

Table 1 and Figure 3: Composition by bird groups in census statistics for the ten years 1994 to 2003. 'Raptors' refers to species of raptors associated with wetlands.

General distribution and habitats

Waterbirds inhabit a wide variety of wetlands throughout Sri Lanka from sea level to c. 1,900 m. Large concentrations are found in the coastal and inland wetlands of the dry zone: (See Fig. 1). The cross-hatching on the map shows the richest areas. Much useful information on waterbird habitats in the country including detailed lists of wetlands is presented by Scott (1989) and Hoffmann (1982, 1993b).

Table 2 and Fig. 4 reflect the predominance in numbers along and near the coastal areas. Among these their preference is clearly seen for sites less populated and altered by humans, with the exception of salterns. The coastal systems favoured in Sri Lanka by waterbirds are lagoons, marshes, estuaries, mangroves, the seashore, islets in the sea, sand and mud flats, and salterns. Large numbers of birds in these habitats belong to Families Anatidae, Charadriidae, Scolopacidae, Laridae and Sternidae. Locally numerous at these sites are species in Ardeidae, Ciconiidae, Threskiornithidae and Phoenicopteridae. Most of the coastal waterbird species, including all the forms found in large numbers, are migrants.

The favoured systems inland are paddy fields and marshes, reservoirs and their associated wetlands. Waterbirds inland are much less numerous. Large populations, however, are seen of species in

Phalacrocoracidae and Ardeidae. Locally common are species in Anatidae, Rallidae and Ciconiidae. A number of species in Rallidae are of a retiring nature, and hence the figures in the census and other records of inland birds tend to under-represent their already relatively low populations and their species diversity. Most of the inland species are residents.

***Table 2**:* Waterbird census, 2003: groups of waterbirds by region

NUMBERS of WATERBIRDS by REGIONS - 2003

GROUP	SPECIES	TOTAL	JAFFNA REGION	MANNAR REGION	PUTTALAM TO CHILAW -- COASTAL	PUTTALAM TO CHILAW -- INLAND	SOUTH OF CHILAW, TO GALLE	SOUTH OF GALLE, TO YALA	YALA EAST, TO BATTI-CALOA	SOUTH-EAST -- INLAND	REST OF ISLAND -- INLAND
Grebes	1	700	40	3	-	210	17	-	133	9	288
Pelicans	1	475	11	-	-	-	57	2	241	18	146
Cormorants, Darters	4	9,301	783	81	-	1,076	158	348	3,869	420	2,566
Herons	13	21,813	1,793	60	14	409	308	3,394	5,410	1,039	9,386
Storks	5	1,964	839	92	-	506	4	82	246	87	108
Ibises, Spoonbills	3	1,271	205	190	-	25	-	358	172	21	300
Flamingos	1	6,410	860	5,000	-	-	-	550	-	-	-
Ducks	10	138,988	22,188	101,285	-	2,017	282	1,845	9,857	587	927
Rails, Coots	6	4,610	20	2,014	-	267	141	614	1,064	281	209
Jacanas	1	1,276	25	11	-	126	21	76	415	390	212
Waders	38	27,012	5,850	14,311	166	21	35	3,757	2,357	313	202
Gulls, Terns	14	51,074	2,841	43,248	545	487	53	283	2,211	35	1,371
Raptors	5	175	61	5	3	7	7	18	24	3	47
TOTAL	102	265,069	35,516	166,300	728	5,151	1,083	11,327	25,999	3,203	15,762

Table 2 is part of the last full set of data published of a census and relates to 2003 (Sirivardana 2003a). The records of the CBC for the 2002-2003 migrant season within and out of the period of this count demonstrate a deficiency in such censuses explained by the factors listed earlier. In September 2002 a concentration of 80-100,000 waders was seen in the Batticaloa area (Gunawardena & Wikramanayake 2002), but the total number of waders counted in Sri Lanka during the census (as the table shows) is c. 27,000, although the area in question was covered well.

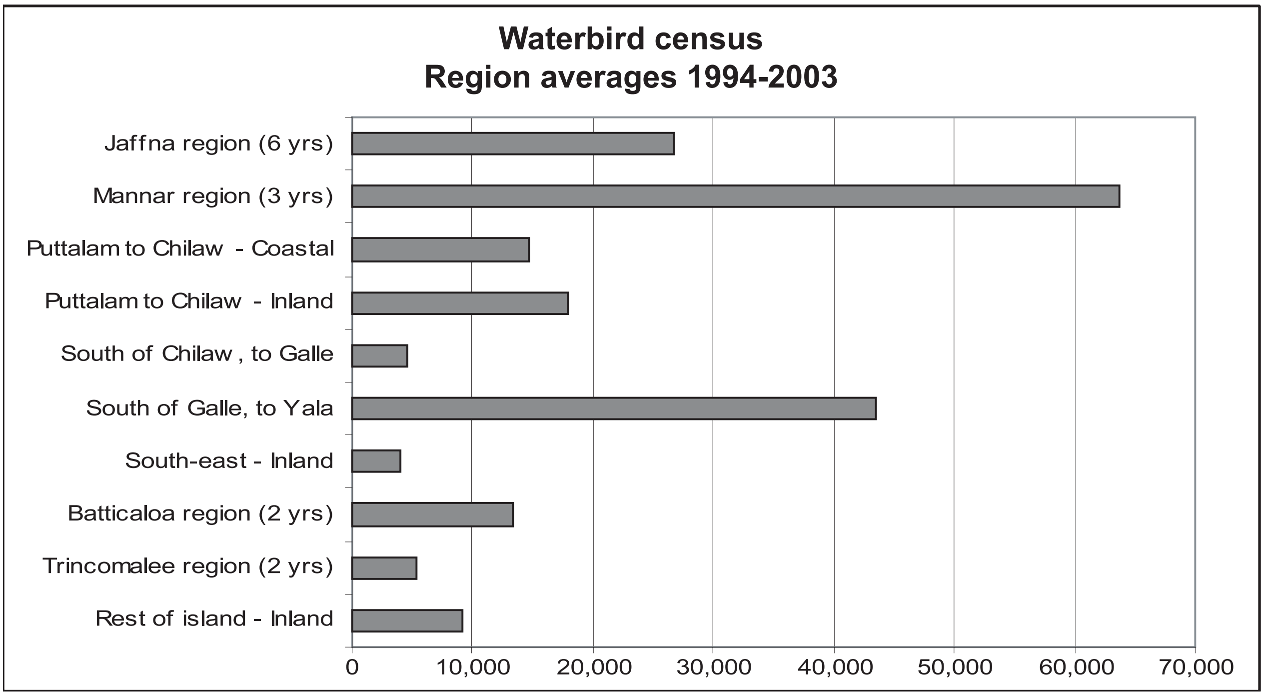

Figure 4: Distribution of waterbirds among regions, from census data, 1993 to 2004

Temporal trends in populations

Instances of changes in the populations of certain species are given in the section on ‘Changes in Status’ below. Other than these no significant long-term trends of changes in numbers have been noted in a species or the total of waterbirds counted in the census. This is illustrated by Figs. 5 and 6. The variations seen in these are explained by the factors listed in the section on ‘Background’ above. There has been no large fluctuation noted in the numbers of any common migrant waterbird species from year to year, as has been observed in a few other common migrant species.

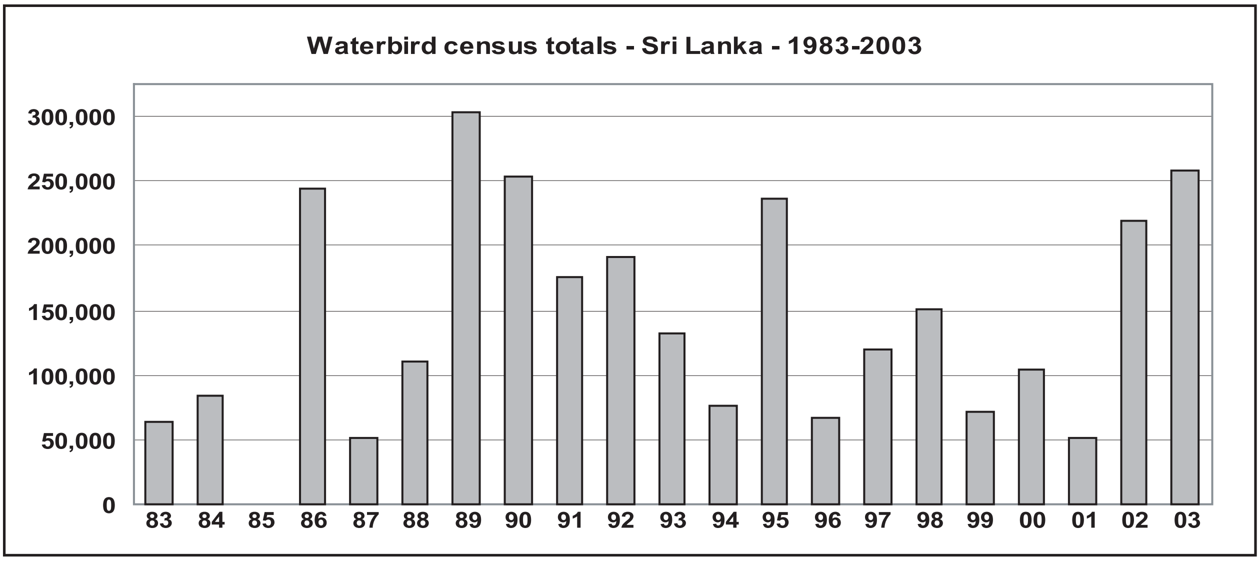

Figure 5: Variations in total number of waterbirds in census, 1983 - 2004.

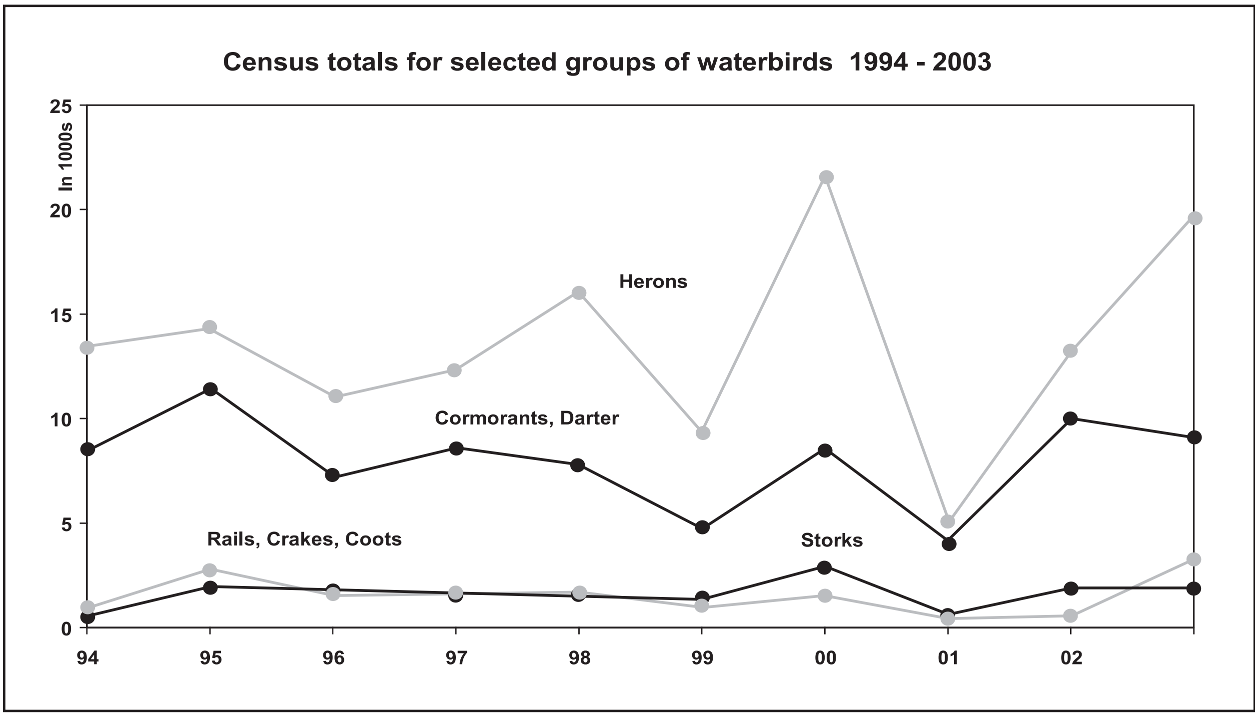

Figure 6: Variations in totals of selected groups of waterbirds in census.

Species 'globally threatened' according to IUCN

In the IUCN 2004 global red list (IUCN 2004) among 'globally threatened' waterbirds in the 'Critically endangered' category is one species found in Sri Lanka, the Sociable Plover *Vanellus gregarius*. In the last half-century the only records of it in the island have been a large flock in 1960, one bird in 1962 and a flock of 12 in 1972 (Henry 1998). The 'Endangered' category also holds one species for Sri Lanka, the Spoon-billed Sandpiper *Eurynorhynchus pygmeus*. It has been recorded in the island only once, in 1978 (Henry 1998).

The 'Vulnerable' category lists three waterbird species pertinent to Sri Lanka.

- The Spot-billed Pelican *Pelecanus philippensis* occurs in South and South-East Asia and is reckoned to total 12-15,000 in its range (Wetlands Inernational: in press). The authors estimate its population in Sri Lanka at over 3,000. This appears to be increasing over the long term. From records it is wholly resident. A major nesting colony in Ruhuna East National Park was destroyed when the Park was abandoned during the armed conflict but is regenerating well, according to an official of the Department of Wildlife Conservation who has been familiar with the area across several decades (Perera S 2004: pers. comm.). The Lesser Adjutant *Leptoptilos javanicus* breeds in Sri Lanka, the rest of South Asia, and South-East Asia. Its world population is estimated at c. 5,000 (WI: in press). In the island it is recorded only in very small numbers except when congregating for water in drought (Ceylon Bird Club Notes 1943 to 2004). The population in Sri Lanka of each of these two species appears to be stable.
- The Wood Snipe *Gallinago nemoricola* had been reported in Sri Lanka when snipe shooting was prevalent in the island but there is no definite record (Henry 1998).

  In the 'Near Threatened' category are six species of waterbirds in Sri Lanka.
- The Black-necked Stork *Ephippiorhynchus asiaticus* has a very small population in the island, estimated by the authors as 10-15. This appears to be stable, as for many decades about six birds in total have been regularly seen in Ruhuna and Ruhuna East National Parks, and young birds are noted there from time to time (Ceylon Bird Club Notes 1965 to 2004).
- The Indian Darter *Anhinga melanogaster,* Painted Stork *Mycteria leucocephala* and White Ibis *Threskiornis melanocephalus* have stable resident populations with quite satisfactory numbers (Hoffmann 1983 to 1998; Gunawardena 1999 to 2001; Sirivardana 2002, 2003a).
- The Great Snipe *Gallinago media* has been recorded very few times in the island and the Asiatic Dowitcher *Limnodromus semipalmatus* twice (Henry 1998; Ceylon Bird Club Notes 2002: 215).

Changes in status

There have been significant changes in the actual or known status of several species of waterbird during the past half-century.

The Common Tern *Sterna hirundo* and Bridled Tern *Sterna anaethetus* were considered migrants, the latter offshore on passage, until 1980 and 2003 respectively. The two species were then found to breed on islands in the sea off Sri Lanka, the former by the east, and subsequently north-west, coasts and the latter north-west (Hoffmann 1980; Perera L 2003). Until very recently the Spot-billed Duck *Anas poecilorhyncha* was a very rare migrant in Sri Lanka. In 2003 it was found to be established as a breeding resident, in the north-west and north of the island, where the armed conflict has restricted access by observers (Sirivardana et al. 2003; Gunawardena et al. 2003).

Until very recently the Common Coot *Fulica atra* was recorded as a scarce breeding resident and only in northern areas of the island. There has now been a great increase in the number of birds and of sites where it is noted, a few 1,000s of birds being observed during migrant seasons and a few 100s with young at other times of year. (Ceylon Bird Club Notes 1943 to 2004; Sirivardana 2003b).

The two migrant species Wigeon *Anas penelope* and Black-tailed Godwit *Limosa limosa* were very rarely recorded in Sri Lanka until a few decades ago. Since then during most seasons they have been recorded in the 1,000s (Ceylon Bird Club Notes 1943 to 2004).

The Glossy Ibis *Plegadis falcinellus* and Comb Duck *Sarkidiornis melanotos* are recorded as having been breeding residents in Sri Lanka. About a century ago they became extinct in the island. They have reappeared as migrants, scarce and rare respectively (Henry 1998; Bavinck 2002, 2003; Prasad 2003).

Conservation of waterbirds

The habitat niches of waterbirds are provided by wetlands, and the protection of these is essential for their survival. Wetlands in Sri Lanka are of a special importance in being the final destination each year for tens of thousands of migrant birds flying southward along the broad Central-South Asia 'flyway'. Conversely, waterbirds form a chief part of the ecology of wetland ecosystems, hence the conservation of waterbirds is essential for the continuance of wetlands. Waterbirds are an important measure of the health of a wetland system, for their presence is an indicator of food availability and habitat conditions.

Several wetlands in the island are Protected Areas, for example the Kalametiya, Anavilundawa and Chundikkulam Santuaries. Several are within Protected Areas such as the Bundala, Ruhuna, Ruhuna East and Maduru Oya National Parks.

Wetlands throughout the island constantly face threats, among which are filling, other transformations by humans, pollution, alteration of water level, loss of nesting sites, hunting (despite a total ban) and raiding of heronries. Many wetlands have already been destroyed or badly damaged. Threats and harm in recent years have been described in detail, and remedies suggested, by many parties, e.g. by the CBC in its journal (Ceylon Bird Club Notes 1995 to 2004) and by the CBC and other bodies in other media (Hoffmann 1995, 1996, 1998; Warakagoda & Gunawardana 1999; Gunawardena 1999 to 2001; Sirivardana 2002, 2003a). The CBC has taken by far the leading role in providing authentic information and applying effective persuasion to Governments to afford Protected and Ramsar Site status to such sites.

A case of current relevance is the lagoon Karagan Lewaya, a prime site for waterbirds in the south-east of Sri Lanka. In the past several years a larger area which includes this site has been the subject of proposals by the State for development in various forms, the most recent being a harbour, by which it would be lost to the birds. The data compiled for the site in the recently conducted census for 2004 included, as conservative estimates: c. 15,000 Pintail *Anas acuta,* 8,000 Garganey Anas querquedula, 10,000 Curlew Sandpiper *Calidris ferruginea*, 8,000 Little Stint *Calidris minuta,* 8,000 Marsh Sandpiper *Tringa stagnatilis,* 3,500 Lesser Sand Plover *Charadrius mongolus* and 200 Kentish Plover *Charadrius alexandrinus.* (Seneviratne et al. 2004). It is a prime feeding site in the south-east for Greater Flamingo *Phoenicopterus ruber* during their stay in Sri Lanka.

Hoffmann (1998) proposes thirteen more Ramsar Sites listed in order of importance. The first, Kalametiya has only suffered further. Anavilundava was declared but then faced human-caused problems now being addressed by the authorities. Listed next are the Mannar mainland, the Sri Lankan side of Adam's Bridge, and Giant's Tank. The next seven sites are in the Jaffna region, and the last on the east coast. The present lessening of the armed conflict allows meaningful work to begin on these.

The site which the CBC at present considers to be of the highest priority for receiving Protected Area status and effective protection is the 'Vankalai Triangle' in the Mannar area. (Gunawardena et al. 2003; Warakagoda & Sirivardana 2003; Sirivardana 2003b). It qualifies for Ramsar Site status and this too is urged. A preliminary proposal has been submitted to the Department of Wildlife Conservation by the club. Presently receiving the club's attention for similar proposal is Navadankulama Tank in the North Western Province.

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Appendix 1: Waterbirds in Sri Lanka, their general distribution and abundance

Status:

R - Resident, M - Migrant

Distribution Zones:

C - Coastal, I - Inland

Abundance:

C - Common (found in fair numbers islandwide within its zone/s

L - Locally common (occurs in fair numbers locally but is rare or not well distributed elsewhere)

U - Uncommon (found in small numbers throughout its zone /s or locally)

R - Rare (occurs in the island only in very small numbers or only occasionally).

Species	Resident/ Migrant	Zone	Abun-dance
Family Podicipedidae			
Little Grebe *Tachybaptus ruficollis*	R	I, C	C
Family Phalacrocoracidae			
Little Cormorant *Phalacrocorax niger*	R	I, C	C
Indian Shag *Phalacrocorax fuscicollis*	R	I, C	C
Great Cormorant *Phalacrocorax carbo*	R	I	U
Family Anhingidae			
Indian Darter *Anhinga melanogaster*	R	C, I	U
Family Pelecanidae			
Spot-billed Pelican *Pelecanus philippensis*	R	C, I	L
Family Ardeidae			
Eurasian Bittern *Botaurus stellaris*	M	I	R
Yellow Bittern *Ixobrychus sinensis*	R,M	I, C	C
Chestnut Bittern *Ixobrychus cinnamomeus*	R	I	U
Black Bittern *Ixobrychus flavicollis*	R,M	I, C	U
Malay Bittern *Gorsachius melanolophus*	M	I	R
Night Heron *Nycticorax nycticorax*	R	I, C	C
Little Green Heron *Butorides striatus*	R	I, C	U
Indian Pond Heron *Ardeola grayii*	R	C, I	C
Chinese Pond Heron *Ardeola bacchus*	M	C, I	R
Median Egret *Ardea intermedia*	R	C, I	C
Cattle Egret *Ardea ibis*	R,M?	I, C	C
Grey Heron *Ardea cinerea*	R	C, I	L
Purple Heron *Ardea purpurea*	R	I, C	C
Goliath Heron *Ardea goliath*	M	C?	R
Large Egret *Egretta alba*	R	C, I	C
Little Egret *Egretta garzetta*	R	C, I	C
Indian Reef Heron *Egretta gularis*	M	C	R
Family Ciconiidae			
Painted Stork *Mycteria leucocephala*	R	C, I	L
Openbill *Anastomus oscitans*	R	I, C	C

Black Stork *Ciconia nigra*	M	I	R
White-necked Stork *Ciconia episcopus*	R	I, C	U
White Stork *Ciconia ciconia*	M	C, I	R
Black-necked Stork *Ephippiorhynchus asiaticus*	R	C	R
Lesser Adjutant *Leptoptilos javanicus*	R	I, C	R
Family Threskiornithidae			
Glossy Ibis *Plegadis falcinellus*	M	C, I	R
White Ibis *Threskiornis melanocephalus*	R	C, I	L
Spoonbill *Platalea leucorodia*	R	C, I	L
Family Phoenicopteridae			
Greater Flamingo *Phoenicopterus ruber*	M	C	L
Family Anatidae			
Large Whistling Teal *Dendrocygna bicolor*	M	I	R
Lesser Whistling Teal *Dendrocygna javanica*	R	I, C	C
Greylag Goose *Anser anser*	M	C	R
Ruddy Shelduck *Tadorna ferrugineaI*	M	C	R
Comb Duck *Sarkidiornis melanotos*	M,R?	I	R
Cotton Teal *Nettapus coromandelianus*	R	I	U
Wigeon *Anas penelope*	M	C	L
Gadwall *Anas strepera*	M	C	R
Common Teal *Anas crecca*	M	C	U
Spot-billed Duck *Anas poecilorhyncha*	R,M?	C, I	R
Pintail *Anas acuta*	M	C, I	L
Garganey *Anas querquedula*	M	C, I	L
Shoveller *Anas clypeata*	M	C, I	U
Tufted Duck *Aythya fuligula*	M	I	R
Family Rallidae			
Water Rail *Rallus aquaticus*	M	I	R
Blue-breasted Banded Rail *Gallirallus striatus*	R,M?	I, C	U
Banded Crake *Rallina eurizonoides*	M	I	U
Baillon's Crake *Porzana pusilla*	M	I	R
Ruddy Crake *Porzana fusca*	R	I, C	U
Corncrake *Crex crex*	M	I	R
White-breasted Waterhen *Amaurornis phoenicurus*	R	I, C	C
Common Moorhen *Gallinula chloropus*	R	I, C	U
Purple Coot *Porphyrio porphyrio*	R	I, C	C
Watercock *Gallicrex cinerea*	R	I, C	U
Common Coot *Fulica atra*	R	I, C	L
Family Jacanidae			
Pheasant-tailed Jacana *Hydrophasianus chirurgus*	R	I, C	C
Family Rostratulidae			
Painted Snipe *Rostratula benghalensis*	R	I, C	U
Family Haematopodidae			
Oystercatcher *Haematopus ostralegus*	M	C	R

Family Recurvirostridae			
Black-winged Stilt *Himantopus himantopus*	R,M	C, I	C
Avocet *Recurvirostra avosetta*	M	C	R
Family Dromadidae			
Crab Plover *Dromas ardeola*	R	C	R
Family Burhinidae			
Stone-Curlew *Burhinus oedicnemus*	R	C, I	U
Great Stone-Plover *Esacus recurvirostris*	R	C, I	U
Family Glareolidae			
Indian Courser *Cursorius coromandelicus*	R	C	R
Collared Pratincole *Glareola pratincola*	M	C	R
Oriental Pratincole *Glareola maldivarum*	R	I, C	L
Little Pratincole *Glareola lactea*	R	C, I	U
Family Charadriidae			
Little Ringed Plover *Charadrius dubius*	R,M	C, I	U
Ringed Plover *Charadrius hiaticula*	M	C, I	R
Kentish Plover *Charadrius alexandrinus*	R,M	C, I	L
Lesser Sand Plover *Charadrius mongolus*	M	C, I	C
Large Sand Plover *Charadrius leschenaultii*	M	C	R
Caspian Plover *Charadrius asiaticus*	M	C	R
Oriental Plover *Charadrius veredus*	M	C	R
Asiatic Golden Plover *Pluvialis fulva*	M	C, I	L
Grey Plover *Pluvialis squatarola*	M	C	U
Yellow-wattled Lapwing *Vanellus malabaricus*	R	C, I	U
Grey-headed Lapwing *Vanellus gregarius*	M	C	R
Red-wattled Lapwing *Vanellus indicus*	R	I, C	C
Sociable Plover *Vanellus gregarius*	M	C	R
Family Scolopacidae			
Great Knot *Calidris tenuirostris*	M	C	R
Red Knot *Calidris canutus*	M	C	R
Sanderling *Calidris alba*	M	C	U
Red-necked Stint *Calidris ruficollis*	M	C	R
Little Stint *Calidris minuta*	M	C, I	C
Temminck's Stint *Calidris temminckii*	M	C, I	R
Long-toed Stint *Calidris subminuta*	M	C	R
Pectoral Sandpiper *Calidris melanotos*	M	I	R
Sharp-tailed Sandpiper *Calidris acuminata*	M	C	R
Curlew Sandpiper *Calidris ferruginea*	M	C, I	C
Dunlin *Calidris alpina*	M	C	R
Spoon-billed Sandpiper *Eurynorhynchus pygmeus*	M	C	R
Broad-billed Sandpiper *Limicola falcinellus*	M	C	U
Buff-breasted Sandpiper *Tryngites subruficollis*	M	C	R
Ruff *Philomachus pugnax*	M	C	U
Jack Snipe *Lymnocryptes minimus*	M	I	R

Common Snipe *Gallinago gallinago*	M	I, C	R
Great Snipe *Gallinago media*	M	C, I	R
Pintail Snipe *Gallinago stenura*	M	I, C	C
Swinhoe's Snipe *Gallinago megala*	M	I	R
Wood Snipe *Gallinago nemoricola*	M	I	R
Asiatic Dowitcher *Limnodromus semipalmatus*	M	C	R
Woodcock *Scolopax rusticola*	M	I	R
Black-tailed Godwit *Limosa limosa*	M	C, I	C
Bar-tailed Godwit *Limosa lapponica*	M	C	R
Whimbrel *Numenius phaeopus*	M	C	U
Eurasian Curlew *Numenius arquata*	M	C	U
Spotted Redshank *Tringa erythropus*	M	C	R
Common Redshank *Tringa totanus*	M	C, I	C
Marsh Sandpiper *Tringa stagnatilis*	M	C, I	C
Common Greenshank *Tringa nebularia*	M	C, I	U
Green Sandpiper *Tringa ochropus*	M	I, C	R
Wood Sandpiper *Tringa glareola*	M	C, I	U
Terek Sandpiper *Xenus cinereus*	M	C	R
Common Sandpiper *Actitis hypoleucos*	M	C, I	U
Turnstone *Arenaria interpres*	M	C	U
Red-necked Phalarope *Phalaropus lobatus*	M	C	R
Family Laridae			
Sooty Gull *Larus hemprichii*	M	C	R
Great Black-headed Gull *Larus ichthyaetus*	M	C	L
Common Black-headed Gull *Larus ridibundus*	M	C	R
Brown-headed Gull *Larus brunnicephalus*	M	C	L
Slender-billed Gull *Larus genei*	M	C	R
Heuglin's Gull *Larus fuscus*	M	C	L
Yellow-legged Gull *Larus cachinnans*	M	C	R
Family Sternidae			
Gull-billed Tern *Sterna nilotica*	M,R	C, I	L
Caspian Tern *Sterna caspia*	R,M	C, I	L
Large Crested Tern *Sterna bergii*	R	C	L
Lesser Crested Tern *Sterna bengalensis*	M	C	L
Sandwich Tern *Sterna sandvicensis*	M	C	R
Black-naped Tern *Sterna sumatrana*	M	C	R
Roseate Tern *Sterna dougallii*	R	C	U
Common Tern *Sterna hirundo*	M,R	C	L
Bridled Tern *Sterna anaethetus*	M,R	C	R *
Little Tern *Sterna albifrons*	R	C, I	L
Saunders's Tern *Sterna saundersi*	R	C	R
Whiskered Tern *Chlidonias hybridus*	M	C, I	C
Black Tern *Chlidonias niger*	M	C	R
White-winged Black Tern *Chlidonias leucopterus*	M	C, I	L

* Common passage migrant off coast

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Taxonomic Status of the Mammals of Sri Lanka

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Abstract

According to literature, there are 91 species of indigenous mammals in Sri Lanka, of which 16 species are endemic to the island. Another 12 species have been introduced to Sri Lanka, of which four species, namely *Bubalis bubalis*, *Equus caballus*, *Equus asinus* and *Rattus norvegicus* have well established feral populations. In addition 26 species of marine mammals have been recorded from the maritime zone of Sri Lanka. The paper highlights the issues and research gaps related to the taxonomy of mammals in Sri Lanka.

Key words: *Mammals, Taxonomy, Research gaps, Conservation*

Introduction

Many authors have reviewed the taxonomic status of the mammals of Sri Lanka. Some of these reviews were on a local scale while others are on a regional scale. Although a number of mammals were described prior to the mid nineteenth century, the first systematic account of the mammals of Sri Lanka was given by Kelaart (1851). Thereafter, Phillips (1935) wrote an extensive review of the mammals of Sri Lanka which, even though somewhat outdated in terms of information remains the standard reference work for the mammals of Sri Lanka even at present.

After Phillips, several attempts have been made to revise the taxonomic status of the country's mammals. Some of these reviews have focused specifically on the Sri Lankan situation (W.C.O.Hill, 1939; Eisenberg and Mckay, 1970; J.E.Hill, 1980; Mckay 1984) while others treated the country's mammals in a regional context (Ellerman and Morrison-Scott 1966; Corbet and Hill, 1992). In addition there are number of reviews that have focused on specific taxonomic groups (Moore, 1960; Ellerman, 1961; Marshall, 1977; Musser, 1981; Bates and Harrison, 1997; Sirinivasulu and Pradhan, 2003; Chakraborty et al., 2004; Sirinivasulu and Jordan, 2004; Sirinivasulu and Sirinivasulu, 2004; Sirinivasulu et al., 2004a and Sirinivasulu et al., 2004b).

The taxonomic status of several mammals of Sri Lanka has changed since the last complete revision by Mckay (1984). The aim of this paper is to synthesize the information presented in recent literature to construct a list of mammals as it stands today.

The current taxonomy of the mammals of Sri Lanka

A total of 144 species and subspecies of mammals were described from Sri Lanka from 1758 to1965. Of these 24 are currently considered as valid species. According to literature, there are 91 species of indigenous mammals in Sri Lanka (annex 1), of which 16 species are endemic to the island. Another 12 species have been introduced to Sri Lanka (annex 2) by humans of which four species, namely *Bubalis bubalis*, *Equus caballus*, *Equus asinus* and *Rattus norvegicus* have well established feral populations. In addition 27 species of marine mammals have been recorded from the maritime zone of Sri Lanka (annex 3). A summary of the mammalian fauna of Sri Lanka is given in Table 1.

Table 1: Summary of the mammal species recorded from Sri Lanka

Order	Number of families	Total		Endemic		Introduced	
		Genera	Species	Genera	Species	Genera	Species
Pholidota	1	1	1	-	-	-	-
Insectivora	1	4	9	1	4	-	-
Chiroptera	7	15	30	-	-	-	-
Primates	2	4	5	-	3	-	-
Carnivora	6	9	14	-	1	2	2
Proboscidea	1	1	1	-	-	-	-
Perrisodactyla	1	-	-	-	-	1	2
Artiodactyla	4	6	8	-	2	5	6
Rodentia	4	14	22	1	6	1	1
Lagomorpha	1	1	1	-	-	1	1
Total	28	55	91	2	16	10	12
Cetacea	5	19	26	-	-	-	-
Sirenia	1	1	1	-	-	-	-
Total	**6**	**20**	**27**	**-**	**-**	**-**	**-**

Eisenberg and McKay (1970) proposed a system for classifying the habitats of mammals in Sri Lanka based on the climate map of Muller-Dombois and Sirisena (1967); they recognize seven mammalian zones, namely monsoon scrub jungle in the northwest (A1) and southeast (A2), monsoon forest and grassland (B), inter monsoon forest (C), rain forests and grasslands below 3000 feet (D1), between 3000-5000 feet (D2) and above 5000 feet (D3). However, the distribution of the mammals in the present list follows a more recent classification proposed by Wijesinghe *et al*. (1993), where the country has been divided to six bioclimatic zones (Figure 1):

A. low and mid country wet zone,

B. dry zone,

C. low and mid country intermediate zone,

D. montane wet zone,

E. montane intermediate zone

F. arid zone.

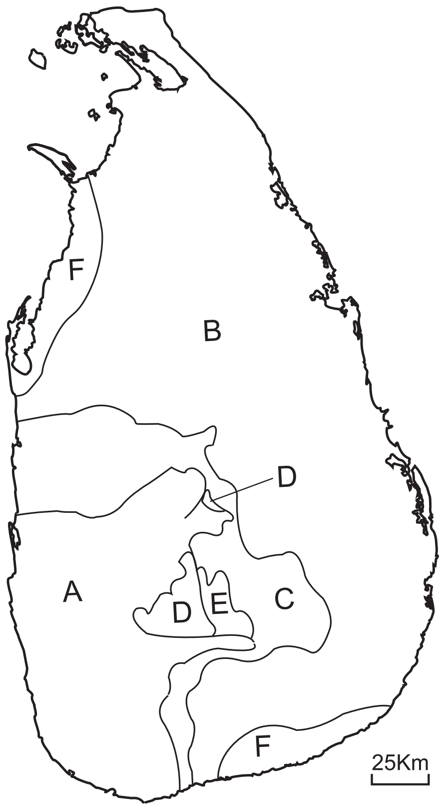

Figure 1: Bioclimatic zones of Sri Lanka

The endemic status of two Sri Lankan shrews has been changed as they have recently been reported from equivalent bioclimatic zones in India. In 1997 Pradhan *et al.* has recorded Kelart's long-clawed shrew, *Feroculus feroculus,* from Kerala and Tamil Nadu provinces, while the Sri Lanka highland shrew, *Suncus montanus,* was recorded from Upper Nilgiri region by Shankar and Sukumar (1998). At the same time two recent revisions of the South Asian murids (Sirinivasulu and Pradhan, 2003), primates (Walker and Molur, 2004), and artiodactyls (Groves and Meijaard, 2005) have indicated that the flame striped jungle squirrel *Funambulus layardi,* the red slender loris *Loris tardigradus* and two species of mouse deer, *Moschiola meminna* and *M. kathygre* are endemic to Sri Lanka. Therefore, the number of endemic mammals in Sri Lanka stands at 16 at present. Revision of the South Asian primates also resulted in the change of the species name of the Grey langur found in Sri Lanka to *Semnopithecus priam.*

Issues pertaining to taxonomy of the mammals of Sri Lanka

Most revisions of Sri Lankan mammals have been based mainly on museum collections rather than detailed field studies. The work of Phillips therefore remains the only truly reliable source today, even though advances in systematics during recent years has made some of his nomenclature obsolete and, as noted above, the endemic status of several species of mammals has changed. Other aspects that need to be resolved are the sub specific status of some Sri Lankan mammals, the doubtful records of some marine mammals, and the status of two species of small mammals described by Deraniyagala (1958 and 1964), *Gatamiya weragami* and *Podihik kura.*

Gatamiya weragami and *Podihik kura* are nowadays omitted from the list of Sri Lankan mammals. Corbett and Hill (1992) consider that the former is probably a synonym of *Mus booduga,* while the description of the latter is based on a juvenile of *Suncus murinus.* However, Deraniyagala placed *P. kura* in the subfamily Soricinae, which possess reddish incisor enamel, while the subfamily Crocidurinae, to which *Suncus* belongs, has white enamel a character unlikely to be mistaken by Deraniyagala. Thus the status of *Podihik*, at least, needs to be re-examined.

Similarly the Southern bottlenose whale recorded by Deraniyagala (1960), and subsequently by National Aquatic Resource Agency as well as Ilangakoon (2002), has been listed as a questionable record by Corbet and Hill (1992). According to them this species is confined to the southern polar region, and what Deraniyagala recorded was most probably Cuvier's beaked whale, *Ziphius cavirostris.*

All this points to the need to carry out a systematic review of the taxonomy of Sri Lankan mammals based on detailed field collections as well as existing museum specimens.

Research gaps related to the taxonomy of mammals of Sri Lanka

Most of the research on mammals of Sri Lanka has been biased towards the large charismatic animals with little emphasis on the small mammals. Many of the small mammals have not been recorded in recent times and their present status remains unknown. Furthermore, many areas of Sri Lanka, such as the north, northwest, isolated hills in the dry zone and the montane regions (especially the Knuckles Range, Deniyaya-Rakwana hills, Peak wilderness, and the Nuwara Eliya region), have not been properly surveyed and may harbour species that are not recorded to date. It is extremely important, therefore, for Sri Lanka to establish a systematic survey program for the country's mammals (for both terrestrial and marine mammals), with a special emphasis on small mammals, under the auspices of the national museum or other relevant government agency. Such a survey would bring about a wealth of information on the mammalian fauna of Sri Lanka as well as provide us the basis to resolve many of the taxonomic issues that we face today.

Conservation issues pertaining to mammals of Sri Lanka

Even though many of the mammals show a wide distribution within Sri Lanka, a majority of the endemic and threatened mammals are confined to the wet zone and especially the montane zone, where habitat loss and degradation are taking place at a rapid rate. Furthermore, fragmentation of habitats also has a detrimental effect on mammal populations, especially small mammals who have low mobility. Expansion of human settlements into forested areas has resulted in an influx of pest species, such as house rat and brown rat that compete with indigenous species, and domestic predators such as cats and dogs have brought about increased predator pressure. A number of small predators, such as the fishing cat and brown mongooses, live in small urban forests and marshes which are at risk of being converted to human use, endangering these small urban populations. Hunting and killing to avoid conflict also remains a major concern, especially for the large charismatic species.

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Annex 1: List of naturally occurring terrestrial mammals of Sri Lanka

(Note: endemic species denoted by *)

ORDER : PHOLIDOTA
FAMILY : MANIDAE
Manis Linnaeus, 1758
M. crassicaudata Gray, 1827 [E: Pangolin; S: Kaballewa]
Distribution: A,B,C,D,F

ORDER : INSECTIVORA
FAMILY : SORICIDAE
Crocidura Wagler, 1832
C. horsfieldi (Tomes, 1856) [E: Horsfield's shrew; S: Kunuhik-miya]
Distribution: A,C,D,E

**C. miya* Phillips, 1929 [E: Sri Lanka long-tailed shrew; S: Sri Lanka Kunuhik-miya]
Distribution: D1,E

Feroculus Kelaart, 1852
F. feroculus (Kelaart, 1850) [E: Kelaart's long-clawed shrew; S: Pirihik-miya]
Distribution: D1,E

Solisorex Thomas, 1924
**S. pearsoni* Thomas, 1924 [E: Pearson's long-clawed shrew; S: Sri Lanka Mahik-miya]
Distribution: A, D

Suncus Ehrenberg, 1832
S. etruscus (Savi, 1822) [E: Pigmy shrew; S: Podi Hik-miya]
Distribution: A,D,F

**S. fellowes-gordoni* Phillips,1932 [E: Sri Lanka pigmy shrew; S: Sri Lanka Podi Hik-miya]
Distribution: D1,E

S. montanus (Kelaart, 1850) [E: Highland shrew; S: Kandu Hik-miya]
Distribution: D,E

S. murinus (Linnaeus, 1766) [E: Common musk shrew; S: Podhu Hik-miya]
Distribution: A,B,C,F

**S. zeylanicus* Phillips, 1928 [E: Sri Lanka jungle shrew; S: Sri Lanka Kele Hik-miya]
Distribution: A,B

ORDER : CHIROPTERA
FAMILY : EMBALLONURIDAE
Taphozous Geoffrey, 1818
T. longimanus Hardwicke, 1825 [E: Long-armed sheath-tailed bat; S: Dikba Kepulum- vavula]
Distribution: A,B,C,F

T. melanopogon Temminck, 1841 [E: Black-bearded sheath-tailed bat; S: Ravulkalu Kepulum- vavula]
Distribution: A,B,C

T. saccolaimus Temminck, 1838 [E: Pouch-bearing sheath-tailed bat; S: Maha Kepulum- vavula]
Distribution: A,B,F

FAMILY : HIPPOSIDERIDAE
Hipposideros Gray, 1831
H. ater Temleton, 1848 [E: Bicolored leaf-nosed bat; S: Depata Pathnehe-vavula]
Distribution: A,B,F

H. fulvus Gray, 1838 [E: Fulvous-leaf nosed bat; S: Malekaha Pathnehe-vavula]
Distribution: C,F2

H. galeritus Cantor, 1846 [E: Dekhan leaf-nosed bat; S: Kesdiga Pathnehe-vavula]
Distribution: A,B,D,E

H. lankadiva Kelaart, 1850 [E: Great leaf-nosed bat; S: Maha Pathnehe-vavula]
Distribution: A,B,C,F

H. speoris (Schneider, 1800) [E: Schneider's leaf-nosed bat; S: Kesketi Pathnehe-vavula]
Distribution: A,B,C,E,F

FAMILY : MEGADERMATIDAE
Megaderma Geoffroy, 1810
M. lyra Geoffroy, 1810 [E: False vampire bat; S: Boru Ley-vavula]
Distribution: A,B,C,F1

M. spasma (Linnaeus, 1758) [E: Long-eared vampire bat; S: Kandiga Boru Ley-vavula]
Distribution: A,B,C,F

FAMILY : MOLOSSIDAE
Tadarida Rafinesque, 1814
T. aegyptiaca (Geoffroy, 1818) [E: Continental wrinkled-lip bat; S: Mahadive Rallithol-vavula]
Distribution: A,C

T. plicata (Buchnnan, 1800) [E: Common wrinkled-lip bat; S: Podhu Rallithol-vavula]
Distribution: A,C

FAMILY : PTEROPODIDAE
Cynopterus Cuvier, 1824
C. brachyotis (Muller, 1838) [E: Lesser dog-nosed fruit bat; S: Heen Thala-vavula]
Distribution: B,C,D,E

C. sphinx (Vahl, 1797) [E: Short-nosed fruit bat; S: Thala-vavula]
Distribution: A,B,C,D,F

Pteropus Brisson, 1762
P. giganteus (Brunnich, 1782) [E: Flying fox; S: Ma-vavula]
Distribution: A,B,C,D,F

Rousettus Gray, 1821
R. leschenaulti (Desmarest, 1820) [E: Fulvous fruit bat; S: Rath dumburu pala vavula]
Distribution: A,B,C,D,F

FAMILY : RHINOLOPHIDAE
Rhinolophus Lacepede, 1799
R. beddomei Anderson, 1905 [E: Great horse-shoe bat; S: Maha Ashladan-vavula]
Distribution: A,B,C,F

R. rouxii Temminck, 1835 [E: Rufous horse-shoe bat; S: Borath Ashladan-vavula]
Distribution: A,B,C,D,E,F

FAMILY : VESPERTILLIONIDAE

Hesperoptenus Peters, 1869

H. tickelli (Blyth, 1851) [E: Tickle's bat; S: Awara-vavula]
Distribution: A,B,C,F

Kerivoula Gray, 1842

K. hardwickii (Horsefield, 1824) [E: Malpas's bat; S: Rathbora Kehel-vavula]
Distribution: A,C

K. pictus (Pallas, 1767) [E: Painted bat; S: Visithuru Kehel-vavula]
Distribution: A,B,C,D,F

Miniopterus Bonaparte, 1837

M. schreibersii (Kuhl, 1819) [E: Long-winged bat; S: Dickpiya-vavula]
Distribution: A,B,C

Myotis Kaup, 1829

M. hasseltii (Temminck, 1840) [E: Brown bat; S: Bora-vavula]
Distribution: B,F2

Murina Gray, 1842

M. cyclotis Dobson, 1872 [E: Tube-nosed bat; S: Nalanehe-vavula]
Distribution: A,D2

Pipistrellus Kaup, 1829

P. affinis (Dobson, 1871) [E: Chocolate bat; S: Bora Koseta-vavula]
Distribution: D1,E

P. ceylonicus (Kelaart, 1852) [E: Kelaart's pipistrel; S: Rathbora Koseta-vavula]
Distribution: A,B,C,D,E

P. coromandra (Gray, 1838) [E: Indian pipistrel; S: Indu Koseta-vavula]
Distribution: A,B,C,F

P. tenuis (Temminck, 1840) [E: Pigmy pipistrel; S: Heen Koseta-vavula]
Distribution: A,B,C,F

Scotophilus Leach, 1821

S. heathii Horsefield, 1831 [E: Great yellow bat; S: Maha Kaha-vavula]
Distribution: A,B,C

S. kuhlii Leach, 1821 [E: Lesser yellow bat; S: Heen Kaha-vavula]
Distribution: B,C,F

ORDER : PRIMATES

FAMILY : CERCOPITHECIDAE

Macaca Lacépéde, 1799

**M. sinica* (Linnaeus, 1771) [E: Sri Lanka toque monkey; S: Sri Lanka Rilawa]
Distribution: A,B,C,D,E,F

Semnopithecus Desmarest, 1822

S. priam Blyth, 1844 [E: Grey langur; S: Eli-wdura]
Distribution: B,C,F

Trachypithecus Reichenbach, 1862

**T. vetulus* (Erxleben, 1777) [E: Purple-faced leaf monkey; S: Sri Lanka Kalu-wandura]
Distribution: A,B,C,D,E,F

FAMILY : LORISIDAE

Loris Geoffroy, 1796

L. lydekkerianus Cabrera, 1908 [E: Grey slender loris; S: Alu Unahapuluwa]
Distribution:,B,C,D,F

**L. tardigradus* (Linnaeus, 1758) [E: Sri Lanka red slender loris; S: Sri Lanka Rath Unahapuluwa]
Distribution: A

ORDER: CARNIVORA

FAMILY : CANIDAE

Canis Linnaeus, 1758

C. aureus Linnaeus, 1758 [E: Jackal; S: Nariya / Hiwala]
Distribution: A,B,C,D,E,F

FAMILY : FELIDAE

Felis Linnaeus, 1758

F. chaus Gueldenstaedt, 1776 [E: Jungle cat; S: Wal Balala]
Distribution: B,C,F

Panthera Oken, 1816

P. pardus (Linnaeus, 1758) [E: Leopard; S: Kotiya/ Diviya]
Distribution: A,B,C,D,E,F

Prionailurus Severtzov, 1858

P. rubiginosus (Geoffroy, 1831) [E: Rusty-spotted cat; S: Kola Diviya / Balal Diviya]
Distribution: A,B,C,D,F

P. viverrinus (Bennett, 1833) [E: Fishing cat; S: Handun Diviya]
Distribution: A,B,C,D,F

FAMILY : HERPESTIDAE

Herpestes Illiger, 1811

H. brachyurus Gray, 1837 [E: Brown mongoose; S: Bora Mugatiya]
Distribution: A,B,C,D,F

H. edwardsii (Geoffroy, 1818) [E: Grey mongoose; S: Alu Mugatiya]
Distribution: A,B,C,F

H. smithii Gray, 1837 [E: Black-tipped or Ruddy mongoose; S: Rath Mugatiya / Hothambuwa]
Distribution: A,B,C,D,F

H. vitticollis Bennett, 1835 [E: Stripe-necked or badger mongoose; S: Maha Mugatiya / Gal Mugatiya]
Distribution: A,B,C,D,F

FAMILY : MUSTELIDAE

Lutra Brisson, 1762

L. lutra (Linnaeus, 1758) [E: Otter; S: Diya-balla]
Distribution: A,B,C,D,F

FAMILY : URSIDAE

Melursus Meyer,1793

M. ursinus (Show & Nodder, 1791) [E: Sloth bear; S: Walaha]
Distribution: B,F

FAMILY : VIVERRIDAE

Paradoxurus Cuvier, 1821

P. hermaphoditus (Pallas, 1777) [E: Palm cat; S: Uguduwa]
Distribution: A,B,C,D,E,F

**P. zeylonensis* (Pallas, 1778) [E: Sri Lanka golden palm cat; S: Sri Lanka Ran Kalawedda]
Distribution: A,B,C,D,E,F

Viverricula Hodgson, 1838

V. indica (Desmarest, 1817) [E: Ring-tailed civet; S: Urulewa]
Distribution: A,B,C,F

ORDER: PROBOSCIDEA

FAMILY : ELEPHANTIDAE

Elephas Linnaeus, 1758

E. maximus Linnaeus, 1758 [E: Elephant; S: Etha / Aliya]
Distribution: A,B,C,D,E,F

ORDER: ARTIODACTYLA

FAMILY : BOVIDAE

Bubalus Smith, 1827

B. arnee (Kerr, 1792) [E: Wild buffalo; S: Kulu Haraka / Wal Meema]
Distribution: B,C,F

FAMILY : CERVIDAE

Axis Smith, 1827

A. axis (Erxleben, 1777) [E: Spotted deer; S: Tith Muwa]
Distribution: B,C,F

A. porcinus (Zimmermann, 1777) [E: Hog deer; S: Vil Muwa / Gona Muwa]
Distribution: A

Cervus Linnaeus, 1758

C. unicolor Kerr, 1792 [E: Sambur; S: Gőna]
Distribution: A,B,C,D,E,F

Muntiacus Rafinesque, 1815

M. muntjak (Zimmermann, 1780) [E: Barking deer; S: Olu Muwa / Weli Muwa]
Distribution: A,B,C,D,E,F

FAMILY : SUIDAE

Sus Linnaeus, 1758

S. scrofa Linnaeus, 1758 [E: Wild boar; S: Wal Ura]
Distribution: A,B,C,D,E,F

Family : Tragulidae

Moschiola Hodgson, 1844

** M. meminna* Erexleben, 1777 [E: Sri Lanka mouse-deer; S: Sri Lanka Meminna]
Distribution: A,B,C,D,E,F

** M. kathygre* Groves & Meijaard, 2004 [E: Sri Lanka pigmy mouse-deer; S: Sri Lanka Kuru Meminna]
Distribution: A, D

ORDER: RODENTIA

Family : Hystricidae

Hystrix Linnaeus, 1758

H. indica (Kerr, 1792) [E: Procupine; S: Ittewa]
Distribution: A,B,C,D,E,F

Family : Muridae

Bandicota Gray, 1873

B. bengalensis (Gray 1835) [E: Mole rat; S: Heen Uru-miya]
Distribution: A,B,C,F

B. indica (Bechstein, 1800) [E: Malabar bandicoot; S: Uru-miya]
Distribution: A,B,C,E,F

Cremnomys Wroughton, 1912

C. blanfordi (Thomas, 1881) [E: White-tailed rat; S: Waligasudu-miya]
Distribution: B,F

Golunda Gray, 1837

G. ellioti Gray, 1837 [E: Bush rat; S: Panduru-miya]
Distribution: B,C,D,F

Millardia Thomas, 1911

M. meltada (Gray, 1837) [E: Soft-furred field rat; S: Kesmudu Keth-miya]
Distribution: B,C,D,F

Mus Linnaeus, 1758

M. booduga (Gray, 1837) [E: Field mouse; S: Wel Heen-miya]
Distribution: A,B,C,D,F

**M. fernandoni* (Phillips, 1932) [E: Sri Lanka spiny mouse; S: Sri Lanka katu Heen-miya]
Distribution: B,C,F2

**M. mayori* (Thomas, 1915) [E: Sri Lanka spiny rat; S: Sri Lanka Depahe Katu Heen-miya]
Distribution: A,D,E

M. musculus Linnaeus, 1758 [E: Indian house mouse; S: Ge Heen-miya/ Koseta-miya]
Distribution: A,B,C,F

Rattus Fischer, 1803

**R. montanus* Phillips, 1932 [E: Nelu rat; S: Sri Lanka Nelu Miya]
Distribution: D1,E

R. rattus (Linnaeus, 1758) [E: Common rat; S: Podu Ge Miya]
Distribution: A,B,C,D,E,F

Srilankamys Musser, 1981

S. ohiensis (Phillips, 1929) [E: Sri Lanka bicolored rat; S: Sri Lanka Depehe-miya]
Distribution: A,D

Vandeleuria Gray, 1842

V. nolthenii Phillips, 1929 [E: Sri lanka long-tailed tree mouse; S: Sri Lanka Gas-miya]
Distribution: A,D,E

V. oleracea (Bennett, 1832) [E: Long-tailed tree mouse; S: Gas-miya]
Distribution: A,B,C,D,E,F

Tatera Lataste, 1882

T. indica (Hardwicke, 1807) [E: Antelope rat; S: Weli-miya]
Distribution: A,B,C,F

FAMILY : PTEROMYIDAE

Petaurista Link, 1795

P. philippensis (Elliot, 1839) [E: Giant flying squirrel; S: Ma-hambawa]
Distribution: A,D

Petinomys Thomas, 1908

P. fuscocapillus (Jerdon, 1847) [E: Small flying squirrel; S: Heen-hambawa]
Distribution: A,B,C,D

FAMILY : SCIURIDAE

Funambulus Lesson, 1835

F. layardi (Blyth, 1849) [E: Sri Lanka flame-striped jungle squirrel; S: Sri Lanka Mukalan Leena]
Distribution: A,B,C,D

F. palmarum (Linnaeus, 1766) [E: Palm squirrel; S: Leena]
Distribution: A,B,C,D,E,F

F. sublineatus (Waterhouse, 1838) [E: Dusky-striped jungle squirrel; S:Punchi Leena]
Distribution: A,B,C,D,E

Ratufa Gray, 1867

R. macroura (Pennant, 1769) [E: Giant squirrel; S: Dandu-leena]
Distribution: A,B,C,D,E,F

ORDER: LAGOMORPHA

FAMILY : LEPORIDAE

Lepus Linnaeus, 1758

L. nigricollis Cuvier, 1823 [E: Black-naped hare; S: Wal Hawa]
Distribution: A,B,C,D,E,F

Annex 2: List of introduced terrestrial mammals of Sri Lanka

ORDER: CARNIVORA
FAMILY : CANIDAE
Canis Linnaeus, 1758
C. familiaris Linnaeus, 1758 [E: Domestic dog; S: Balla]
Distribution: Domestic. Feral in some districts.

FAMILY : FELIDAE
Felis Linnaeus, 1758
F. catus Linnaeus, 1758 [E: Domestic cat; S: Balala / Pusa]
Distribution: Domestic.

ORDER: ARTIODACTYLA
FAMILY : BOVIDAE
Bos Linnaeus, 1758
B. indicus Linnaeus, 1758 [E: Domestic hump-backed cattle; S: Sinhala Elaharaka/ Batu Haraka]
Distribution: Domestic. A small feral population is present in the Block II of Ruhuna National Park.
B. taurus Linnaeus, 1758 [E: European cattle; S: Rata Elaharaka]
Distribution: Domestic

Bubalus Smith, 1827
B. bubalis (Linnaeus, 1758) [E: Domestic water buffalo; S: Mee Haraka]
Distribution: Domestic. Feral populations are reported from zones B,C,D2,F.

Capra Linnaeus, 1758
C. hircus Linnaeus, 1758 [E: Domestic goat; S: Eluva]
Distribution: Domestic

Ovis Linnaeus, 1758
O. aries Linnaeus, 1758 [E: Domestic sheep; S: Betaluwa]
Distribution: Domestic

FAMILY : SUIDAE
Sus Linnaeus, 1758
S. domesticus Brisson, 1762 [E: Domestic pig; S: Gam Ura]
Distribution: Domestic

ORDER: PERISODACTYLA
FAMILY : EQUIDAE
Equus Linnaeus, 1758
E. asinus Linnaeus, 1758 [E: Donkey; S: Buruwa / Puttalam Buruwa]
Distribution: Domestic. Feral populations are reported from zone F1

E. caballus Linnaeus, 1758 [E: Mannar ponies/Delft ponies/Horse; S: Diweldiwa Poniya/Poniya/Ashwaya]
Distribution: Domestic. Feral populations are reported from zone F1

ORDER: RODENTIA
FAMILY : MURIDAE
Rattus Fischer, 1803
R. norvegicus (Berkenhout, 1769) [E: Brown rat; S: Bora Miya]
Distribution: A,B,F

ORDER: LAGOMORPHA

FAMILY : LEPORIDAE

Oryctolagus Lilljeborg, 1874

O. cuniculus (Linnaeus, 1758) [E: Domestic rabbit; S: Rata Hawa]

Distribution: Domestic

Annex 3: List of marine mammals recorded from the Indian Ocean around Sri Lanka

ORDER: CETACEA

FAMILY : BALAENOPTERIDAE

Balaenoptera Lacepede, 1804

B. acutorostrata Lacepede, 1804 [E: Mink Whale; S: Minki thalmaha]

B. edeni Anderson, 1879 [E: Bryde's Whale; S: Brydige thalmaha]

B. musculus Linnaeus, 1758 [E: Blue Whale; S: Nil thalmaha]

B. physalus (Linnaeus, 1758) [E: Fin Whale; S: Waral thalmaha]

Megaptera Gray,1846

M. novaeangliae (Borowski, 1781) [E: Hump backed Whale; S: Molli thalmaha]

FAMILY : DELPHINIDAE

Delphinus Linnaeus, 1758

D. delphis Linnaeus, 1758 [E: Common Dolphin; S: Sulaba mulla]

Feresa Gray, 1870

F. attenuata Gray, 1875 [E: Pygmy killer Whale; S: Kuru minimaru thalmaha]

Globicephala Lesson, 1828

G. macrorhinchus Gray, 1846 [E: Short finned pilot whale; S: Ketiwaral niyamu thalmaha]

Grampus Gray, 1828

G. griseus (Cuvier, 1812) [E: Rissos Dolphin / Gray Dolphin; S: Malina mulla]

Lagenodelphis Fraser, 1957

L. hosei Fraser, 1957 [E: Fraser's Dolphin; S: Keti hota mulla]

Orcinus Fitzinger, 1860

O. orca (Linnaeus, 1758) [E: Killer Whale; S: Minimaru thalmaha]

Peponocephala Nishiwaki & Norris, 1966

P. electra (Gray, 1846) [E: Melon headed Dolphin; S: Puhulolu thalmaha]

Pseudorca Reinhardt, 1862

P. crassidens (Owen, 1846) [E: False killer Whale; S: Boru minimaru thalmaha]

Sousa Gray, 1866

S. chinensis (Osbeck, 1765) [E: Indo-pacific hump-back Dolphin; S: Kabara mulla]

Stenella Gray, 1866

S. coeruleoalba (Meyen, 1833) [E: Striped Dolphin; S: Thith mulla]

S. attenuata (Gray, 1846) [E: Pan tropical spotted Dolphin; S: Wairam mulla]

S. longirostris (Gray, 1828) [E: Spinner Dolphin; S: Sannali mulla]

Steno Gray, 1846

S. bredanensis (Lesson, 1828) [E: Rough-Toothed Dolphin; S: Ralu dat mulla]

Tursiops Gervais, 1855

T. truncatus (Monotagu, 1821) [E: Bottle nosed Dolphin; S: Digasubu mulla]

Family : Phocoenidae

Neophocaena Palmer, 1899

N. phocaeroides (Cuvier, 1829) [E: Finless Propoise; S: Awaral mulla]

Family : Physeteridae

Kogia Gray, 1846

K. breviceps (Balainville, 1838) [E: Pygmy sperm Whale; S: Kurumanda thalmaha]

K. simus (Owen, 1866) [E: Dwarf sperm Whale; S: Miti-manda thalmaha]

Physter Linnaeus, 1758

P. macrocephalus Linnaeus, 1758 [E: Sperm Whale; S: Manda thalmaha]

Family : Ziphiidae

Mesoplodon Gervais, 1850

M. densirostris (Blainville, 1817) [E: Blainville's beaked Whale; S: Blainvillege hota-ul thalmaha]

M. ginkgodensis Nishiwaki & Kamiya, 1958 [E: Ginko-toothed beaked Whale; S: Japan hota-ul thalmaha]

Ziphius Cuvier, 1823

Z. cavirostris Cuvier, 1823 [E: Goose beaked Whale/Cuvier's beak whale; S: Cuvierge hota-ul thalmaha]

ORDER: SIRENIA

Family : Dugongidae

Dugong Lacepede, 1799

D. dugon (Muller, 1776) [E: Common Dugong, Sea cow; S: Muhudu ura]

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Ecological Traits of Endemic Small Mammals in Rainforests of Sri Lanka, and Their Implications for Conservation

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Abstract

Small mammals are of particular interest to Sri Lanka because they form a conspicuous part of the mammalian fauna of the country, represented by 31 species of rodents and shrews. Furthermore, they contribute significantly to the nation's endemic faunal component. Many of these endemics inhabit the fragmented rainforests of southwest Sri Lanka and are extremely vulnerable to habitat destruction. Several ecological traits of endemic small mammals render them more susceptible to anthropogenic habitat destruction than the widespread species. The paper elaborates on specific ecological traits of endemic small mammals with implications for their conservation.

Key words: *Small mammals, Endemic, Conservation*

Introduction

Small mammals are generally small sized animals predominantly included in the two orders Rodentia and Insectivora. Many of these species are difficult to observe in the wild because of their small size and their secretive and/or nocturnal habit. Small mammals play diverse ecological roles that have an impact on the structure and function of many ecosystems. In rainforests, rodents and shrews are integral components, because they function as prey, predators and seed dispersers. Their disappearance may thus bring about changes in the diversity of other faunal and floral elements in such ecosystems. Small mammals can also be regarded as excellent subjects to test suppositions about population growth, migration and reproduction, and, in particular, to study how human-induced changes in landscape patterns have affected vertebrate fauna

Compared to other groups of mammals, small mammals have been largely neglected as a target group for conservation efforts. One reason for this discrepancy is their general r-selective strategy, which makes them highly prolific and hence less vulnerable to environmental deterioration and human control. Many of the widespread species are also classified as pests. In addition, the taxonomic difficulties in identifying species, insufficient knowledge of their distribution patterns, and the lower appeal of rodents to the general public, also have been contributory factors (Amori and Zima 1994). Human impact on natural habitats has nevertheless affected several native and endemic small mammal species throughout the world with a large number of extinctions being recorded (Ceballos and Brown 1995).

Richness of endemic small mammals in Sri Lanka

For Sri Lanka, small mammals are of particular interest because they form a conspicuous part of the mammalian fauna of the country. Of the 90 species of mammals recorded in the island, 31 species are rodents and shrews. Additionally, small mammals are also of considerable biological importance because they contribute significantly to the nation's endemic faunal component. The endemic rodents include *Mus fernandoni, M. mayori , Rattus montanus, Srilankamys ohiensis,Vandeleuria nolthenii* and *Funambulus layardi* while the endemic shrews include *Crocidura miya, Solisorex pearsoni, S. fellowes-gordoni* and *S. zeylanicus*. Many of these endemics inhabit the fragmented rainforests of southwest Sri Lanka and are, hence, extremely vulnerable to habitat destruction. Consequently, a majority of these species have been recognized as threatened or endangered at the national level (IUCN 2000). They are thus subjects of legitimate concern.

Ecological traits with conservation implications

Several ecological traits of endemic small mammals render them more susceptible to anthropogenic habitat destruction than the widespread species. A study carried out in Sinharaja across habitats representing varying levels of disturbance clearly demonstrated that endemic rodents and shrews are incapable of utilizing disturbed areas surrounding the natural forest (Wijesinghe 2001). In contrast, the non-endemics were seen to be able to utilize both forest and non-forest habitats or were restricted to the disturbed areas. In fact, some non-endemics were seen to thrive in plantation and abandoned habitats adjacent to the natural forest.

This difference in the distribution patterns between endemics and non-endemics can be attributed to several factors. The habitat usage patterns of selected rat and mice species within the forest have shown that endemic species are more specialized in their habitat requirements than the non-endemics (Goodyear 1992). Endemic species consistently use closed canopy areas where the undergrowth is relatively sparse. On the other hand, non-endemics such as *Rattus rattus kandianus* displayed an ability to use canopy gaps and areas with a dense understorey. Also, the endemic rat Srilankamys ohiensis had a larger home range than the non-endemic *Rattus rattus* (Wijesinghe 2001) suggesting that the endemics have a specialized diet and/ or habitat preferences (Mazurkiewickz and Rajska-Jugiel 1998; Tobin et al. 1996; Wijesinghe 2001). Furthermore, demographic analysis of murids indicated that the endemics, in contrast to the non-endemics, are incapable of surviving and reproducing in disturbed areas that border the natural forest (Alder and Wilson 1987).

In addition to their specialized nature, several lines of investigations suggest that endemics are in fact inferior competitors and so may face adverse consequences when competing with widespread non-endemics (e.g. Hadfield et al. 1993; Goodman 1995). Negative abundance relationships were recorded between endemic and non-endemic rat species in study sites within Sinharaja suggesting that these species are competing. Captive experiments further supported the fact that endemic species are inferior competitors (Wijesinghe 2001).

The demography and ecology of the endemic small mammals has many important implications for conservation. As many endemics are core-forest species, forest destruction and fragmentation will lead to the loss of more habitats for these species than for the species that utilize non-forest habitats. Habitat loss also causes habitat fragmentation, which leads to the creation of small isolated patches. Because range restricted species generally have a lower population density than those that are widespread, their surviving populations will be smaller and hence face greater extinction. As one of the best predictors of persistence of non-volant mammals is density (Laurance 1991), the low densities of the endemics may indicate greater vulnerability. Fragmented forests also suffer from edge effects, which threaten core-forest species but have a favorable impact on habitat generalists, particularly invasive species (Laurance 1991). As the invasion of communities is greatly enhanced by habitat disturbance, there is a possibility that the forest-adapted endemics would be displaced by such non-endemics.

Future research directions

The present status of our knowledge of the ecology of fauna of the wet zone is very poor. Future research should include studies that monitor faunal populations at regular intervals to determine changes in abundance over time. The viability of species in habitat fragments, ability for species to utilize habitat linkages and their dispersal patterns across modified landscapes should also be addressed. Further, investigations should also focus on aspects of fine scale habitat usage, as this will remain an important component when selecting suitable sites for conservation. Additionally, taxonomic issues of species should be resolved.

If biodiversity is to be protected high priority in conservation strategies should be given to species with restricted distributions. Small mammals have been used as experimental model systems to study the effects of habitat disturbance on the demography and behavior of other vertebrate groups. Thus, knowing the ecological and demographic traits of rainforest small mammals, especially those of endemics, might help us to assess their capacity to adapt to human-induced changes, and so provide a step in evaluating how populations of endemic vertebrates in general react to the loss and fragmentation of their natural habitats.

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The Ecology of the Wild Cats of Sri Lanka

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Abstract

The ecology of the four wild cats of Sri Lanka is reviewed in this paper. Their geographical distribution, taxonomic status and ecology within the island is discussed. Past and present research of each species is reviewed. Their conservation status and threats both globally and in Sri Lanka is reviewed and recommendations made for immediate and essential research.

Keywords: *Leopard, Jungle cat, Fishing cat, Rusty spotted cat, Sri Lanka*

Introduction

Despite its small size, Sri Lanka is an island that boasts of great ecosystem and species diversity (Jansen & Soysa 1992; Wijesinghe, 2000; Wijesinghe et al, 1993). Among the 91 species of native mammals found in the island are 14 species of the order Carnivora (Weerakoon & Goonatilake, this volume; Phillips, 1984). Of these, are four members of the Felid family: the Leopard *(Panthera pardus kotiya),* the Jungle cat *(Felis chaus),* the Fishing cat *(Prionailurus viverrinus)* and the Rusty-spotted cat *(Prionailurus rubiginosa)* (Phillips, 1984).

Based on their body size, the cat family can be divided into three groups. The leopard is classified as a medium sized cat with a body mass of 40-60 kg, which feeds on larger prey ranging from 2 kg to their own mass and larger; while the Jungle cat, Fishing cat and Rusty-spotted cat are classed as small cats, less than 20 kg in mass, which eat small prey weighing less than 1 kg (Seidensticker, 2002; Emmons, 1991).

Leopards are sleek medium-sized cats with head and body lengths ranging from 910-1910 cm and an average mass of 37-90 kg for males and 28-60 kg for females (Seidensticker & Lumpkin, 1991). There is marked sexual dimorphism in leopards, with males varying greatly in size across their geographical range (Miththapala, 1992; Van Valkenburg & Ruff, 1987). In Sri Lanka, this dimorphism is pronounced, likely due to the absence of competitors (Seidensticker & Lumpkin, 2004). In Sri Lanka, the leopard is distinguished easily from the other wild cats by its larger size. (Figure 1)

Of the three small cat species in Sri Lanka, the Jungle cat is long-limbed, with an average head and body length of 739 mm for males and 628 mm for females, and an average mass of 7.9 kg and 4.8 kg for males and females respectively (Sunquist & Sunquist, 2002); the Fishing cat is the heaviest and stockiest with a head and body length of 718 mm for males and 660 for females and a mass of 15 kg for males (Sunquist & Sunquist, 2002); the Rusty-spotted cat is the tiniest – in fact it is one of the smallest cats in the world – measuring a mere 370 mm in head and body for females and weighing a little over a kilogram for females and 1.5kg for males (Sunquist & Sunquist, 2002, Phillips, 1984). (See Figure 2)

Leopard coats are marked with clusters of spots called dark brown/black rosettes and the base colour is a golden tawny in Sri Lanka (Phillips, 1984). (Figure 1) The Jungle cat is unmistakable in Sri Lanka because its coat is an unpatterned sandy brown or reddish grey, with some stripes on its limbs and with black ear tufts (Sunquist & Sunquist, 2002) (Figure 3). The Fishing cat is an olive grey in colour, with rows of black spots extending from its head to its back; it also has a short tail that is only one third of its head and body length (Sunquist & Sunquist, 2002) (Figure 4). As its name implies, the Rusty spotted cat's coat is russet coloured with rust coloured blotches patterning its body and stripes on its face. (Sunquist & Sunquist, 2002).

It has long been accepted that top predators play a critical role in structuring communities (Soulé & Terborgh, 1999; Clark et al., 1999; Seidensticker, 2002) as they not only control overabundance of prey, but also control medium sized predators (Karanth & Sunquist, 1995, 2000; Palomares & Caro, 1999; Seidensticker, 2002). They are also the first to disappear as a result of anthropogenic activities such habitat degradation, habitat fragmentation and the proliferation of roads around protected areas (Seidensticker, 1986, Kerley et al., 2002, Maehr, 1997). Therefore, top carnivores are pivotal components of biodiversity conservation (Seidensticker, 2002). As Seidensticker (2002) succinctly states:

‘We must shift our thinking from viewing top carnivores as an isolated part of ecosystem management to viewing their maintenance as an essential component. . . Top carnivores can be the stars in our ongoing efforts to restore and maintain biodiversity. But the star power of top carnivores, their flagship and umbrella role, is more than symbolic. Without top carnivores, our efforts to stem the loss of biodiversity will ultimately fail.

Until recently, small cats were given scant attention in the preparation of conservation plans and little is known about their ecology and biology (Cat Specialist Group, 2003). Yet, they are important components of ecosystems as they prey, inter alia, on rodents and insectivores, which can become serious pests if their populations are unchecked.

In this paper, I review the ecology of the four wild cats of Sri Lanka and discuss their geographical distribution, taxonomic status and their distribution and ecology within the island, reviewing also past and present research on the species. I examine their conservation status and threats both globally and in Sri Lanka, and finally make recommendations for their conservation.

Distribution

Leopards are cosmopolitan animals, having one of the largest geographic distributions of all terrestrial mammals, and range from the southern cape mountains of South Africa, through most of sub-Saharan Africa in a wide range of habitats from humid rainforests to arid desert habitats; through forest and Mediterranean scrub of Northwest Iran and the Caucasus; in most of the Indian subcontinent excepting the deserts and the mangroves of the Sunderbans; in most of China and even in the Himalayas below the timber line; and through the cloud forests of mainland Malaysia (Bertram, 1979; Bothma & Riche, 1986; Hamilton, 1986; Hoppe-Dominik, 1984; Illany, 1986; Johnsingh, 1983; Neff, 1981; Schaller, et al, 1985; Seidensticker, 1986, Seidensticker, 2002; Seidesticker et al, 1990; Karanth & Sunquist, 1995; Karanth & Sunquist, 2000). They are also extant on Java, Zanizibar, Kangea and Sri Lanka (Johnson & O’Brien 2005).

Leopards have been reported as living in close proximity to humans, and even around major cities and towns such as Nairobi in Kenya, Bombay in India and Kandy in Sri Lanka (Bajoria, 2003; Felidtag, 2003; Jayewardene, 2002). Extremely generalist in their prey utilization, leopards prefer small and medium sized ungulates, but have been known to eat primates preferentially when the ungulate prey base is low or depauperate such as in rain forests or deserts (Hoppe-Dominik, 1984; Illany, 1986).

The conservation status of leopards is disparate: the IUCN red list (2003) lists selected populations/ subspecies in South Arabian, North African and Amur populations of leopards as Critically Endangered; and North Chinese, Sri Lankan, Javan and Persian leopards as Endangered; while no other leopard populations are noted as being subject to threat. CITES places the entire species on Appendix I, yet permits quotas for the export of sport hunting trophies from Botswana, the Central African Republic, Ethiopia, Kenya, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe. (CITES, 2003)

The Jungle cat has a wide distribution ranging from Egypt through the Middle East to central Asia, the Indian subcontinent and Sri Lanka and extending to south western China into the Malaysian peninsular and Myanmar.

In contrast, both the Fishing cat and the Rusty spotted cat have limited geographical distributions, the latter with a very restricted range. The Fishing cat is distributed discontinuously in Pakistan and the foothills of the Himalayas, in south India (where there are scattered populations), Sri Lanka, Bangladesh, Myanmar, northern Thailand and Vietnam as well as on the islands of Sumatra and Java (Sunquist & Sunquist, 2002).

The Rusty-spotted cat's range is even more restricted to an isolated patch in north India in the Kashmir region, southern India and Sri Lanka. Recently, photographs of this species have been recorded as far east as Panna National Park, in central India, where they are reported from scrubland with the invasive Lantana (Seidenstiker & Lumpkin, 2004).

Resource use

Leopards are generalists that are among the most adaptable of all cats and can occupy a broad range of habitat from forests and scrub to desert and hills (Seidensticker & Lumpkin, 1991).

Jungle cats use a wide range of habitats, from tall grass, thick brush and desert scrub to riparian habitats as well as cultivated areas, indicating that they are generalists in their habitat use (Sunquist & Sunquist, 2002). In contrast, Fishing cats are habitat specialists, always associated with wetlands and marshes. Seidensticker & Lumpkin (2004) note that fishing cats live 'in a linear, one-dimensional landscape rather than in a two-dimensional area, because their home areas stretch along the linear extent of the stream or pond bank, not over an area whose boundaries form a polygon.' Rusty spotted cats in India are found in dry and moist deciduous forests, scrub forests and grasslands; in Sri Lanka they are found where there is forest cover (Sunquist & Sunquist, 2002; Phillips, 1984).

Taxonomic status

Molecular genetic analyses have revealed that all modern cats evolved about 10.2 million years ago, during the Miocene, and diverged into eight major lineages (Johnson & O'Brien, 2005; Johnson & O'Brien, 1997).

About 1.8 million years ago, the *Panthera* lineage diverged giving rise to the Genus *Panthera;* molecular research indicates that leopards originated in Africa, some 470 000825 000 years ago and radiated into Asia (Uphyrkina et al, 2001)

Leopards in Sri Lanka have been isolated from mainland leopards of India since the end of the Pleistocene some 10,000 years ago (Bossuyt et al 2004; Jacob, 1949). Molecular biological analyses using three different matrices (protein polymorphism, mitochondrial DNA restriction fragment polymorphisms, and variation in variable nuclear tandem repeats) and morphometric analysis has revealed that the Sri Lankan leopard is a unique and distinct subspecies, one of ten subspecies in the world (Miththapala, 1992; Miththapala et al, 1996, Uphyrkina et al, 2001).

The earliest recorded history of leopards in Sri Lanka is from two main ancient chronicles of history – the Mahawamsa and Chulavamsa (Jayewardene, 2002).

In recent history, one of the earliest records of leopards in Sri Lanka is by d'Oyly (1812, in Jayewardene, 2002) who writes of a chieftain who kills a leopard. Since then, there have been many incidental records of leopards (Jayewardene, 2002).

During the British occupation of Sri Lanka in the 19th century, leopards were considered vermin, killed actively, and trapped, with bounties provided for each skin (Jayewardene 2002). Between 1872 and 1899, records reveal that 8,873 leopards were killed (Jayewardene 2002). This killing, now for sport, continued in the early 20th century, and here too records reveal a high rate of slaughter. In the British Museum of Natural History, are eight skulls of leopards shot by one hunter, in one region of Sri Lanka, during an eight-month period at the turn of the 20th century (Miththapala, personal observation).

Notwithstanding this decimation of the leopard population of Sri Lanka, molecular studies reveal that Sri Lankan leopards have retained within-group genetic diversity consistent with an ancient population bottleneck less than 10,000 years ago circa 2000 years ago, as compared to other species such as Asiatic lions *(Panthera leo asiatica)* in India that are genetically homogeneous as a result of a recent (100 year old) population bottleneck (Miththapala, 1992). Nonetheless, Sri Lankan leopards show markedly less genetic variation than their Indian counterparts, indicative of a population insulated from gene flow from the mainland (Miththapala, 1992; Miththapala et al., 1996; Uphyrkina et al, 2001).

About 3.95 million years ago, the Leopard cat lineage diverged in Southeast Asia, giving rise, among other cat species, to the Fishing cat (Johnson & O'Brien, 1997). The Rusty spotted cat diverged as far back as 10 million years ago and no one really knows where it fits into the felid phylogenetic tree (Johnson & O'Brien, 1997).

The Domestic cat lineage also diverged from its common ancestor some 10 million years ago in the Mediterranean region and radiated in the Pliocene (6 million years ago) giving rise to several Eurasian and African species, including the Jungle cat (Johnson & O'Brien, 1997).

It is apparent therefore, that each of the Sri Lankan cat species belongs to a different clade or group that had its origins in different times and in different regions of the world, and are all, therefore, taxonomically unique.

The validity of the subspecific status and of the smaller Sri Lankan wild cats is is highly questionable as rigorous molecular and morphometric analyses have not been carried out.

Distribution and ecology within Sri Lanka.

Leopards

In 1935, Phillips noted that the range of the Sri Lankan leopard at the turn of the century extended from sea level to Horton Plains in the central hills (over 2000m) in all forests of the island, but that through trophy hunting and loss of forests, it was confined to the national parks of Sri Lanka. Santiapillai (2002), nearly 70 years later, echoes these observations and writes that the range of leopards in Sri Lanka includes some 624,484 ha, or 78% of the country's protected areas. He notes that Sri Lankan leopards are found in all types of forests: from thorn scrub and dry deciduous forests, to lowland rain forests and montane forests (Santiapillai, 2002).

In the early 1970s, John Eisenberg and his collaborators carried out a seminal study on the ecology of leopards in Wilpattu National Park – the key results of which are summarised in Table 1 (Eisenberg & Lockhart, 1972; Muckenhirn & Eisenberg, 1973). The 1980s and 1990s saw only a very few and sporadic field studies, likely as a result of the then political situation in the island which made field research both risky and sporadic. These are: Santiapillai et al, 1982 and Chambers et al, 1983, which preceded island wide political unrest, Amerasinghe et al., 1990, Amerasinge and Ekanayake, 1992, de Silva and Jayaratne, 1994 and Ranawana et al., 1998. The results of these studies are also summarised in Table 1.

Thankfully, for the future of the Sri Lankan leopard, the mid 1990s and the early years of the 21st century saw an increased interest in Sri Lanka's top carnivore. For several decades now, Lal Antonis has been taking still photographs of leopards and in the last decade, Rukshan Jayawardene and Gehan de S Wijeratne have focused on photographing the leopard in Yala Block I (Miththapala, personal observation). These efforts as well as a BBC documentary initiated by Jehan Kumara in the early years of the new millennium put the Sri Lankan leopard in the spotlight and greatly increased awareness of and interest in this top carnivore.

Meanwhile, since 1994, Perera, Kumara, Samarasingha (Kumara & Samarasingha, 2002; Samarasinha, 2002) have focused on identifying individual leopards in Yala Block I, using spot pattern variation (based on

Table 1: Past and present ecological studies of the leopard in Sri Lanka.

Area of study	**Researchers**	**Estimated population size**	**Home range size**	**Home range overlap**	**Prey analysis**	**Time of activity**
Wilpattu National Park	Eisenberg & Lockhart, 1972	20 residents	estimated 29 sq km in Villu habitat 8- 10 sq km	Males and female Males show little overlap	48.3% Axis; 27.59% Sus; 3.45% Cervus: 6.90% Presbytis; 6.90% Lepus; 3.45% Hystrix; 3.45% Bulbalus (calf)	0600 - 1000 hr 1500 -18.30 hr called at night
Wilpattu National Park	Muckenhirn & Eisenberg, 1973		concentrate round permanent water holes.	none	31.7% Axis; 25.49% Sus; 5.88% Cervus; 7.84% Presbytis; 5.88% Lepus; 1.96% Hystrix; 7.84% Bulbalus; 3.92% Muntiacus; 3.92% Ratufa; 1.96% Bird; 3.92% unsure	
Ruhuna National Park (Yala Block I)	Santiapillai et al, 1982	25 in Block I	5.6 sq km (rough estimate)	Considerable overlap	mentions Axis as main prey species	0700 - ‘1100 hr 1500 - 2100 hr with two peaks at 0700 and ‘1800 with shift from diurnal during the dry season to nocturnal during wet season.
Wilpattu, Ruhuna, Wasgamuwa Nat. Parks	Amerasinghe et al., 1990	not estimated	not estimated	not estimated	Wilpattu: 76.5% Axis, 17.7% Bubalus Yala: 54.3% Axis, 20.7 % Sus Wasgamuwa: 50% Lepus, 37.5% Tragulus, 12.5 % Axis	not estimated
Ruhuna National Park (Yala Block I)	Amerasinghe & Ekanayake, 1992	not estimated	not estimated	not estimated	51% Axis; 45% of Bubalus & Sus then, Presbytis and/or Macaca, and Ratufa in a single scat.	not estimated.

Area of study	**Researchers**	**Estimated population size**	**Home range size**	**Home range overlap**	**Prey analysis**	**Time of activity**
Ruhuna National Park (Yala Block I)	De Silva & Jayaratne, 1994	16	Males: Coastal - 10 km^2 Inner forest - 33 km^2 Females - Coast: 8 km^2 Inner forest - 25 km^2	Females have overlapping ranges	not estimated.	0700-0900 hr after 1600 hrs
Horton Plains, Hakgala, Peak Wilderness	Ranawana et. al., 1998	not estimated	not estimated	not estimated	Horton Plains: 75.8% Cervus Hakgala: 42.8% Cervus Peak Wilderness: 64.2% Presbytes, 14.2% Cervus	not estimated
Ruhuna National Park (Yala Block I)	Kittle & Watson, 2002	45 total 33.75 resident 11.25 transient	male = 38.8 sq km, core 23.7 sq km female = 6.8 sq km	averaged 5.9 sq km (range 2.5-9 sq km)	48% Axis; 22% Sus; 10% Bulbalus; 7% mixed 3% Cervus; 4% Presbytes; 2% Lepus; 4% Hystrix;	peaks of activity at crepuscular hours but visible all day. cubs 8 mnth - 2 yr are more visible
Dunumdallawa FR (Kandy)	Kittle & Watson, 2003 unpulbished data ongoing study	3, 1 inferred 1 resident male 1 resident female 1 cub 1 resident female inferred	Male partially within FR but also outside female's within the study area	not yet estimated	not done yet, but Muntiacus, Tragulus, Sus, Hystrix, Lepus, Macaca and Jungle fown in study area	not yet estimated

Pennycuik & Rudnai 1970 and Miththapala et al. 1989). Since 1994, Samarasingha has been maintaining a 'life history' file of every leopard that he has sighted in Yala, and information recorded includes individual identification, location of sighting, as well as parents and siblings/ cubs where known (Kumara & Samarasingha, 2002; Samarasinha, 2002). The result was that in the span of four years, these researchers were able to identify and sex 30 different individuals in Yala Block I (Kumara, 2001; Kumara & Samarasingha, 2002; Samarasinha, 2002).

An intensive study that included over 250 sightings and extended over a 20-month period from October 2000 to June 2002, carried out by Kittle and Watson, began to look at the demography, behaviour and ecology of leopards in Yala Block I (Kittle & Watson, 2003). Involving both day and night time fieldwork, the research has provided valuable data on a number of important facets for this population of leopards (Kittle & Watson, 2002, 2003 and unpublished data).

Kittle & Watson's detailed study of the Yala Block I leopards reveals a very high density of leopards with 35.75 adults residents; an adult resident population density for Yala Block I of 0.15 leopards / km2 per year or 6.6 km2/adult leopard (Kittle & Watson, 2002). This reported figure is much higher than densities of leopards elsewhere in the world (Norton & Henley 1987; Bothma & Le Riche 1984; Hamilton 1976; Schaller 1972 quoted in Kittle & Watson, 2003) and comparable only to densities in South Africa (Bailey, 1993 quoted in Kittle & Watson, in press). Kittle & Watson (in press) consider this substantially high density a result of the conditions in Block I 'approaching what could be considered ideal for leopards.' They attribute this to many facets of leopard ecology, biology and behaviour and extrinsic factors: the fact that leopards are dominant predators in this ecosystem; that there is an abundance of the preferred prey species (Wignaraja et al., 1978) but also because they can also easily switch prey, as evidenced by scat analysis; that despite the Park being in the arid zone of Sri Lanka (where rainfall is less than 1000mm per annum) there are artificially maintained permanent water holes; that their intrinsic behaviour patterns allow for maintenance of home ranges within those of others, as well as maintaining tiny home ranges for females; and that their reproductive rates are high (litters were observed almost every month of the year).

Further details of their study in Yala are tabulated in Table 1.

Ratnayeke and her co-workers have examined the diversity and habitat use of carnivores in Wasgamuwa National Park and her initial data reveal high densities for leopards in Wasgamuwa too (Ratnayeke, personal communication).

After completion of their study in Yala, Kittle & Watson (unpublished data) moved to Dunumadallawa Forest Reserve in Kandy and in an ongoing study, have estimated three to five individuals resident within the area. They note that this forest reserve connects, albeit patchily, to Hantane. There have been other reports of leopards in the Hantane area, which is just south of the heavily populated city of Kandy in the central hills (Jayewardene, 2002). These patches of forest continue south to Galaha and eventually to Pidurutalagala and Nuwara Eliya. The latter connects through Horton Plains National Park to the Peak Wilderness Sanctuary. They note that although this 'corridor' leads through Pinus plantations, roads, tea estates and villages, it provides a link between protected areas and is used by leopards.

What is critically important in these initial data is that they confirms earlier reports (Jayewardene, 2002) that there are leopards outside the protected area system, contrary to Phillips (1984) and Santiapillai (2002) who state that leopards would be confined within the protected area system. These data are buttressed by other island wide data (Kittle & Watson, unpublished data), again from an ongoing study, which show many sightings of leopards on the edge of, or outside protected areas (Figure 5).

Currently, Bambaradeniya and his associates are carrying out a resource inventory of Wilpattu National Park, and their research includes surveys of the leopards, including coordinates of sightings. Samarasinha is also carrying out a study of the ecology of leopards in Wilpattu.

Jungle Cats

According to Phillips (1984), the Jungle cat is limited to the northern monsoon forests of the dry zone, and southwards through Puttlam and Chilaw up to Kurunegala.

The work of current researchers appears to confirm Phillips' observation that the Jungle cat is largely a species of the dry zone, as it has been recorded patchily: wherever there is forest cover, except in the wet zone. (See Figure 4; Balagalle et al., unpublished document IUCN, 1997, 2000; Nekaris, 2003; Ratnayeke, personal communication;) Ratnayeke et al., find that relative abundances for Jungle cats is higher in Wasgomuwa National Park than in Yala Block 1 (Ratnayeke, personal communication). Nekaris sited this species in three locations in the dry zone and one in the intermediate zone (See Figure 6.)

There are no direct studies of the feeding ecology of this species in Sri Lanka. Phillips (1984) records that the Jungle cat feeds on small mammals and ground dwelling birds. Nekaris (2003) suggests that Jungle cats may prey on the Grey Slender Loris (Loris lydekkerianus) In other countries examination of stomach remains of Jungle cats reveal a preponderance of rodents, and ranked next, 'game' birds (Sunquist & Sunquist, 2002). It has been noted that they will feed opportunistically on reptiles and frogs as well as fish. A study in Russia has also revealed that Jungle cats may supplement their winter diets by eating fruit (Sunquist & Sunquist, 2002).

Little is known about the breeding biology of this species, except that litters consist usually of one or two kittens who are not spotted (Seidensticker and Lumpkin, 1991).

Again, little is known about its social organization, except for the observation that, like most other cat species, it is solitary (Sunquist & Sunquist, 2002).

Fishing Cats

According to Phillips (1984), the Fishing cat is found all over the island, even at high elevations and in the forests of both the wet and dry zones, but has not been reported north of the Central province.

An ongoing study by Balagalle et al., seeks to survey selected urban and suburban habitats to determine the presence or absence of Fishing cats and Rusty spotted cats in populated areas, with the expected outcome of obtaining their geographical distribution and ensuring that measures for their conservation are incorporated in urban planning programmes. Thus far, their study - using camera traps around the suburbs of Colombo - has revealed the presence of Fishing cats in the outskirts of Colombo in the Bellanwila-Attidiya Sanctuary, which is a wetland habitat and one which also has an ancient Dutch canal running by it; and in Nawala, which is a residential suburb of Colombo, but which also has a canal that runs alongside the town (Balagalle et al., unpublished document, Seidensticker, 2004) (See Figure 7). They have also documented Fishing cats in Wasgomuwa National Park, which is in the dry zone, both in the buffer zone area and within the park.

Nekaris (2003) reports a sighting of a Fishing cat in Polonnaruwa (Figure 7).

Kittle & Watson (unpublished data) report, as incidental sightings along with their ongoing project on leopard ecology, Fishing cats in several dry zone sanctuaries and Wasgomuwa National Park, as well as other locations in the north central province (most of which are associated with ancient tanks in the dry zone). (See Figure 5.) They also report sightings in the central hills, both in Horton Plains National Park as well as in a tea estate (Bogawantalawa) and a forest reserve (Dunumadalawa) (Figure 7). Kittle & Watson's data corroborates Balagalle et al.'s research and report sightings in populated suburbs around Colombo (Piliyandala, Kotte, Battaramulla, Attidiya, Panadura) as well as around the towns of Ja-ela and Negombo, further north (Figure 7). In all of these towns, there are disused canals, flooded areas or wetlands (Ranjit Galappatti, personal communication). It appears, therefore, from these preliminary findings that although Fishing cats are considered habitat specialists, they are able to adapt to human presence and live in and around human habitation, as long as there is water.

Contrary to Balagalle et al., Ratnayeke et al., in an ongoing study of carnivores in Wasgamuwa National Park, do not record any Fishing cats, although they report sightings in Pottuvil and Kantalai (Ratnayeke, personal communication, Figure 7).

Balagalle identified Porcupine (Hystrix indica) remains in the scats of fishing cats, indicating that they are supplementing their aquatic prey with terrestrial species (Seidensticker, 2004). These researchers have not yet reported densities of this species in the areas they have been photographed. Balagalle et al's research also shows that Fishing cats are both diurnal and nocturnal (Seidensticker, 2004).

Elsewhere in the world, it has been reported that fishing cats prey primarily on fish, next on water birds and on small mammals, although they are known to eat dogs, calves and fawns and even small children (Sunquist & Sunquist, 2004).

Little is known about the social organization or reproductive biology of Fishing cats.

Rusty spotted cats:

Phillips (1984) records that the elusive Rusty spotted cat is resident in all forested areas of the island.

Based on museum records that show the presence in and around Colombo of Rusty spotted cats some 30-50 years ago, Balagalle et al., set out to camera trap this species, but so far have not succeeded in photographing it in the suburbs of Colombo, Dambulla or Kandalama (Balagalle et al., unpublished document.)

Nekaris (2003) lists nocturnal sightings in Yala Block 1. Kittle & Watson (in press) also record 30 sightings of Rusty spotted cats but only in the southern and central part of Yala Block 1. They attribute the lack of sightings in other areas of the park to the floristic composition, which is open scrub in the northern part of Block 1, and relate this absence to the need of Rusty spotted cats to use dense vegetative cover. They confirm that Rusty spotted cats can live in arid conditions (See Figure 8), as does Nekaris (2003) who reports sightings from scrub forests.

All Kittle and Watson's sightings were between 19.00 and 6.00 supporting previous reports that the Rusty spotted cat is truly nocturnal. Kittle & Watson (in press) report that Rusty spotted cats are more commonly sighted in the wet season, close to or on roads.

Ratnayeke's ongoing study of carnivores reveals that the densities of this species are higher in Yala than in Wasgomuwa (Ratnayeke, personal communication).

Nekaris (2003) reports one sighting of predation of an Antelope Rat (Tatara indica) by a Rusty spotted cat in Yala Block 1. Apart from this sighting, nothing much is yet known about the feeding ecology, social organization of this species nor their breeding biology except for Phillips' (1984) account that there are two kittens born per litter.

In captivity, it has been reported that Rusty spotted cats have prodigious appetites - and they eat more than 6% of their body weight each day (Sunquist & Sunquist, 2002). They are known to have very high basal metabolic rates and therefore are very active, and have been dubbed 'the hummingbirds of the cat family' (Seidensticker & Lumpkin, 2004, Sunquist & Sunquist, 2002). Elsewhere in the world, their prey appears to consist mainly of birds and small mammals (Sunquist & Sunquist, 2002). Phillips (1984) reports the same diet in Sri Lanka.

Conservation status and threats to the wild cats of Sri Lanka

Leopards

Leopards are protected by the Flora and Fauna Ordinance of Sri Lanka, where killing or selling leopards or leopard parts carries with it a fine of ten to thirty thousand rupees and a possible prison term of two–five years (FFPO, 1992).

Notwithstanding this national and global protection (the Asian leopards are on Appendix I of CITES where trade is prohibited), there have been reports of leopards caught in wire snares purportedly set for wild boar and deer; poisoning of cattle carcasses on which leopards feed; shooting and spearing (Jayewardene, 2002; Kittle & Watson, 2002). IUCN Sri Lanka notes that annually the Department of Wildlife Conservation records at least five leopard kills and that snares and noose traps set for other species also result in the deaths of leopards (IUCN, 2003). A recent report by Kittle and Watson (2002) warns of increased leopard poaching that is a 'mere tip of the iceberg.' In the course of their 2-year field research, they report having seen 26 skins of leopards near national parks (10 from around Wasgamuwa; five from around Udawalewe; five from Yala, four from Wilpattu and two from the central hill region) (Kittle & Watson, 2002). It appears from their report that although there is a high demand for leopard products in the region, there is an additional demand for leopards in Sri Lanka for medicinal purposes (Kittle & Watson, 2002).

Much more insidious and as debilitating to the population of leopards in Sri Lanka, is habitat loss, habitat degradation and habitat fragmentation. Sri Lanka has only 23.8% of area under forest cover, and has lost approximately half the area of forests it had in the 1950s (Wijesinghe, 2000). Although there has been an island wide moratorium on logging since the 1980s, illicit tree felling and clearing for shifting cultivation (in the dry zone) still continues (Wijesinghe 2000, Miththapala, personal observation). Collection of non-timber forest products and widespread poaching of ungulates contributes to habitat degradation (Wijesinghe 2000, Jayewardene, 2002).

Sri Lanka boasts of some 70 protected areas in the island (40 of which were declared in the 1990s), and has, at least on paper, a reasonably extensive system extending over nearly 14% of its total land area (WCMC, 2000, Conservation International 2004). However, these areas are under constant threat of illegal/unsustainable extraction of resources and encroachment from a burgeoning population of humans (19.2 million in 2000) (Wijesinghe, 2000). It should be noted that except for a few protected areas in the Mahaweli region, most Sri Lanka's protected areas are islands in a sea of human habitation (see Figure 3).

Jungle Cats

The Jungle cat is listed in the IUCN Red list of 2003 as a species of least concern, and on CITES Appendix II (IUCN 2003, CITES 2003). Hunting of this species is prohibited in Bangladesh, China, India, Israel, Myanmar, Pakistan, Tajikistan, Thailand and Turkey (Nowell & Jackson, 1996).

In Sri Lanka, the Jungle cat is afforded full protection under the Flora and Fauna Protection Ordinance and listed as threatened in the National list of flora and fauna (FFPO, 1992; IUCN, 2000).

Like other species, the Jungle cat is affected by habitat loss, although its generalist habits may confer a degree of adaptability that ensures its survival (Sunquist & Sunquist, 2002). An alarming threat to its survival has been the illegal trade in skins, particularly in India, where 306,343 skins were declared when export was banned in 1979, and 14,242 skins found in 1980 (Sunquist & Sunquist, 2002). Way back in 1973, de Alwis stated that forest clearing had a ruinous effect on Jungle cat populations, as suitable prey were being decimated and that many jungle cats then resorted to killing livestock, and were in turn being killed by farmers (de Alwis, 1973). He also reported the alarming rate of killing of twelve jungle cats per month (de Alwis, 1973).

Bambaradeniya and Amerasinghe (2001) report that feral dogs kill Jungle cats.

Fishing cats

The Fishing cat is listed as Vulnerable in the IUCN Red List and on Appendix II of CITES (IUCN, 2003; CITES 2003). The Red List also estimates the effective global population size at below 10,00 mature individuals and recognizes a declining trend in population size. The Felid Taxonomic Group identifies the Javan population as Critically Endangered, as there are less than 200 individuals (Felidtag, 2003). Eighty fishing cat skins were found in 1991 in North Bengal (Sunquist & Sunquist, 2002).

Fishing cats are protected under the FFPO and are considered nationally threatened (FFPO, 1992; IUCN, 2000).

Balagalle et al. note that conflict with humans is high for this species as they kill chickens (Seidensticker, 2004). Bambaradeniya & Amerasinghe (2001) list snares and noose traps set for wild boar as threats to Fishing cats, as well as accidental falls into uncovered wells in human habited areas. They also note that road kills, particularly on the Colombo-Kandy road, are becoming a threat to this species. Kittle & Watson (personal communication) observe that in the Hingurangoda/ Kaudulla forest area in the north central province Fishing cats are hunted and eaten by villagers.

Rusty spotted cats

Rusty spotted cats are listed as vulnerable in the IUCN Red list with a declining global population (IUCN, 2003). Trade of Indian Rusty spotted cats is prohibited under CITES as this population is listed in Appendix I and the Sri Lankan population, on Appendix II.

Like the other wild cats of Sri Lanka, the Rusty spotted cat is protected in Sri Lanka and is considered nationally threatened (FFPO,1990; IUCN 2000).

De Alwis (1973) reports that this species is killed for its flesh, and that adults are killed mistakenly as leopard cubs. Bambaradeniya & Amerasinghe (2001) note road kills in the Hambantota District, and state that road kills and feral dogs are beginning to pose threats to this species. Kittle & Watson's observation (in press) that Rusty spotted cat is more commonly found in and around roads in Yala Block 1 during the wet season lends support to Bambaradeniya & Amerasinghe's statement.

A more insidious threat is Kittle & Watson's observation (in press) of a mating between a Rusty spotted cat and a domestic cat, confirming Phillips' comment that such matings would be likely. Cross species matings could erode the genetic integrity of Rusty spotted cats. Similar events in the recent history of Florida panthers *(Puma concolor coryii)* resulted in genetic introgression, so that certain individuals had alleles from two different subspecies (O'Brien et al., 1990).

Conservation needs for the wild cats of Sri Lanka

Leopards

Thankfully, the 1990s and the 21st century have seen several results-driven studies of leopards (Kittle & Watson 2003; Kumara & Samarasingha, 2002; Miththapala et al., 1996; Ratnayeke, personal communication).

However, what we have is fragmented knowledge. There are serious gaps in the data available on Sri Lankan leopards and we lack a national picture for this species. Data are urgently needed about these unique sub-species across its entire range in Sri Lanka, so that a meaningful and effective plan for conservation, that transcends park boundaries and ecosystems and one which includes all stakeholders, is developed. We need to know these answers because of the reality conveyed in the axiom 'good conservation is based on good science'. Without data, we have no basis for conservation. Without a proper road map for conservation, we cannot minimise risks for the species in question.

Listed below are recommendations for further study of the Sri Lankan leopard that need priority attention**.**

- Obtaining the national distribution of leopards.

  A rigorous and standard method should be employed to examine the distribution of leopards in Sri Lanka, initially as presence/absence noted with an exact location. This should exclude reports, however reliable, and only document, using geographical coordinates for exact locations, actual sightings or the presence of scats. Kittle and Watson are developing such a distribution map and their work needs to be supported so that they can continue this documentation. Incidental but reliable data such as data from the National Conservation Review could be included.

- Estimating populations, densities and home ranges in different habitats and all national parks.

  There is a real danger that Kittle & Watson's density and population estimates of Yala Block I will be extrapolated to estimate the population of leopards in Sri Lanka. In the past, some authors have estimated national figures for leopards extrapolating from data that Eisenberg and Lockhart obtained in Wilpattu in 1972.

  We cannot fall prey to this trap, as the indisputable fact is that we have insufficient data to estimate leopard numbers in Sri Lanka. The necessary data must be obtained from scientific estimates based on home range sizes for leopard in all national parks and in different habitats.

  Pabla & Mathur (2001) have recommended monitoring the populations by using pugmarks, but this is only good for establishing presence/absence of a species in an area. Karanth et al. (2003) have demonstrated that pugmark censuses of tigers in India have not been a reliable means of assessing numbers of individuals. Therefore, we should not also resort to census-based studies, but must rely on sample-based research.

  Before any national estimates are attempted, home ranges sizes and density estimates for leopards in different habitats in different parts of the island must be obtained.

  If, as Kittle & Watson (in press) posit, Yala Block I is a near-ideal habitat for leopards, then would population sizes be smaller in wetter areas of lowland rainforest and in central hills? This needs examination.

  Particularly important are border areas where there has been ethnic conflict. Kittle & Watson state that they were not able to get down in the Vanni area as it was land-mined, but note that all the way on the Vavuniya-Mannar road there still was forest (Watson, personal communication).

  As a priority, estimates must be obtained for previously inaccessible conflict areas. In other areas occupied by government forces, there has been evidence of poaching of primates and ungulates (Miththapala, personal observation.)

- Examining scats in different habitats.

  Although there is good data on prey utilization in Yala Block I and Wilpattu (in the past), we need scat analyses in other protected areas and habitats in both wet and dry seasons to identify the preferred prey of leopards as well as other prey species eaten in other habitats.

- Estimation of ungulate and other potential prey populations in different habitats.

  Top carnivores cannot survive if they do not have adequate numbers of prey. This facet of conservation was largely ignored until Karanth (1993) demonstrated quantitatively a correlation between tiger (Panthera tigris) and prey densities and Wikramanayake et al., (1998) confirmed that suitable patches of tiger habitat existed sans tigers. Since then, empirical data from most of South and Far Eastern Asia, has shown that there are no tigers even in sizeable spaces of suitable habitat when prey populations have been decimated by poaching (Karanth & Stith, 1999; Miquelle et al., 1999).

  Although leopards are far more of generalist in feeding as compared to tigers, and have the ability to switch prey species and survive on small mammals and insects (Seidensticker, 2002), we cannot be complacent, as there are some potential problems if there is prey depletion. Firstly, a shift of prey use by leopards from a preferred prey species to smaller sized prey will place an additional demand on the prey-base of medium and small sized carnivores, with the result that one or more of these species may become threatened with extinction (Seidensticker, 1985). This, in turn, will change community structure. Secondly, if prey numbers are not sufficient, then leopards could turn to preying on livestock, which, in turn, generates conflict between leopards and humans.

  Thus, an estimation of ungulates and other prey species must be an essential component of the conservation of leopards. Again, methods of estimation must be scientific, and consistent methodology must be used island wide.

- There is a critical and imminent need to examine leopards living outside protected areas.

  That there are leopards living outside the protected area system of Sri Lanka can be construed as good news, as it could be inferred that this is a result of healthy populations that have enough cover and prey to survive and reproduce. Their inferred movement between protected areas (Kittle & Watson, unpublished data) is also excellent in terms of their genetic diversity as isolated populations are also at risk of homogenisation of their genetic variation because they are unable to disperse and breed outside their natal areas.

  The other side of this coin is that leopards could be outside protected areas because they do not have adequate room within. The leopards in Yala Block I (Kumara & Samarasingha, 2002; Kittle & Watson, in press) could easily spill over outside within a few years. Kittle & Watson (in press) have noted that sub adults from Yala Block I disappear at the end of two years. This observation begs the question: where to?

  The other negative facet of leopards living outside protected areas in that they very easily become problem animals. Our neighbour India is struggling with the issue of leopard attacks in Mumbai, which is one of the only places in the world where there is a park (which is 103km2) within the city limits, housing 40 leopards. In the last two years there have been 22 deaths among 45 attacks by leopards, mostly on children (Bajoria, 2003). It has been also reported that leopards forage in garbage bins at night (Bajoria, 2003).

  We are hearing of a much smaller scale problem in Hantane where new residents are asked not to allow domestic pets, especially dogs, to range free as they will be eaten by leopards (Ranjan Brekenridge, personal communication). We cannot permit an escalation of this conflict to the level that we learn of in Mumbai.

  It is imperative that leopards living outside national parks are radio collared and their home ranges, the routes they take, their dispersal patterns, what prey they are taking are examined. Kittle & Watson's study in the Dunumadallawa Forest Reserve should be expanded and supported to allow these researchers to follow leopards as they move.

  Leopards are known to be excellent dispersers, travelling at night across open areas devoid of cover as well as across roads (Seidensticker, 2002; Seidensticker et al., 1990; Sunquist, 1983). This ability, coupled with their capacity to live in close proximity to human habitation and their adaptability of prey utilization, gives them a tremendous survival advantage over other large carnivores such as tigers (Seidensticker, 2002).

  However, these leopards are at high risk because they are exposed to new menacing dangers: direct conflict with humans and their livestock, exposure to new diseases from livestock and deaths due to road accidents. We need to minimise these risks for this species.

- In order to understand and minimise the direct threat that leopards face, we have to identify exactly what they are, and examine whether there are threats specific to particular areas.

  An islandwide survey on the threats to leopards is needed. If measures are to be taken to minimise risk to this species in a changing landscape, then we need to identify where poaching is highest, where snaring is predominant (whether for other species or not), where leopards are being killed for medicinal purposes, where leopards are taking livestock, whether leopards are susceptible to being killed by vehicular traffic as they traverse main roads. Kittle & Watson's report of leopard poaching (2002) highlights a specific threat to leopards for medicinal purposes and requires further investigation.

  The Department of Wildlife Conservation and the Forest Department can be requested to assist in this survey. It is only when we know where the problems are greatest that we can attempt to find solutions to them.

- Awareness of the need for the conservation of this top carnivore must be created nationally.

  Good science will result in good conservation only if that good science is disseminated in understandable language to the general populace. To this end, the publication of books on leopards and the publication of posters (Jayewardene et al, 2002, de S. Wijeratne, 2004, Kittle & Watson, 2005) will help, but only with a select group of the national population. A targeted series of national public awareness programmes on the ecologically important role that leopards play in Sri Lanka, as well as their genetic, behavioural and ecological uniqueness, is needed urgently in the regions where it lives.

The small cats

In 2001, Bambaradeniya & Amerasinghe recommended that the focus of research should shift from leopards to small cats. Without shifting the focus, several-pronged research efforts are currently being made to study both leopards and small cats (Balagalle et al., ongoing study; Kittle & Watson, ongoing study; Ratnayeke et al., ongoing study). Despite these efforts, it should be noted that there are yet very large lacunae in our knowledge of these three species.

We know very little about the national distribution, feeding ecology, habitat use and breeding biology of the small wild cats of Sri Lanka. Except for the Fishing cat, for which there are data accumulating of habitat use, we know nothing about their specific habitat and prey requirements nor how they interact with each other and with other meso-carnivores. All these data are essential if we are to formulate meaningful conservation strategies for these wild cats.

Listed below are recommendations for further study that need attention as a priority.

- Obtaining the national distribution of these three species.

  An initial picture of the presence/absence nationwide of these three species is essential.

  Balagalle et al.'s study proposes a three-tier focus of camera trapping, first in and around Colombo, then Muthurajawala and finally Dambulla in the north central zone. They are poised to begin the second phase of their study that entails the use of radio telemetry and comparison of the distribution of fishing cats and their densities in suburban/urban versus natural habitats (Seidensticker, 2004). All that is needed is augmentation and extension of their camera trapping survey across the country.

  Kittle & Watson (in press) have also provided valuable sightings for two of the three species and if their leopard work is supported, then these incidental data will continue.

  Ratnayeke et al.'s ongoing study of carnivore density/ habitat use in Wasgomuwa and Yala should yield results that are extremely beneficial to our understanding of these species.

  It is essential however, that these three important studies are supported and expanded to obtain island wide distribution data.

- Assessing habitat use:

  Across its distribution, the Fishing cat has been identified at a habitat specialist associated with riparian or wetland habitats, whereas the Jungle cat is known to be a generalist (Seidensticker & Lumpkin, 2004; Sunquist & Sunquist, 2002). The distribution map of the Rusty spotted cat in Sri Lanka obtained from incidental reports shows that it is found in the dry, wet and arid zones, and in different habitats (Figure 6). Does this mean that the Rusty spotted cat is a generalist in habitat use? Why then is it so restricted in its geographic range and considered a rare species?

  We need to identify which of these species is sympatric with each other and for this, we need clear locational data and GPS positions plotted on habitat overlay maps to identify specific habitat uses of each of these species. With these locational data, microhabitat variables such as, inter alia: altitude; slope; visibility; percentage cover; weather conditions; number of trees0 to 7 cm dbh; number of trees > 7cm dbh; surface area covered by fallen logs and trees; surface area covered by rocks, presence/ absence of a known water source; percentage ground cover are needed for comparison among species.

- Examining scats of the three different species:

  In order to better understand the ecology of these species, it is imperative that their food habits are studied thoroughly. We need to know what their preferred prey species are, as well as to identify whether and how they switch prey in lean times.

  We need to understand the feeding habits of Rusty spotted cats. A female at a mere 1.1kg, is possibly as small as it can get, given constraints imposed by pregnancy and lactation. Yet, reportedly it has an insatiable appetite in captivity (Seidensticker & Lumpkin, 2004) . In the wild, this would mean that it has to feed very often, several times a day. In competition with other species, what are they eating, particularly in the arid and dry zones, where food is scarce during the drought period?

- Identifying potential competitors:

  Once habitat use and dietary needs are identified and locational data are obtained, it will be possible to assess which species are sympatric with each other. The approximate distribution maps of Jungle cats and Fishing cats (Figure 3 & 4) reveal sightings in similar locations. Whether they are indeed sympatric or whether there are specific habitat differences that are not reflected in the map, needs further study.

  It is also important to identify other carnivore competitors as well as their dietary requirements. Balagalle et al.'s camera traps revealed the Ruddy mongoose (Herpestes smithii), the Brown mongoose (Herpestes fuscus), the Striped–necked mongoose (Herpestes vitticolis), the Otter (Lutra lutra) and the Ring-tailed civet (Viverricula indica), as well as the Golden jackal (Canis aureus) along with Fishing cat photographs in Wasgomuwa and Dambulla.

  There are also other potential competitors like raptors and snakes, which must not be overlooked.

  It is particularly important that the four mongoose species are studied, as based on their body sizes, they may be the closest in size as potential competitors of the Rusty spotted cat.

  The role of jackals as competitors also needs investigation.

  Many scientists have presented empirical evidence of increased densities of smaller carnivores (meso-carnivore release) as a consequence of the absence of the top carnivore in a habitat. The eminent mammalogist John Eisenberg believed that leopards preyed on Jungle cats and that accounted for their scarcity in Sri Lankan forests (Sunquist & Sunquist, 2002). The absence of leopards and the presence of Fishing cats in the suburbs of Colombo is extremely interesting. This presence/absence will be studied further by Balagalle et a.l. (Seidensticker, 2004).

  Ratnayeke's results of carnivore habitat use and densities will come in extremely useful to identify sympatric species.

- Assessing specific threats to survival:

  Reclamation of wetlands is often cited as the main threat to Fishing cats worldwide (Sunquist & Sunquist, 2002; Wikramanyake et al., 2003) Yet, initial reports place this species within the heart of towns and cities. Does this mean that what it needs is water and adequate prey, not necessarily wetlands, and that man-made canals and tanks would suffice? For this, Balagalle et al.'s, telemetric study will be invaluable.

  Identifying where human conflict is highest, where direct and accidental snares and poaching is highest, where road kills are significant is also essential.

- Assessing genetic threats to the Rusty spotted cat:

  Kittle & Watson report on cross mating between a domestic cat and a Rusty spotted cat needs investigation. Given its phylogenetic uniqueness (it does not really fit into any cat lineage and is a very old species) the extent and character of genetic diversity in the Rusty spotted cat need examination.

Conclusions

We need to ensure that the road map for the conservation of Sri Lankan wild cats is not only based on good science, but is results-driven, not activity-driven. We need a goal and a vision for the conservation of these cats that we should all work towards, using a holistic approach that includes all stakeholders.

We, as a nation, take responsibility and act to conserve our top carnivore, so that we can minimise risk to this species in the face of pressure from human activities. We cannot fall back on global monitors to do so.

We need also to guarantee that action is taken now. Back in 1982, Santipillai made several recommendations for the conservation of leopards inter alia of setting up buffer zones to avoid conflict and Jayewardene (2002a) makes an impassioned plea for the conservation of leopards. But there has been no national strategy so far.

Seidensticker & Lumpkin (2004) state concisely the importance of understanding how species are distributed in space, estimating their abundance and discerning what their inter connections are:

'Conservation biologist Michael Soulé pointed out "…diversity and rarity are synonyms for "everything" in ecology." If ecologists can explain and predict patterns of diversity and rarity in landscapes or regions, they understand one of the most fundamental issues in biology.'

It is only when we know the true distribution of the wild cats of Sri Lanka, when we truly understand their biology and ecology and recognise specific threats to each species, that we can begin to formulate meaningful strategies for their conservation.

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Figure 1: Leopard, *Panthera pardus kotiya*
Photograph by: Gehan de Silva Wijeratne©

Figure 2: Rusty Spotted Cat, *Prionailurus rubiginosa*
Photograph by: John Seidensticker

Figure 3: Jungle cat, *Felis chaus*
Photograph by: Jayewardene *et* al, 2002 (source)

Figure 4: Fishing cat**,** *Prionailurus viverrinus*
Photograph by: Rod Williams/Howletts and Port Lympne Zoo Parks, Kent. Kitchener, 1991 (source).

Distribution maps of the four wildcat species in Sri Lanka

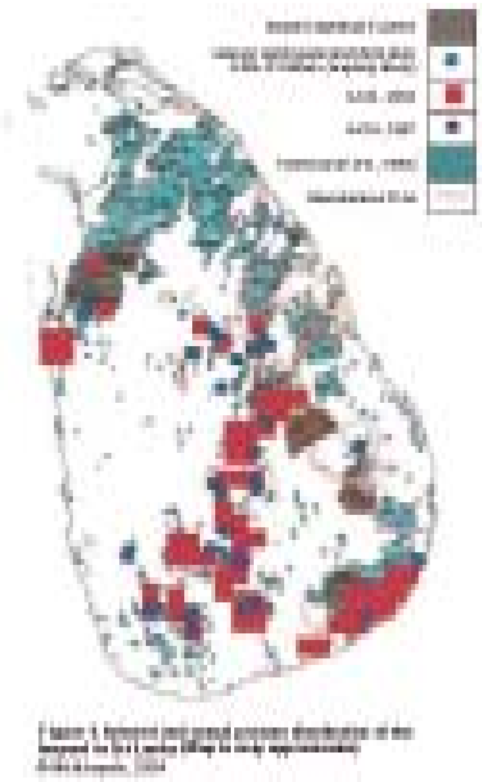


Figure 5: Inferred and actual present distribution of the leopard in Sri Lanka (Map is only approximate) © Miththapala, 2004

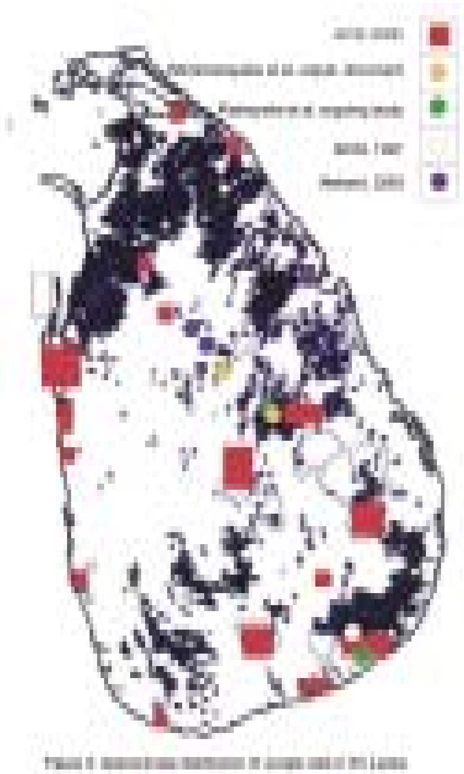


Figure 6: Approximate distribution of Jungle cat in Sri Lanka.

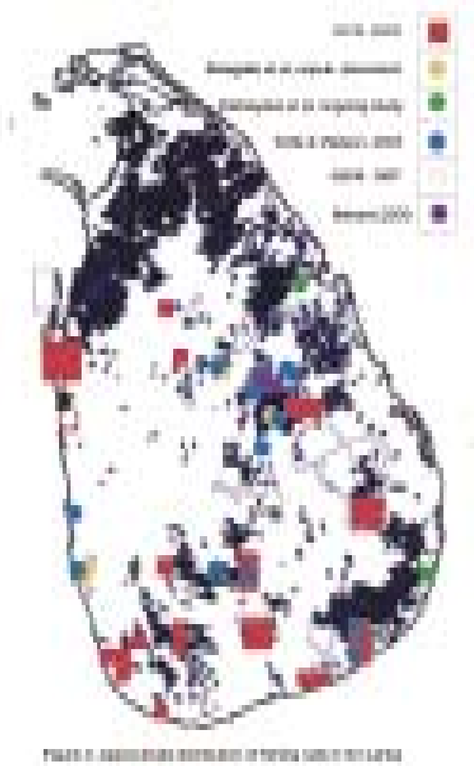


Figure 7: Approximate distribution of fishing cat in Sri Lanka.

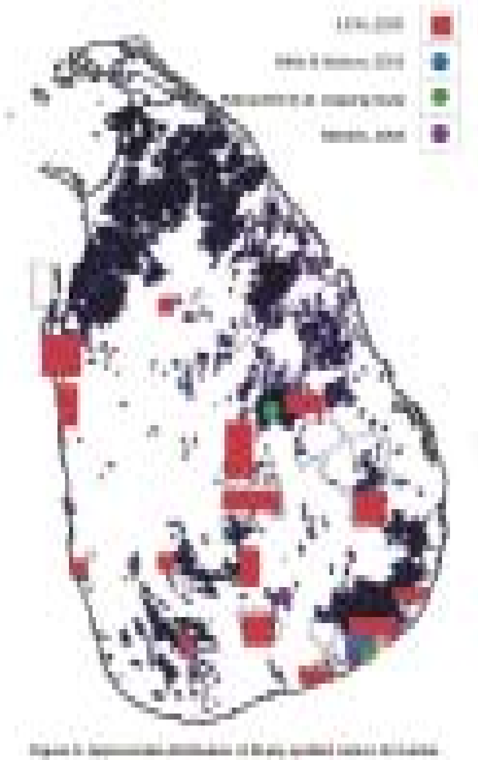
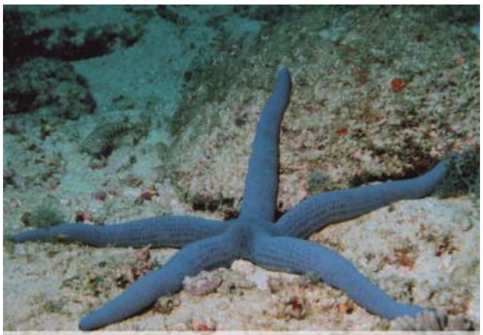


Figure 8: Approximate distribution of Rusty spotted cat in Sri Lanka.

Section 3:

Status of Marine Fauna in Sri Lanka



Linckia laevigata
Saman Liyanage

Dasyatis kuhlii
Nishan Perera

Chromodesmus sp.
Nishan Perera

Culcita schmideliana
Malik Fernando

Stenella longirostris
Anouk Ilangakoon

The Fauna of Sri Lanka (2006): 259-273

Coral Associated Invertebrates: An Overview of the Current Taxonomic Status

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Abstract

This paper provides a detailed description of six groups of coral associated invertebrates; Ascidians, Sponges, Sea Anemones, Polychaete worms, jellyfish and Echinoderms. There has been a steady increase in interest in these invertebrates, as there is a realization that further to their intrinsic value as reef constituents, these species have tremendous commercial value. Lack of research in to this group of marine fauna has resulted in a deficit of information with regards to the taxonomy, biology and distribution of many groups. The author identifies the underlying causes for the lack of research conducted, and provides methods of overcoming the obstacles associated with research. It is imperative that information be gathered which will enable the compilation of a definitive checklist and identification guide, to ensure the conservation of these species.

Key words: *Marine invertebrates, Coral, Conservation*

Introduction

Many invertebrates, together with algae, are associated with hard and soft corals, and reef fish to constitute a healthy reef. A healthy coral reef is one that is in equilibrium, with a high diversity of hard corals and fish and associated invertebrates. These latter animals perform numerous functions in maintaining reef health: browsing animals (like some sea urchins and starfish) prevent overgrowth by algae; many invertebrates are preyed upon by fish and other invertebrates; filter feeders help in improving water clarity by filtering plankton and increasing light falling on corals etc.

Apart from their intrinsic value as reef constituents some have commercial value - principally for the aquarium industry; a fishery for consumption exists only for Holothuria (sea cucumbers) and lobsters. There is a risk of over-exploitation as extraction is un-regulated. A few organisms are protected under the Fauna & Flora Protection Ordinance (Cap 469) as amended by Acts nos. 44 of 1964, 1 of 1970 and 49 of 1993 (FFPO). The protected organisms are listed in Schedule IVA [§ 72, 49 of 1993]: List of Invertebrates that are Protected.

Many filter-feeding invertebrates (such as ascidians, sponges and polychaete worms) often respond to organic pollution by multiplying and may threaten other organisms, especially corals; these animals can be used as indicators of pollution. Others, such as Corallimorpharian anemones, have shown growth suggesting that they may be invasive and impact adversely on coral (Christoffelsz *et al*, 2000). One species, the Crown-of thorns starfish, preys on hard corals and is a pest on coral reefs.

The aesthetic value of invertebrates becomes increasingly important as recreational diving gains in popularity – both among Sri Lankans and tourists. Colourful reefs with a variety of life attract visitors and are potential money-spinners; beach communities are among the beneficiaries. If visitors understand what they see, the value of the experience is enhanced, therefore the taxonomy of reef constituents becomes important.

Very little information is available about the taxonomy, biology and distribution of many groups of marine invertebrates occurring in the coastal waters of Sri Lanka. Most information that is available is from papers published in the nineteenth or early twentieth centuries. Very little work has been done recently; and very few scientists are currently engaged in research on them. Many of those engaged in identifying marine invertebrates and observing them underwater are non-scientist divers.

The aquarium trade has been responsible for showcasing many diverse marine animals (such as a number of nudibranchs and starfish) that would otherwise have remained unrecognised members of Sri Lanka's marine biodiversity. The identities of many of them have also been established, as they enter the international trade lists. A number are recognisable from colour illustrations in guides – but there is a danger in relying on guides, especially those prepared from photographs taken in other areas; the species present locally may be different, though superficially similar to an illustration. Identification should be based on recognised anatomical criteria.

Some of the literature available relates to the "Indian Ocean", the coast of India or the "Ceylon Area" that encompasses the adjacent coast of India, the Gulf of Mannar and the Palk Bay. It is necessary that the fauna of the Sri Lanka coastal waters is studied to establish its biodiversity rather than relying on old reports from a much wider area or assuming similarity with the coast of a neighbouring country. In the three appendices to this paper are lists that have been published by early workers that are reproduced without comment; and wherever any identification of recent material has been done, these are indicated. Reference is made in the appropriate sections about available literature: these are listed in the Select Bibliography.

Much of the early-published work had been done in connection with the Pearl Fishery in the early part of the 20th century. Collections were made principally using dredges and trawls. Recent collections are by divers who generally pick exposed material. Numbers of burrowing forms is therefore likely to be much less than from dredge samples. There is a rich variety of material available in the tanks of ornamental fish exporters and collectors. This resource is available for the non-diver who wishes to engage in the taxonomic study of marine invertebrates. A major drawback is the poor and often unreliable data on locality and habitat. But it does make specimens from a wide area available.

The following groups are discussed in this paper as the author has some familiarity with them: Ascidians, Sponges, Sea Anemones, Polychaete worms, Jellyfish and Echinoderms. A number of other groups of invertebrates are dealt with by other authors – e.g. molluscs and crustaceans. Readers are referred to the Report on the Pearl Oyster Fisheries by W. A. Herdman (1903) and the numerous Supplementary Reports upon the Marine Biology of Ceylon by other naturalists that contain descriptions and species lists of many invertebrates that are not discussed here.

Phylum Chordata, Class Ascidiacea - Sea squirts

Ascidians are placed in the Phylum Chordata (that includes all the vertebrates) on account of the presence of a notochord in the larva (the notochord is a rod of cells that develops into the spinal column in higher animals). No list of ascidians of the Sri Lanka coast is available. Ascidians are filter feeders that occur as solitary individuals or aggregated into colonies that form colourful mats on hard substrates. They respond to organic pollution by increased growth and at times may pose a threat to hard corals, by competition for food or by smothering. Laksiri Karunaratne and Prasanna Weerakkody reported some years ago that the corals at Rumassala were so threatened. They are not exploited.

Phylum Porifera - Sponges

There is no distribution list of sponges in Sri Lanka other than those listed by Herdman (1903) in Part III of his report. Sponges are filter feeders that occur in many forms of which the encrusting types are important from an ecological perspective as these animals too respond to organic pollution by increased growth and may threaten corals. Some sponges have been studied in this country for bioactive substances. At least 2 species of unknown identity are collected for the aquarium trade (Wood, 1996.)

Phylum Cnidaria, Order Actiniaria – Sea anemones

Sea anemones are polypoid members of the Phylum Cnidaria. They are placed in the order Actiniaria (Class Anthozoa; Subclass Zoantharia or Hexacorallia) together with the stony corals (Madreporaria), zooanthids (Zooanthidea), black corals (Anthipatharia) and cerianthids (Ceriantharia or Cerianthidea). The other subclass (Alcyonaria or Octocorallia) contains the soft corals and sea fans. (Hyman, 1940)

Many small sea anemones occur on rocky shores and shallow reefs that do not seem to have been studied in recent years. E. F. Kelaart (1819-1860) listed 22 species and paintings of many of them are in the UK (Pethiyagoda & Manamendra-Arachchi, 1997; Appendix I). Large sea anemones that host anemone fish (*Amphiprion* spp.) are collected for the aquarium trade; many occur in association with corals on hard substrates and others on sandy bottoms. Elisabeth Wood (1996) listed them in her report on the marine ornamental fishery in Sri Lanka. These host anemones usually have the sexes separate. They probably liberate eggs and sperm for external fertilization. Their reproductive success appears to be low as small anemones are seen rarely. Some species may multiply by fission (Fautin & Allen, 1992.) Both small and large host anemones are collected and exported – mostly of the genus *Stichodactyla*. The collection and export of these species (particularly large *Heteractis*) should be considered for regulation, as they are likely to be vulnerable to over-collection. Data needs to be gathered.

A colonial form of anemone with close affinity to corals (Order CORALLIMORPHARIA) has been recognized in recent years occurring on reefs. They grow in close-packed sheets and crowd around corals (Christoffelsz et al, 2000). The taxonomy is unknown. However, no conclusive evidence has been found to suggest that this is an invasive species that is a possible threat to corals. Surveillance should be maintained to detect invasive tendencies. Another colonial form that may cover dead coral is Palythoa spp. (ZOOANTHIDEA, ZOOANTHIDAE). It does not appear to be invasive (Prasanna Weerakkody, pers. comm.). Again, the taxonomy is unknown.

One tube-dwelling genus occurring on sandy bottoms - *Cerianthus* spp. (CERIANTHARIA, CERIANTHIDAE) - is protected under the Fauna and Flora Protection (Amendment) Act, No. 49 of 1993, Schedule IVA. Several species occur in Sri Lanka; the taxonomy of the genus is poorly known (Wood & Rajasuriya, 1996). (See Appendix I for a list of sea anemones and identification notes for the larger species.)

Phylum Annelida, Class Polychaeta – Segmented worms

The first extensive collection of polychaete worms from the coast of Sri Lanka was by Herdman in 1902 and reported by Willey (Ceylon Pearl Oyster Fisheries, 1905, Supplementary Reports XXX). Three older reports of smaller collections were by Schmarda (1861), Grube (1874) and Michaelson (1892) (Willey, 1905). Willey described 111 species of tube-dwelling and free-living polychaete worms collected from the Pearl Banks, Galle Bay, Panadura and Chilaw. Later, Pillai (1970, 1971) published two papers on collections of Spirobids and Serpulids from Sri Lanka. There has been no recent work on Sri Lanka species, as far as is known.

Some species of tube-dwelling annelids have been collected for the aquarium trade but are now protected: schedule IVA to the FFPO lists the groups as Tube worms and Fan worms (families Serpulidae [calcareous tubes] & Sabellidae [mucous tubes] respectively). These annelids are filter feeders and respond to organic pollution by increased growth.

Phylum Cnidaria, Classes Scyphozoa & Hydrozoa - Jellyfish

Although medusae (Phylum Cnidaria or Coelenterata) are pelagic they generally have vegetative (polypoid or hydroid) generations that are attached reef dwellers. They are included in this paper as some of them are capable of stinging humans and some forms may have commercial value. The leatherback or leathery turtle *Dermochelys coriacea* (TESTUDINES, DERMOCHELYDAE) feeds on jellyfish.

The earliest reports of the jellyfish of Sri Lanka were by Haeckel (1888) who described the Siphonophora (an order of the Class Hydrozoa or Hydromedusae) collected by him (Browne, 1905). In 1905 E.T. Browne reported on the jellyfish collected by Herdman in 1902 at the Pearl Banks and in Galle Bay. The list published by him is reproduced in Appendix II: many have not been identified to specific rank as the specimens were in poor condition. Most of the species listed are Hydromedusae, with a few in the Class Scyphozoa or Scyphomedusae and two ctenophores (comb jellies), now considered under the Phylum Ctenophora: they do not possess cnidocysts (nematocysts). (Hyman, 1940) These are included in the Appendix for completeness.

We have been able to identify a number of species of Scyphomedusae collected since 1990 – mostly off the Colombo beaches. The study was commenced to identify the species responsible for stinging swimmers and divers. Specimens were collected on casual encounter during recreational diving and visual searching during the southwest monsoon when swarms of them are seen off Colombo. Beach specimens were also useful, at times.

Four venomous species have been identified: Chrysaora quinquecirra (compass jellyfish), Cyanea purpurea (lion's mane jellyfish), Chiropsalmus buitendijki (box jellyfish) and the siphonophore Physalia utriculus with a single stinging tentacle (Kramp, 1961; Menon, 1930 & 1932; Peter Fenner pers. comm.) These animals occasionally harm bathers and divers (Fernando, 1994 & 2001) but their stings usually cause only transient pain. Numerous small hydromedusae of unknown identity are sometimes troublesome for swimmers and divers by their irritating stings that, though mild, are repetitive.

There has been a dramatic reduction of the jellyfish seen off Colombo following the el Niño ocean warming event of 1998. Recovery is slow. There is no commercial fishery for jellyfish in Sri Lanka, but this is a resource worth investigating. Large numbers are seen off the east coast seasonally but their identity is not known to the author.

Phylum Echinodermata – Featherstars, Starfish, Brittlestars, Sea Urchins and Sea cucumbers

The first publication on the echinoderms of the country was that by F. J. Bell in 1882 where he described 19 species (excluding holothurians) from Galle. Subsequent workers added to the list. The holothurians were dealt with by J. Pearson in 1913 in his paper on the Holothurioidea of the Indian Ocean. Clark & Rowe relied on these many papers to write their Monograph of shallow-water Indo-west Pacific Echinoderms (1971). A checklist for the "Ceylon Area" has been summarised from this monograph; recent records are indicated, together with new records of species not listed by Clark & Rowe (Appendix III). The "Ceylon Area" includes Sri Lanka "and the opposing Indian shores of the Gulf of Mannar and Palk Bay including Tuticorin, Rameswaran and Mandapam." The list relates to forms down to a depth of 20 metres. It would be ideal if the checklist were confined to forms occurring in Sri Lankan waters and expanded to include animals from deeper water, say to 40 m, a depth reached by divers collecting ornamental fish.

A few workers have been identifying Sri Lankan echinoderms. Collections are now made by divers: either specifically for study or for the marine aquarium export trade or, in the case of holothurians, for beche-de-mer (trepang) manufacture. This contrasts with early collection methods that relied on dredging and trawling. Hand collection does not extend to burrowing forms, except tests of dead echinoids lying on the seabed and the occasional starfish. Beach seines and bottom-set nets are a good source of sand dwelling asteroids.

Class Crinoidea (Feather stars) Twenty-six species in 7 families are listed in the checklist with 4 doubtful records. There is no current taxonomic work. A few species are collected for the aquarium trade, usually in small numbers. An attempt should be made to identify even these.

Class Asteroidea (Starfish) Forty-six species in 11 families are listed in the checklist with 3 doubtful records. We have been identifying asteroids using the key in Clark & Rowe. Specimens have been either collected personally by diving or from net spoil or else obtained from the tanks of an aquarium fish exporter. Twenty-two species have been identified, including 5 new records that include 1 new family. One species from water deeper than 20 m has not been identified even to family level; it belongs to a family not included in the identification key in the monograph; this has not been taken into account. A species of *Pentaceraster* seen in a display aquarium has also not been counted as no reliable evidence of collection in Sri Lanka waters has been obtained. Ten species are exported. With the opening of the northern areas of the country to free travel, large numbers of starfish not seen previously have been entering the market. Some of these are juveniles and therefore have not been identified to species level. One starfish, *Acanthaster planci* (crown-of-thorns starfish) preys on hard corals and is a pest. Conservation of coral reefs may require destruction of these animals at times when their populations increase.

Class Ophiuroidea (Brittlestars) Forty species in 10 families are listed in the checklist with 1 doubtful record. Weerakkody (1998) has surveyed 7 shallow reefs between Akurala and Devundara and has recorded 13 species, including 6 new records. He reports that *Ophiocoma erinaceus* is collected for the aquarium trade.

Class Echinoidea (Sea urchins) Forty-nine species in 17 families are listed in the checklist with 1 doubtful record. The author has recorded 15 regular echinoids (with radial symmetry) of which 1 is a new record; 8 are collected for the aquarium trade. Nine irregular echinoids (with bilateral symmetry) have been recorded, 8 from dead tests only; 3 are new records. Seven depressed echinoids (sand dollars) have been recorded, 5 from dead tests only. One of these (*Echinodiscus bisperforatus*) is used at Kirinda by a dealer in shell-craft to fashion tails of peacocks. They are collected live from the sandy seabed in waist-deep water.

One regular sea urchin (*Heterocentrotus mammillatus* - Slate pencil urchin) is protected. It is listed in the Schedule as “mammiliatus”. There is a doubtful second species present: some were collected for export, detained by the Customs and identified as “not definitely *H. mammillatus*”, leading to their release.

Some echinoids are ecologically important: members of the family Diadematidae and *Echinometra mathei*. These algal browsers prevent overgrowth of green algae and allow coral recruitment to take place. Population explosions of them (for example by over extraction of fish that prey on them), on the other hand, have the opposite effect as newly recruited corals may be killed by the browsing sea urchins. Culling of these sea urchins has been resorted to in Kenya as a management option in the rehabilitation of reefs (Talbot & Wilkinson, 2001). *E. mathei* is exported from Sri Lanka; over collection could have deleterious effects on reefs. The sand dwelling urchin *Tripneustes gratilla* is harvested in some South East Asian countries for their edible gonads. They are not consumed in Sri Lanka.

Class Holothurioidea (Sea cucumbers) Fifty-two species in 8 families are listed in the checklist. These animals have been fished commercially since historical times from shallow water by wading, breath-hold divers or by spearing. They are cured to produce the product known as beche-de-mer or trepang for export to the far east. Adithiya (1967) gives an interesting account of the traditional curing process at that time. In recent years, collectors of ornamental fish have branched out into collecting holothurians from deeper water using diving gear. They are a high value product and collection has been intense. In one recently discovered area (1995) off Kalmunai intensive fishing by large numbers of divers resulted in the area being fished out within three years causing the fishery to collapse and the promoters (investors) to suffer financially (Rajasuriya, 1999). Activity has now moved to Kalpitiya where diving is going on by night – when the animals are active and move into the open to feed.

Unrestricted intensive collection is likely to lead to depletion of this area too – a Protected Area. Reports suggest that once a holothurian bed is fished out, recovery to a state where a commercial fishery is viable is of the order of 50 years (Bruckner et al, 2003). There is a danger that the absence of the bottom feeding holothurians, with their ability to process the surface layers of sand containing detritus, could lead to changes in seabed character that may preclude its re-colonisation.

Identification of commercially fished holothurians is being performed by the National Aquatic Resources Research and Development Agency (NARA). To date 16 species have been identified (DCT Dissanayake pers. comm.). An identification key (Conand, 1998) published by the Food and Agriculture Organisation is being used in this project. As a welcome step in the right direction, the Department of Fisheries has initiated action to regulate the holothurian fishery to ensure its sustainability.

One species (*Holothuria edulis*) is collected for the aquarium trade. One species (*Pseudocolochirus* sp. Royal sea cucumber) is protected. It is listed in the schedule simply as “Royal sea cucumber” without a scientific name.

Conclusion

The ornamental marine aquarium fish industry, that includes invertebrates, is thriving. It is largely unregulated, but collection of certain species is prohibited by law, usually on the assumption that they are rare and therefore susceptible to over-exploitation. The fishery for holothurians is poorly regulated and little information is available about the species make-up of the catch. There is little information about the biodiversity of much of the coastal waters around the Island, making assessment and subsequent monitoring of sites identified for development very difficult.

Not only is there paucity of information about the taxa present, there is a dearth of skilled scientists able to generate the information and to provide scientific data that would justify management options such as establishing catch restrictions or banning collection. Compounding the lack of personnel is the lack of appropriate taxonomic literature within the country.

Much work needs to be done in compiling definitive checklists and identification guides of the marine invertebrates. Without such material, managing marine ecosystems becomes difficult. With increasing pressures on reefs and other marine ecosystems by ornamental species collectors, commercial fin fisheries using destructive methods (e.g. bottom set nets, trawls and sadly blast fishing) that destroy the habitat the need for effective regulation is becoming more and more important.

Marine biologists should ideally be competent divers and make their own observations and collect their own material. Facilities for gaining such competence are readily available in Sri Lanka. But until an ideal state is reached, reliance could be placed on diving enthusiasts to enable specimen collection; the aquarium export traders are also good suppliers of material. Volunteers from the Sri Lanka Sub-Aqua Club have been associated with the Coral Ecology Unit of NARA for many years, helping with reef monitoring. Members of this club with an interest in preserving the integrity and biodiversity of Sri Lanka’s marine ecosystems would be willing to assist marine biologists in search of specimens for taxonomic studies.

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Appendix I: Sea anemones

Class Anthozoa

List of species from the notes and paintings of E. F. Kelaart (1819-1860)

This list is compiled from Appendix I to The life and work of Edward Fredric Kelaart by Rohan Pethiyagoda & Kelum Manamendra-Arachchi (1997). *J. South Asian nat. Hist.* vol. 2 no. 2.

ORDER: ACTINIARIA

Actinia arachnida
Actinia aurea
Actinia austinii
Actinia fluctuosa
Actinia Indiana
Actinia meleagrina
Actinia passiflora
Actinia pudica
Actinia refulgens
Actinia smaraqdana [smaragdana]
Actinia tranchellana [tranchelli]
Actinia vermicosa
Actinia wardiana [wardii]
Actinodendron argentea
Actinodendron horologia
Actinodendron viridis
Actinodendron zeylanicus
Capnea (?) blythiana
Dioscosoma (Actinodiscus) zeylanica
Dioscosoma ceylonica [zeylanica]
Peacha gosseana [gossei]
Zoanthura mamalifera

List of species used in the aquarium trade.

This list is based on Elisabeth Wood *The marine ornamental fishery in Sri Lanka: current status and management* needs (1996). Marine Conservation Society, UK.

Taxonomy and identification after Fautin, Daphne G. & Gerald R Allen (1992). *Anemone fishes and their host sea anemones.* (Internet edition).

Note: Most adult sea anemones are large – 25 cm to 1 metre in diameter according to the species. Only small specimens are usually collected for the aquarium trade.

ORDER: ACTINIARIA

FAMILY: ACTINIIDAE

Entacmaea quadricolor (Rüppell & Leuckart, 1828) Bulb-tentacle sea anemone[1]

STICHODACTYLIDAE

Heteractis aurora (Quoy & Gaimard, 1833) Beaded sea anemone[2]
H. crispa (Ehrenberg, 1834) Leathery sea anemone, long-tentacled sea anemone[3]
H. magnifica (Quoy & Gaimard, 1833) Magnificant sea anemone[4]
Stichodactyla haddoni (Saville-Kent, 1893) Haddon.s sea anemone[5]

---

1 Tentacles with a bulb-like swelling at or just below the tip. The bulb with a white band around its middle.

2 Tentacles with a series of swellings on each giving them a beaded look.

3 Tentacles long (100 mm), sinuous, evenly tapered to a point, numerous. Column buried in sediment, oral disc lying at the surface or the pedal disc attached to branching coral.

4 Tentacles finger-like, hardly tapering, blunt or pointed tip, to 75 mm. Typically occupies fully exposed, prominent position on hard objects like a coral boulder.

5 Lives in sand with the oral disc spread over. Disc slightly to deeply folded, a central tentacle-free area 10-20 mm diameter surrounds mouth, usually of a colour contrasting with the disc. When disturbed withdraws rapidly below the sand.

? *S. gigantea* (Forsskäl, 1775)[6]
? *S. mertensii* Brandt, 1835 Merton's sea anemone[7]

Other sea anemones of interest or of ecological importance.

ORDER: CERIANTHARIA

Family: CERIANTHIDAE

Cerianthus spp. Sand anemone.[8] Protected.

ORDER: CORALLIMORPHARIA

Family: DISCOMATIDAE?

Undetermined species[9]

ORDER: ZOOANTHIDEA

Family: ZOOANTHIDAE

Palythoa spp.[10]

6 Deeply folded oral disc covered with short (10 mm) tentacles lies on the surface of sand, the pedal disc attached to a buried object. Much of the central oral area devoid of tentacles. In shallow water, often among corals.

7 Oral disc diameter may be very large (1 m), often oval in shape. The disc lies evenly spread over the hard substrates on which it lives; the small pedal disc often attached in a crevice into which the animal can withdraw (but not rapidly).

8 A sand-dwelling animal with very long tentacles that occupies a soft tube into which it can withdraw. The only protected sea anemone in Sri Lanka.

9 Brown anemones 5-6 cm diameter with numerous short tentacles arranged in concentric circles radiating outwards on the oral disc. Occur in colonies of hundreds of individual animals packed together forming extensive sheets, possibly impacting on coral.

10 Colonial animals compacted into sheets. Each small anemone-like polyp is buried in a common soft or leathery matrix. Can be mistaken for corals when open or for sponges when closed. Not thought to impact on corals.

Appendix II: Medusae

Classified list of the species described by Edward T. Browne

This list is compiled from *Report on the Medusae (Hydromedusae, Scyphomedusae, and Ctenophora) collected by Professor Herdman, at Ceylon, in 1902*, by ET Browne. *In* WA Herdman, *Report to the Government of Ceylon on the Pearl Oyster Fisheries of the Gulf of Manaar*, Pt. IV. Suppl. Reps. no. XXVII: 131-166, 4 pls. Royal Society, London.

HYDROMEDUSAE

ANTHOMEDUSAE

Dipurena sp?
Proboscidactyla minima. n. sp.
Cytoeis herdmani, n. sp.

LEPTOMEDUSAE

Laodice indica n. sp.
Eutima curva n. sp.
Irene ceylonensis n. sp.
Octorchis orientalis n. sp.
Aequorea conica n. sp.
Mesonema pensile (Modeer)
Mitrocomium assimila n. sp.
Irene palkensis n. sp.
Irenopsis hexanemalis Goette
Octocanna polynema (Haeckel)
Aequorea parva n. sp.

TRACHYMEDUSAE

Gonionemus hornelli n. sp.
Liriope tetraphylla (Cham. et Eys.)
Olindias sp.?

NARCOMEDUSAE

Solmundella bitentaculata (Quoy et Gaim.)

SIPHONOPHORA

Diphyes chamissonis Huxley
Agalmopsis sp?
Porpita sp?
Cupulita sp?
Physalia utriculus Esch.

SCYPHOMEDUSAE

Charybdea sp?
Pelagia sp?
Nausithoe punctata Köll
Crambessa sp?

CTENOPHORA

Pleurobrachia globosa Moser var. *ceylonensis*
Beroe flemingi (Esch.)

Note: Ctenophora now has Phylum rank. Medusae proper (jellyfish) are members of the Phylum Cnidaria (Coelenterata) characterised by the presence of cnidocysts (nematocysts).

List of species recorded by Malik Fernando

HYDROZOA (HYDROMEDUSAE)

SIPHONOPHORA

Physalia utriculus *Porpita* sp. *Velella* sp.

SCYPHOZOA (SCYPHOMEDUSAE)

CUBOMEDUSAE

CHIRODROPIDAE

Chiropsalmus buitendijki Horst, 1907. Box jellyfish

SEMAEOSTOMEAE

PELAGIIDAE

Chrysaora quinquecirra (Desor, 1848). Compass jellyfish

CYANEIDAE

Cyanea purpurea Kishinouye, 1910. Lion's mane jellyfish
Cyanea sp? Giant Lion's mane jellyfish[1]

RHIZOSTOMEAE (Kolpophorae, Actinomyariae)

CEPHEIDAE

Netrostoma coerulescens Maas, 1903

(Daktyliophorae, Inscapulatae)

CATOSTYLIDAE

?*Crambionella* sp.
Acromitus sp.

LYCHNORIZIDAE

Lychnorhiza malayensis Stiasny, 1920

[1] Cyanea sp. 30-45 cm diameter occurring in swarms have been identified as C. purpurea based on the canal system of the lappet margins. Cyanea sp. 60 cm or more, occurring as solitary individuals have not been examined anatomically. These are thought to be a separate species.

Appendix III

Checklist of the Echinoderms of Sri Lanka

Summarized from A.M. Clark & F.W.E. Rowe (1971) *Monograph of shallow-water Indo-west Pacific Echinoderms* with recent additions to this list and observations.
** Recent records by Malik Fernando
* Recent records by Prasanna Weerakkody (Ophiuroidea)
NR = new record; $ = exported ornamental species; P = protected

CLASS CRINOIDEA

Family Comasteridae
- *Capillaster multiradiatus*
- *Capillaster sentosus*
- *Cornanthina schiegeli*
- *Comanthus parvicirrus*
- *Comanthus samoanus*
- *Cornatella maculata*
- *Comatella stelligera*
- *Comatula pectinata* (?)

Family Zygometridae
- *Zygometra andromeda*(?)

Family Himerometridae
- *Amphimetra ensifera*
- *Heterometra amboninae*
- *Heterometra bengalensis*
- *Heterometra reynaudi*
- *Himerometra robustipinna*

Family Mariametridae
- *Lamprometra palmata*
- *Oxymetra finschi*
- *Stephanometra echinus* (?)
- *Stephanometra indica* (?)
- *Stephanometra spicata*
- *Stephanometra tenuipinna*

Family Colobometridae
- *Cenometra herdmani*
- *Decametra modica*
- *Decametra taprobanes*
- *Oligometra serripinna*

Family Tropiometridae
- *Tropiometra carinata*

Family Antedonidae
- *Mastigometra micropoda*

CLASS ASTEROIDEA

Family Luidiidae
- *Luidia hardwicki*
- *Luidia herdmani*
- *Luidia maculata* **
- *Luidia savignyi*

Family Astropectinidae
- *Astropecten andersoni* **
- *Astropecten bengalensis*
- *Astropecten euryacanthus*
- *Astropecten hemprichi*
- *Astropecten indicus*
- *Astropecten mauritianus* (?)
- *Astropecten polyacanthus*
- *Astropecten sarasinorum*
- *Astropecten vappa* **
- *Astropecten velitaris* **
- *Astropecten zebra*

Family Goniasteridae
- *Anthenea pentagonula*
- *Anthenea regalis*
- *Anthenea rudis*
- *Siraster tuberculatus*
- *Stellaster equestris*

Family Oreasteridae
- *Culcita schmideliana* **
- *Choriaster granulatus* **NR
- *Pentaceraster mammillatus* **?NR$[1]
- *Pentaceraster affinis* **?$
- *Pentaceraster multispinus* (?)
- *Poraster superbus*
- *Protoreaster linckii* **$
- *Protoreaster nodosus*

[1] Three species of Pentaceraster have been collected but not identified with confidence.

Family Ophidiasteridae

Dactylosaster cylindricus
Fromia indica **$
Fromia milleporella **$
F. ?ghadaqana **NR$
Fromia nodosa
Gomophia egyptiaca **$
Linckia guildingi **
Linckia laevigata **
Linckia multifora **
Nardoa lemonnieri **$
Paraferdina sohariae **NR$[2]

Family Metrodiridae

Metrodira subulata

Family Asteropidae

Asteropsis carinifera

Family Asterinidae

Asterina burtoni **
Asterina coronata
Asterina lorioli
Asterina sarasini
Tegulaster ceylanica

Family Acanthasteridae

Acanthaster planci **

Family Pterasteridae

Euretaster cribrosus (?)

Family Echinasteridae

Echinaster callosus } **$[3]
Echinaster purpurea }

Family Valvasteridae

Valvaster striatus **NR[4]

CLASS OPHIUROIDEA

Family Ophiomixidae

Ophiomyxa australis
Ophiomyxa compacta *NR

Family Gorgonocephalidae

Astroboa clavata

Family Ophiacanthidae

Ophiacantha indica

Family Amphiuridae

Amphioplus depressus
Amphiura luetkeni

Family Ophiactidae

Ophiactis savignyi

Family Ophiotrichidae

Gymnolophus obscura
Macrophiothrix aspidota
Macrophiothrix hirsuta (?)
Macrophiothrix longipeda *
Macrophiothrix variabilis
Ophiocnemis marmorata
Ophiogymna elegans
Ophiomaza cacaotica
Ophiopteron elegans
Ophiothrix exigua
Ophiothrix foveolata
Ophiothrix trilineata
Ophiothrix proteus
Ophiothrix purpurea
Ophiothrix nereidina

Family Ophiocomidae

Ophiarthrum elegans
Ophiocoma brevipes *
Ophiocoma dentata *NR
Ophiocoma erinaceus *$
Ophiocoma pica
Ophiocoma scolopendrina
Ophiocomella sexradia
Ophiomastix annulosa *

Family Ophionereidae

Ophionereis dubia *
Ophionereis porrecta

Family Ophiodermatidae

Cryptopelta grannulifera *NR
Ophiarachna incrassata
Ophiarachnella gorgonia *
Ophiarachnella macrantha *NR

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[2] Published in 1991. Synonymy, if any, unknown.

[3] Juvenile specimens of uncertain specific rank

[4] Known from a single, damaged net spoil specimen. The family not reported by Clark and Rowe from this area.

Ophiarachnella septemspinosa
Ophiarachnella sphenisci
Ophiochaeta hoeschmai *NR
Ophiopeza fallax
Ophiopeza spinosa *NR

FAMILY OPHIURIDAE
Ophiolepis cincta *
Ophiolepis rugosa
Ophiolepis superba
Ophioplocus imbricatus
Ophiura kinbergi

CLASS ECHINOIDEA

FAMILY CIDARIDAE
Eucidaris metularia
Phyllacanthus imperialis } ?**[5]
Prionocidaris baculosa } ?**[5]
Prionocidaris bispinosa

FAMILY ECHINOTHURIIDAE
Asthenosoma varium
Asthenosoma intermedium ?**NR$[6]

FAMILY DIADEMATIDAE
Astropyga radiata **$
Diadema savignyi **
Diadema setosum **
Echinothrix diadema **

FAMILY STOMOPNEUSTIDAE
Stomopneustes variolaris **$

FAMILY TEMNOPLEURIDAE
Microcyphus ceylanicus **
Salmaciella dussumieri
Salmacis bicolor **$
Salmacis virgulata **$
Salmacis toreumaticus
Temnotrema siamense

FAMILY TOXOPNEUSTIDAE
Gymnechinus robillardi
Pseudoboletia indiana
Pseudoboletia maculata **$
Toxopneustes pileolus **$
Tripneustes gratilla **

FAMILY ECHINOMETRIDAE
Colobocentrotus atratus
Echinometra mathaei **$
Echinostrephus molaris **
Heterocentrotus mammillatus **P

FAMILY ECHINONEIDAE
Echinoneus cyclostomus **
Echinoneus abnormalis **NR

FAMILY CLYPEASTERIDAE
Clypeaster fervens
Clypeaster humilis **
Clypeaster rarispinus **
Clypeaster reticulatus **

FAMILY FIBULARIIDAE
Fibularia cribellum (?)
Fibularia oblonga (?)
Fibularia volva (?)

FAMILY LAGANIDAE
Laganum depressum **
Peronella lesueuri
Peronella macroproctes **
Peronella oblonga

FAMILY SCUTELLIDAE
Echinodiscus auritus **
Echinodiscus bisperforatus **

FAMILY ECHINOLAMPADIDAE
Echinolampas alexandri
Echinolampas ovata **

FAMILY SPATANGIDAE
Maretia planulata
Pseudomaretia alta

FAMILY LOVENIIDAE
Lovenia elongata **

FAMILY SCHIZASTERIDAE
Paraster gibberulus **
Prymnaster ? *investigatoris* **NR

[5] One species: preserved material insufficient to distinguish between these two genera.

[6] Preserved material insufficient to distinguish between these two species with confidence, but specimens have the colouration and appearance of A. intermedium though not reported from this area.

Family Brissidae

Brissus latecarinatus **
Metalia latissima
Metalia sternalis **
Metalia dicrana **NR
Rhynobrissus pyramidalis

CLASS HOLOTHUROIDEA

Family Holothuriidae

Actinopyga echinites
Actinopyga lecanora
Actinopyga mauritiana
Actinopyga miliaris
Actinopyga serratidens
Bohadschia argus
Bohadschia marmorata
Bohadschia tenuissima
Bohadschia vitiensis
Holothuria (Halodeima) atra
Holothuria (Halodeima) edulis
Holothuria (Lessonothuria) glandifera
Holothuria (Mertensiothuria) fuscocinerea
Holothuria (Mertensiothuria) leucospilota
Holothuria (Mertensiothuna) pervicax
Holothuria (Mertensiothuria) scabra
Holothuria (Microthele) nobilis
Holothuria (Platyperona) difficilis
Holothuria (Selenkothuria) erinaceus
Holothuria (Selenkothuria) moebii
Holothuria (Semperothuria) cinerascens
Holothuria (Semperothuria) imitans
Holothuna (Theelothuria) kurti
Holothuria (Theelothuria) spinifera
Holothuria (Thymiosycia) hilla
Holothuria (Thymiosycia) impatiens

Family Stichopodidae

Stichopus chloronotus
Stichopus naso
Stichopus variegatus

Family Psolidae

Psolus complanatus

Family Cucumariidae

Havelockia herdmani
Hemithyone semperi
Pentacta armatus
Pentacta quadrangularis
Pseudocolochirus tricolor P
Staurothyone rosacea
Stolus buccalis
Stolus conjugens
Thyone papuensis
Trachythyone imbricata
Trachythyone typica

Family Phyllophoridae

Actinocucumis typicus
Ohshimella ehrenbergi
Phyllophorus (Phyllophorella) parvipedes
Phyllophorus (Phyllothuria) cebuensis
Phyllophorus (Urodemella) brocki

Family Caudinidae

Acaudina molpadiodes

Family Synaptidae

Opheodesoma grisea
Synapta maculata
Synaptula recta
Synaptula striata

Family Chirotidae

Polycheira rufescens

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Current Status of Taxonomy and Ecology of Marine Molluscs in Sri Lanka

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Abstract

Molluscs make up a major proportion of all marine biodiversity. They are an integral part of marine ecosystems and play a number of roles, which help to support the function and stability of the ecosystems upon which other organisms rely for their survival and well-being. Their distribution is extensive, as remarkable number of adaptations and behaviours has enabled them to live in most of the marine habitats.

This paper describes the current status of taxonomy of marine molluscs and their distribution in Sri Lanka, demonstrating that the state of taxonomic, biological and ecological knowledge regarding marine molluscs is generally poor within the country. The limited knowledge that is present varies with location, habitat and taxonomic group. There are large gaps in our understanding of even the relatively well-studied species or groups while many taxa are very poorly known or completely unstudied. The paper also gives some basic information regarding the intricate linkages between various processes and habitat features that affect the distribution patterns, with some special reference to post El Nino years (after 1998) and highlighting areas of interest and research needs to obtain a comprehensive understanding of the status of marine molluscs in Sri Lanka. Checklists of marine molluscs from post mid-1990s records taken from published and reliable resources are being included within the paper, and again referring to post El Nino years. Finally, the paper illustrates the issues affecting the taxonomy, ecology and conservation status of marine molluscs in Sri Lanka and some concluding remarks including recommendations to address conservation issues.

Key words: *Marine molluscs, Taxonomy, Ecology*

Introduction

Sri Lanka has a rich and diverse marine invertebrate fauna that has been studied since 1800s and among them, marine molluscs had a prominent place (Tennant 1861, Kelaart 1852). As one of the most successful forms of animal life, the molluscs have conquered almost every habitat and exist in all the oceans from intertidal shores to the deepest trenches. Although, the importance of molluscs to the humankind and their significant roles in ecosystems and their functions have been recognized (Kay 1995), in recent time there has been an acceleration in terms of loss of biodiversity of marine molluscs due to natural catastrophes (Brown 1997, Attrill and Power 2000, Addessi 2001) as well as due to harmful anthropogentic activities (Addessi 1994). However, the biological and ecological information available to understand the exact impacts of these threats to marine molluscs in Sri Lanka are scanty.

Marine Molluscs are a taxonomically diverse group, which exhibit a wide range of patterns in body plan (Ponder and Lindberg 1997), distribution (Behens-Yamada 1987), abundance (Hawkins and Harnoll 1980), habitat (de Silva 1998), mode of feeding (Hughes 1980, Hawkins and Harnoll 1983), behaviour (Bullock 1953, Branch 1979, Della Santina and Nayor 1994), etc. They are also diverse in their effects on their surroundings (Raffaelli and Hawkins 1996). This diversity allows them to coexist successfully within their ecosystem. These animals are also known to play an important role in determining the structure of marine communities (Morton and Morton 1983). Within the Phylum of Mollusca, evolutionary modifications of the internal organs and morphological features are quite extensive (Knight et al., 1960, Taylor 1996, Beiler 1992, Ponder and Lindberg 1996). Principal changes generally reflect the mode of feeding, predatory behaviour, and habitat, and the higher taxonomic orders have been shown to exhibit some degree of intelligence (Taylor 1996, Ponder and Lindberg 1996).

Status of taxonomy and ecology

The marine ecosystem has a much greater taxonomic diversity (phyla, classes and orders) of invertebrates than terrestrial or freshwater habitats (WRI 2000-2001). In this section, a brief overview of the diversity and state of knowledge of each of the major groups of Sri Lanka's marine molluscs is provided. This includes a brief description of each major group in terms of distribution and trophic roles, and where available, numbers of identified and estimated total numbers of species have been provided. This account is intended to highlight the diversity of marine mollusc fauna in Sri Lanka, based on the recent (post- mid 1990s and post-1998) quantitative and qualitative data that have been reviewed (De Bruin et al 1995, de Silva 1998, Fernando 2000, de Silva – ongoing study[20]).

The molluscs show a wide variety of morphological differences in terms of their body plan (Knight et al 1960, Taylor 1996) and details of the shells (Linsley 1978). Nevertheless, the basic body plan is one of front-to-back bilateral symmetry, with well-defined nerve ganglia, respiratory, blood circulatory, digestive, reproductive, and excretory organs (Purchon 1968). Despite sharing these common features, the Mollusca is an incredibly diverse group that have radiated into 8 (7) main classes (Taylor 1996) all evolving from a. "hypothetical ancestral mollusc". However, it is now known that molluscan phylogeny is a lot more complex than this (Ponder and Lindberg 1997, Wagner 2001).

There has been a prominent lag in taxonomy related work concerning marine molluscs of Sri Lanka in recent time, except for information that have been generated during other marine faunal surveys, which too tend to be one-off activities (De Bruin et al 1995). There has been occasional phylogenetic research studies based on samples of Sri Lankan marine molluscs. However, the status of those studies is not known due to the information accessibility constraints. Therefore, it should be emphasized that the information to adequately evaluate their current status is extremely limited.

Globally approximately 120,000 species of molluscs (Chase 2002) have been described to date, but the exact number of described marine molluscan fauna in Sri Lanka is not known. A list of nearly 240 species of marine molluscs was compiled (see annex 1) for the current paper, through the review of relevant literature. Recent attempts to identify marine molluscs have indicated that there is also a lot more to be described. While the diverse, large shelled groups are relatively well known because their shells can be collected, a great many smaller species are poorly known. It must be also noted that earlier descriptions and distribution records have covered most of Sri Lankan marine waters (Kelaart 1852, NARESA 1989) including the intertidal areas (Atapattu 1972, Arudpragasam and Ranatunga 1966), but most recent accounts (de Silva 1997) have only concentrated in the southern and western region with more focus towards reef associated fauna.

The molluscs show great structural (Taylor 1996) and ecological variability (Atapattu 1972, de Silva 1998, de Silva 2001) and are found in a wide range of habitats. There are 7 (8) classes under the Phylum Mollusca including Cephalopoda (octopuses, squids), Gastropoda (snails, limpets, nudibranchs), Bivalia (clams, oysters, mussels), Scaphopoda (tusk shells), Polyplacophora (chitons), Monoplacophora and Aplacophora (spicule worms) – Solenogadtres and Caudofoveata. In Sri Lanka, 4 out of the 7(8) classes representing marine molluscs have been recorded at different times in history.

Cephalopoda

Relatively little is known about this class and the systematics are not very clear. The mid-water species under this class have been surveyed from by-catch (De Bruin et al 1995). Many species are harvested as by-catch and some are specifically targeted as a fishery resource, and others are exploited for its shell (e.g. Nautilus). However, much remains to be done on the location of deep-sea species beyond the

[20] This study mainly focuses on biology and ecology of selected keystone marine organisms on intertidal platform reefs in south and west coasts of Sri Lanka. This study also makes an attempt to identify the current status of marine molluscs inhabiting these rocky reefs.

continental shelf. This group includes cuttlefish, octopus and squids that falls within dibranchiates and nautilus which falls under tetrabranchiates. Cuttlefish are generally neritic, demersal, mainly found over mud or silty substrata and sometimes over coral or sandstone, while Octopuses are neritic, benthic, and inhabit on hard substrata of coral or sandstone. Squids are pelagic or semi-pelagic, mainly found on silty substrata and sometimes on sandstone or in harbours. The tetrabranchiates are pelagic, oceanic, and they are occasionally neritic. Nineteen species of cephalopods belonging to 4 orders and 7 families have been recorded in Sri Lanka marine waters.

Gastropoda

The diversity of this class is considerable. However, accurate figures are not available on the number of species or families found in Sri Lanka. The latest classified groups of Gastropods include Patellogastropoda (true limpets); Vetigastropoda (top shells, abalones, turban shells, keyhole limpets, etc.), Neritoida (nerites), Caenogastropoda (periwinkles, whelks, cowries, cones, etc.) and Heterobranchia (seaslugs and air-breathing snails etc.) and all of these groups are represented in the Sri Lankan marine waters.

Patellogastropoda: Sri Lanka has 2 species of true limpets of 2 families being recorded and they are typically present in intertidal rocky shores. The true limpets have an important functional role as grazers and scrapers dominating from upper littoral to mid littoral areas (i.e. high to mid tide levels).

Neritoida: This group is comprised of one family (Nerites) in Sri Lanka and can be found in rocky and muddy shores in high intertidal areas. The nerites feed on algae and detritus.

Vetigastropoda: These are diverse and conspicuous members of the intertidal and subtidal fauna with a recent record of 5 families (abalone, top shells, turbins and false limpts). Most of the members of this group are grazers specialized to feed on a wide range of substrates including detritus, algae, and colonial animals.

Caenogastropoda: This is the largest group of marine gastropoda represented in Sri Lanka. There are indications of 33 families being observed since post-1995. These molluscs show a wide range of shell morphologies (coiled shells, worm-like shells, limpet-forms, etc.), feeding strategies (grazing, predation, parasitism, filter feeding) and habits. Most are benthic crawlers, some burrow, others are sessile, and a few are permanently attached to the substrate. The group also includes cowries, cones, mitres and murexes of interest to shell collectors. Most of the intertidal species, more-prominent subtidal and mid-sea species have been recorded, although taxonomically not completely identified.

Heterobranchia: This group is also morphologically very diverse and includes forms with coiled or limpet-like shells to a wide variety of shell-less slugs. This sub-class has been divided into 3 groups: Heterostrophs, Opisthobranchs and Pulmonates. Heterostropha species are carnivorous, shallow sand dwelling animals. There is one species (sundials) recorded in recent time. The seaslugs including nudibranchs and bubble shells comprise the Opisthobranchia. All recorded species are benthic. Few species are detritus feeders or herbivores and most are carnivorous, preying upon sessile organisms such as sponges, hydroids, actiniarians, and bryozoans. Post-mid 1990s records indicate 10 families out of which 8 families consist of nudibranchs. The marine pulmonata that have been identified recently include a family of air breathing limpets (Siphonariids) that inhabit the rocky intertidal, and a family of estuarine ear shells.

Bivalvia

This class (formerly named Pelecypoda, or Lamellibranchia) is the second largest group of molluscs found in Sri Lanka. Although higher phylogeny is not well recorded for this class in Sri Lanka, there are definite records under 2 out of the 6 subclasses of Bivalia with post-1995 records indicating about 21 families.

Scaphopoda

Recent records do not indicate the presence of this class in Sri Lanka.

Monoplacophora

The few living species are known from the deep-sea and none are yet recorded from Sri Lankan waters.

Polyplacophora

There are records of one grazing species associated with rocky reefs.

Aplacophora

There are no records of these molluscs in Sri Lanka.

General distribution patterns

Sri Lanka has a coastline of about 1,585 km (GSL 1985) with an area of 230,000 km2. The continental shelf around Sri Lanka has an area of about 31,000 km2 and the width ranges from 9 to 45 km with an average depth of 66 m (Cooray, 1967). There are fringing and offshore reefs around the country made up of live corals, calcareous substances, sandstone and granite (Swan 1983). However, the extent of live coral reefs has been reduced drastically since the El Nino event in 1998 (Wilkinson et al. 1999, personal observations). Comparatively, reefs made up of sandstone and granite still remains unchanged except for their ecological compositions and changes due to regular phsio-chemical factors. Reefs are found from near-shore areas to offshore areas to depths more than 50 m. The coastline of Sri Lanka has beaches and sand dunes spreading over 300km. Intermittently, there are rocky reefs, salt marshes and muddy (estuarine) shores. In general, the members of the Phylum Mollusca can be encountered in all the above habitats with varying distribution patterns.

Ecological studies of marine molluscs are generally based on patterns of macro- and micro-scale taxon distribution. However, attempts to understand the ecology and biology of marine molluscan diversity are hampered by the small number of key studies and varying level of knowledge on taxonomic details. There are hardly any complete reports that allow us to have a good understanding of some of the ecological aspects of this group in Sri Lanka. However, based on the availability of information on the extents of various geological features around Sri Lanka will allow us to get a broader understanding of the distribution of marine molluscs at least at the level of the phylum as described above.

Ecological understanding of marine molluscs in Sri Lanka (with examples from rocky shores)

Marine mollusc distribution is closely associated with the geographic location, physio-chemical gradients which include vertical gradients of tides, temperature and currents, horizontal gradients of exposure to wave action, particle size gradients and salinity gradients, geology, topography and ecological features (Raffaelli and Hawkins 1996). The last two factors, i.e. topography and ecological features that operates at a small-scale have been observed to affect a greater extent on the distribution of low taxon levels (e.g. genera, species, etc.) particularly with low abundance (de Silva 1997).

One of the better-studied distribution patterns comes from rocky intertidal shores of southwest Sri Lanka (Arudpragasam and Ranatunga 1966; Atapattu 1972; de Silva 1997). The conspicuous and typical species of open rock surface are either attached (e.g. mussels and oysters) or if mobile (e.g. periwinkles, limpets, topshells etc.), are nevertheless capable of holding tightly to the surface of the rock or retreating to protective crevices as occasion demands. Much less conspicuous are new recruits that tend to live in the secondary habitats such as mussel beds, barnacles and algae during the early settling days (de Silva – on-going1).

Rocky shores such as gently sloping platforms, irregular masses and boulder beaches, which are more common in Sri Lanka, and most of the shallow water reefs tend to demonstrate patchy distribution of species and overlaps with the physical zones. Many of these shores can be seen as a patchwork or a mosaic of species or assemblages on various scales on different phases of succession; from cleared bare rock to complete cover by a dominant species. There are many positive and negative interactions between the various elements in the patches, which make the patches dynamic through time (de Silva 2001, de Silva – ongoing1).

Effects of 1998 El Nino event on marine molluscs

Although quantitative data are still absent, ongoing research activities indicate that there is a considerable drop in the species number, abundance and distribution of subtidal molluscs particularly associated with coral reefs (Wilkinson et al. 1999; Pers. comm. with P. Weerakkody) since the occurrence of El Niño. By some measures, the 1998 El Niño was the strongest on record. This may be due, at least in part, to it being superimposed upon naturally occurring decadal time-scale fluctuations (Kerr, 1999; McPhaden, 1999) and anthropogenic global warming (Trenberth, 1998). However, such effect is not very apparent on most of the intertidal molluscs, except on some subtidal and shallow water species populations that sometimes inhabited pools and depressions of intertidal reefs (personal observations 2001 and de Silva-ongoing1).

Issues affecting the taxonomy and ecology of marine molluscs

Similar to most other invertebrate groups, the state of the taxonomic, biological and ecological knowledge of marine molluscs are extremely poor and patchy in Sri Lanka, been largely concentrated to a few highly visible, relatively common, or commercially important taxa. There are many knowledge gaps even with the relatively well-studied groups, whereas many other taxa are very poorly known or almost completely unstudied. This lack of knowledge have resulted in a less effort in managing and/or conserving the marine molluscs, although this group of marine fauna has proved to be very important for ecosystem functions as well as for the well-being of the humankind (Kay 1995, Duarte 2000).

There are some researches that have been carried out on intertidal, shallow water and coral reef related groups, but in many instances unpublished. As there has not been a continuity of these studies, it is not possible to identify the changes that may have happened within the phylum including possible extinction from Sri Lankan waters, effects of various threats, etc. let alone to predict probable future impacts. Hardly any phylogenetic studies have being carried out in recent time to verify the identified taxa, and in present day there are no local specialists working on taxonomic work. This has led to many researchers identifying mollusc fauna only to higher taxonomic levels and solely using photographic guides.

There is a need for ecological data, long term monitoring and assessments. However, there is a lack of information on basic biology and ecology of most taxa and there are no continuous application of research findings and updated research techniques that get developed in other parts of the world. One of the reasons for the poor knowledge on biology and ecology are due to the non-progress in taxonomic knowledge hindering advances in biological and ecological research. Due to the limited resources allocated comparative to the size of the area concerned, many have not attempted to research on marine molluscs. Resources have been mainly allocated on studies focusing on fishes, largest and colourful or commercially exploitable species. The understanding of their diversity and extent of the marine resource that they represent is very limited. Even the accessible intertidal and shallow-water habitats have not been studied in recent time.

Issues of accessibility to marine mollusc habitats have also led to something of a geographical bias, with research efforts being largely concentrated in the southwestern region. There is significant lack of data from rest of the areas around Sri Lanka and deeper waters. However, even in the better-studied regions of Sri Lanka, there are very few locations where the marine mollusc fauna has been sufficiently surveyed to enable reasonable baseline data to be obtained.

Elsewhere in the world, the use of marine molluscs and their habitats for developing and testing ecological theory has preceded apace in the 1980s and 1990s (Reise 1985; Paine 1994) as their potential as an ecological laboratories seem limitless. While there is a justifiable emphasis in contemporary studies on the collection of quantitative ecological data, there are very few studies being undertaken on the biology covering the natural history of Sri Lankan marine molluscs. With the exception of some commercial species, there is very little research on biological aspects such as feeding, life history, life span, role in ecosystem, etc.

Other reasons for non-progress in understanding this faunal group include lack of interest, lack of dedicated marine stations or departments in universities, and inaccessibility of available knowledge and information. There is a focus of research and conservation efforts towards larger animals rather than small and towards terrestrial rather than marine environments. When establishing research and conservation priorities there is thus an inherent bias, resulting both from the available knowledge base and from the interests of the majority of the people. Therefore, emphasis was never given to establish dedicated institutions to carry out the necessary research or coordinate the essential activities. One must not forget that this faunal group does not interest the public too. Unlike the larger animals, general public rarely encounter animals such as molluscs unless if it has an economic value, and there is also little understanding among the general public of why the knowledge and conservation of marine molluscs matter (Collins and Wells 1983). There are only very few keys and guides that are useful even for simple identification work in Sri Lanka (Kirtisinghe 1978; Abbot 1991; Allen and Steene 1994). There is also the issue of availability of these identification guides as well as other related information within the country. The knowledge and information that are present on marine molluscs of Sri Lanka is very limited and scattered with most documents can be only found in private collections.

There are a number of practical problems that too have contributed to the non-progress in understanding these marine organisms that have direct linkages to issues addressed earlier. These include the impracticality in studying some of the biological and ecological criteria such as population dynamics, recruitment, survival, etc, under natural spatio-temporal variations and difficulty in assessing the extent (in terms of population size and distribution) of such widely scattered marine organisms. Therefore, it is necessary to identify at least the keystone species in each main habitat and carry out detailed biological and ecological research to understand these organisms.

Research gaps in relation to taxonomy and ecology

As discussed above, there are a number of research gaps that should be focused as future interventions to understand and conserve the marine molluscs in Sri Lanka. These include:

- Regular surveys on status of marine molluscs and preparation of checklists;
- Taxonomic studies (phylogentic research) on undescribed taxa;
- Preparation and/or compilation of guides and keys;
- Studies on small-scale distribution at habitat level and species level and distribution ranges;
- Ecological studies (population dynamics, community interactions, etc.) and biological studies (life history, which is inclusive of feeding patterns, reproductive dynamics, etc.) at a local context and particularly focusing on keystone species;
- Ecological processes affecting communities/habitats; and
- Threats to marine molluscs and their habitats.

Conservation issues

There are many threatening processes that although not studied could affect marine molluscs in Sri Lanka. However, it is likely that they are vulnerable to the following potential impacts: pollution, sedimentation, habitat modification, extraction and reductions in population changes of other organisms that have a direct link to the survival of this group. Possible threatening effects due to alien invasive species are unknown, except for the increase of opportunistic organisms (i.e. organisms that increase their abundance due to change of state of habitats) that could be threatening to some of the members of this group (de Silva – ongoing1). Accelerating these threats would include lack of management processes and knowledge and understanding the fauna as a group and their ecosystem functions. The extents of the impacts are poorly understood, except in some localities. This directly connects to the possibility of extinctions at local levels. If it is actually happening, the rate or the scale of extinctions are not known due to the scarcity in other information such as taxonomy and distribution (Carlton 1996). The sea is not immune to extinctions and they are most likely to occur in particular habitats such as estuaries, coral reefs, intertidal shores and shallow water habitats (Carlton et al. 1999).

In Sri Lanka, as it is in most of the other countries of the world, regards marine molluscs as insignificant, although it is now a well recognized fact that they contribute considerably together with other invertebrates to sustain the most essential ecological processes and systems that we depend on (Kay 1995, Duarte 2000). It is also a well-known fact that only a limited number of species are ever likely to be of major economic importance benefiting humans. Since, in most situations the criteria for conservation of organisms are based on possible economic values, conservation of majority of species will not occur. However, one must not forget that an important reason for conserving a broad range of biota is to ensure the survival of the economically important species that are intricately linked to the survival of the rest of the non-commercial or economically unimportant species. Apart from the above reasons, they are also very useful organisms to improve scientific research, useful for educational, aesthetic and recreational activities and for ethical reasons – i.e. their rights to exist and our moral obligation for conserving these organisms for the use of future generations.

There have been relatively few attempts to list vulnerable marine molluscs and there are barely any conservation measures that have been implemented as a group of taxa. There are only 14 species and one genus protected under the last amended Fauna and Flora Protection Ordinance (Anon 1993) and only 2 species identified as lower risk/conservation dependent fauna in the IUCN Global Red List (2002). Not even a single species of marine molluscs have been identified in the IUCN Sri Lanka Red List (2000). Few of the species may have received some protection if present within locations of protected areas such as marine reserves or inaccessible habitats.

A broad range of measures is likely to be necessary for the management and conservation of marine molluscs. While species-specific approach might not be feasible for a country-like Sri Lanka except for most vulnerable or threatened species, and habitat or landscape conservation strategy (Bowen 1997) can be recommended as a better option. Apart from this, it is recommended that the following suggestions be also taken into consideration as part of conservation efforts. These include:

- Policy review and/or reform on conservation and implementation of policies;
- Effective management of threats through institutional coordination and controlling regulations;
- Basic research;
- Education and awareness programmes;
- Community involvement in conservation efforts; and
- Improving access to information.

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Appendix 1: Checklist of Marine Molluscs in Sri Lanka (post-mid 1990s)

CLASS: *Cephalopoda*

ORDER: NAUTILIDEA

FAMILY: NAUTILIDAE

Nautilus pompilius

ORDER: SPIRULIDA

FAMILY: SPIRULIDAE

Spirula spirula

ORDER: TEUTHOIDEA

FAMILY: LOLIGINIDAE

Loligo duvauceli

Loligo singhalensis

Sepioteuthis lessoniana

ORDER: OCTOPODA

FAMILY: OCTOPODIDAE

Cistopus indicus

Octopus aegina

Octopus cyaneus

Octopus defilippi

Octopus globosus

Octopus membranaceus

Octopus vulgaris

FAMILY: ARGONAUTIDAE

Argonauta argo

ORDER: SEPIOIDEA

FAMILY: SEPIIDAE

Sepia aculeate

Sepia latimanus

Sepia pharaonis

Sepia prashadi

Sepiella inermis

FAMILY: SEPIOLIDAE

Euprymna berry

CLASS: Gastropoda

ORDER: PATELLOGASTROPODA

FAMILY: PATELLIDAE

*Cellana radiata**

FAMILY: ACMAEIDAE

Patelloida saccharina

ORDER: NERITOIDA

FAMILY: NERITIDAE

Nerita albicilla*

*Nerita chamaeleon**

*Nerita polita**

ORDER: VETIGASTROPODA

FAMILY: HALIOTIDAE

Haliotis varia

FAMILY: FISSURELLIDAE

*Clypidna notata**

Diodora mus

Scutus unguis

FAMILY: TROCHIDAE

*Euchelus asper**

*Euchelus satratus**

Trochus maculates

*Trochus radiatus**

Umbonium vestiarium

FAMILY: TURBINIDAE

*Astralium rhodostoma**

*Turbo intercostalis**

FAMILY: PHASIANELLIDAE

*Phasianella solida**

ORDER: CAENOGASTROPODA

FAMILY: CERITHIIDAE

Cerithidea cingulata

Cerithidea quadrata

*Clypeomorus chemnitzian**

*Rhinoclavis aspera**

Rhinoclavis sinensis

FAMILY: POTAMIDIDAE

*Telescopium telesopium**

FAMILY: TURRITELLIDAE

Turitella terebra

FAMILY: LITTORINIDAE

Littorina scabra

*Littorina undulata**

*Nodilittorina granularis**

*Nodilittorina pyramidalis**

FAMILY: STROMBIDAE

Lambis chiragra

Lambis crocata

Lambis lambis

Lambis scorpius

Strombus canarium

Strombus listeri

*Strombus mutabilis**

*Strombus plicatus**

Strombus sp.

Tibia insulae

* Species that have been also encountered after 1998 El Nino event

FAMILY: XENOPHORIDAE
*Xenophora pallidula**
Xenophora sp.
FAMILY: CREPIDULIDAE
*Unidentified species**
FAMILY: CYPRAEIDAE
*Cypraea annulus**
Cypraea arabica
Cypraea argus
*Cypraea asellus**
*Cypraea caputserpentis**
Cypraea errones
*Cypraea felina**
Cypraea lynx
Cypraea mappa
*Cypraea monata**
*Cypraea ocellata**
Cypraea scurra
Cypraea talpa
*Cypraea tigris**
FAMILY: OVULIDAE
Ovula sp.
Volva volva
FAMILY: NATICIDAE
*Natica euzona**
FAMILY: CASSIDAE
Cassis cornuta
Cypraecassis rufa
Phalium sp.
FAMILY: BURSIDAE
*Bursa granularis**
Bursa sp.
FAMILY: FICIDAE
Ficus sp.
FAMILY: CYMATIDAE
*Cymatium muricinum**
Cymatium cingulatum
Cymatium pileare
Cymatium aquatile
Charonia tritonis
FAMILY: TONNIDAE
Tonna sp.
FAMILY: MURICIDAE
Chicoreus palmarosae
*Chicoreus ramosus**
Chicoreus torrfactus
*Chicoreus virgineus**
*Drupa morum**
Drupa ricinus*
*Drupella fusconigra**
*Morula granulata**
*Morula marginatra**
Morula sp.
Murex haustellum
Murex racemosa
Murex ternispina
*Purpura pursica**
*Thais bufo**
*Thais tissoti**
FAMILY: BUCCINIDAE
*Babylonia spirata**
FAMILY: FASCIOLARIIDAE
Pleuroploca trapezium
FAMILY: NASSARIDAE
*Nassa francolinus**
Nassarius sp.
FAMILY: COLLUMBELLIDAE
*Pyrene versicolor**
Pyrene spp. (3)
FAMILY: EPITONIIDAE
Gyroscala perplexa
FAMILY: HARPIDAE
Harpa harpa
FAMILY: MARGINELLIDAE
Marginella strigata
Marginella sp.
FAMILY: MITRIDAE
Mitra sp.
*Chrysame ferruginea**
Vexillum sp.
FAMILY: OLIVIDAE
*Oliva reticulata**
Oliva textilina
Oliva miniacea
Oliva sp.
FAMILY: VOLUTIDAE
Unidentified species
FAMILY: TURBINELLIDAE
Turbinella pyrum
Vasum ceramicum
FAMILY: MAGILIDAE
Magilus sp.
Rapa bulbiformis

FAMILY: CONIDAE
*Conus abraeus**
*Conus lividus**
Conus pennaceus
*Conus sulcatus**
Conus zeylanicus
Conus tessulatus
Conus corunatus
*Conus leopardus**

FAMILY: TERIBRIDAE
Terebra sp.

FAMILY: TURRIDAE
Lophiotoma indica
Turriella terebra

FAMILY: VASIDAE
*Turbinella pyrum**

ORDER: HETEROSTROPHA

FAMILY: ARCHITECHTONIDAE
Haliacus variagatus

ORDER: OPISTHOBRANCHIA

FAMILY: HAMINOEDAE
*Haminoea cymbalum**

FAMILY: BULLIDAE
Bulla ampulla

FAMILY: CHROMODORIDIDAE
Chromodoris decora
Chromodoris fidelis
Chromodoris geminus
Chromodoris tennentana
Glossodoris atromarginatra
Hypselodoris kanga
Risbecia pulchella
Risbecia sp.

FAMILY: DORIDIDAE
Jorunna funebris

FAMILY: POLYCERIDAE
Tambyja affinis

FAMILY: PHYLLIDIIDAE
Phyllidia cf. nobilis
Phyllidia spp. (6)
Phyllidia varicose

FAMILY: GLAUCIDAE
Pteraeolidia ianthina

FAMILY: ARMINIDAE
Arminia sp.

FAMILY: PLEUROBRANCHIDAE
Pleurobranchus sp.

FAMILY: POLYCERIDAE
Gymnodoris celonica

ORDER: PULMONATA

FAMILY: SIPHONARIIDAE
*Siphonaria atra**

FAMILY: ELLOBIDAE
Cassidula musterina

FAMILY: SILIQUARIIDAE
Siliquaria anguina

CLASS: Bivalvia

ORDER: MYTILIODA

FAMILY: MYTILIDAE
Brachidontes variabilis
Modiolus tulipa
*Perna perna**
*Perna viridis**
*Septifer bilocularis**
Septifer virgatus

ORDER: ARCOIDA

FAMILY: ARCIDAE
Andara troscheri
Arca lienosa
Arca sp.
Barbatia lima
Barbatia sp.
*Barbatia velata**
*Barbatia virescence**
Cucullaea labiata
*Trisidos tortuosa**

FAMILY: GLYCYMERIDAE
Glycymeris rotunda

ORDER: PTERIOIDA

FAMILY: PTERIIDAE
*Pinctada margaritifera**
Pinctada radiata
*Pinctada vulgaris**
Pteria penguin
Pteria sp.

FAMILY: MALLEIDAE
Malleus malleus

FAMILY: ISOGNOMONIDAE
Isognomon sp.

FAMILY: PINNIDAE
Atrina sp.
*Pinna bicolor**
*Pinna muricata**

ORDER: OSTETREOIDA

FAMILY: OSTREIDAE

*Crassostrea belcheri**
*Crassostrea madrasensis**
*Saccostrea commersalis**
*Saccostrea cucullata**

ORDER: VENEROIDA

FAMILY: CARDITIDAE

*Cardita bicolor**
*Cardita variagata**

FAMILY: CHAMIDAE

Chama fragum
Chama sp. *

FAMILY: CARDIIDAE

Afrocardium sp.
Fulvia sp.
Trachycardium sp.
Vasticardium sp.

FAMILY: TRIDACTINIDAE

Tridacna maxima
Tridacna squamosa

FAMILY: MACTRIDAE

Mactra sp.

FAMILY: SOLENIDAE

Siliqua radiata
Solecurtus sp.
Solen strictus

FAMILY: DONACIDAE

Donax scortum

FAMILY: PSAMMOBIIDAE

Unidentified species

FAMILY: SEMELIDAE

Semele sp.

FAMILY: TRAPEZIIDAE

Diplodonta sp.
Trapezium rostrata

FAMILY: VENERIDAE

Antigona lamellaris
Callista sp.
*Dosinia sericea**
Dosinia sp.
*Gafrarium dispar**
*Gafrarium divaricatum**
Gafrarium tumidum
Meretrix costa
Paphia sp.
*Paphia textile**
Periglypta clathrata
*Peryglypta reticulata**
Sunetta sp.
Tapes sp.
Venus toreuma

FAMILY: PANDORIDAE

Pandora ceylonicus
Pandora sp.

FAMILY: TELLINIDAE

Tellina sp.

CLASS: Polyplacophora

FAMILY: CHITONIDAE

Squamopleura imitatar *

The Fauna of Sri Lanka (2006): 288-293

The Taxonomy and Status of Offshore Birds (Seabirds) of Sri Lanka

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Abstract

A fair proportion of the offshore birds found in Sri Lanka are oceanic species. The checklist presented in this paper lists 54 species of seabirds documented so far, all of which belong to the order Ciconiiformes, represented by five families. The paper briefly discusses conservation issues affecting seabirds, mostly related to fishery and habitat degradation. With regards to the taxonomy, while advancements have been made over the recent years, a serious handicap has arisen from the lack of specimens for comparative study and the limited access to literature.

Key words: *Seabirds, Offshore birds, Conservation, Taxonomy*

Background

This paper considers as offshore birds (seabirds) the purely oceanic species, the coastal birds as well as those individual wide-ranging species which occur in the coastal waters, continental shelf and inland water bodies. All species included here have been recorded from Sri Lanka's territorial waters (i.e. 12 nautical miles or 22.24km from shore). Various workers including Legge (1880), Henry (1955), Phillips (1978), De Silva (1990), Harrison (1999) and others have earlier documented the offshore birds of Sri Lanka. The current paper seeks to supplement the work of these authors.

We exclude from this paper those groups usually classified as seabirds but which in Sri Lanka are not closely connected with the ocean (eg. Pelecanidae, Phalacrocoracidae, etc.). The taxonomy and nomenclature follows Kotagama, De Silva, Wijeyasinghe and Abeygunawardane (in press), which is based on the taxonomy and nomenclature of Inskipp, Lindsey and Duckworth (1996) modified where relevant by the nomenclature of Bourne and Casement (1996). The birds are identified up to species level only, sub-species being excluded. The avifaunal list of Kotagama et al. (in press) separates the species into three categories. The first list (L1) includes those species for which specimens have been collected. The second (L2) catalogues birds which are recorded from three or more sightings or confirmed by capture and release (as in ringing). The third list (L3) records species known from only one or two sightings. In the present paper we follow this arrangement in cataloguing the seabird species. All species of offshore birds catalogued by Kotagama et al. (in press) are included in the checklist appended here. These include 35 species from Ll, one from L2 and 18 from L3.

Species richness of off-shore birds

Ornithologically Sri Lanka can be considered an oceanic island, thus a fair proportion of the offshore birds recorded are oceanic species. The 54 seabird species (Appendix 1) included here all belong to a single Order Ciconiiformes, which is represented in our seas by five families. Of these seven (possibly eight) species are breeding residents (R). Thirteen species are winter visitors (W) from northern regions. None of these breed in Sri Lanka although some may loiter on during the summer months. Six species are summer visitors (S) with two of them *Sterna dougallii* and *S. anaethetus* breeding here, but note that the former species is also believed to be represented by a small resident population. This may well prove to be the case for *S. anaethetus* as well (see below). Three species are regular passage migrants (PM); *Sterna anaethetus* which migrates off the coast in large numbers during the south-west monsoon (De Silva, 1987), *S. fuscata* which does so in small numbers and *Puffinus carneipes* which migrates annually along the west coast on the return journey to its breeding grounds in south-west Australia (De Silva & Perera, 1994). A further eight species are believed to be irregular visitors (I) being recorded in very small numbers in some years and absent in others, but their actual status is uncertain on account of the lack of adequate data. The status of 22 species is uncertain. or unknown (U) at present. This includes 11 species of Procellariidae, eight species of Laridae, two species of Sulidae and one species of Fregatidae. Many earlier authors classed these birds as "vagrants", "stragglers" or "accidentals", which highlights the fact that information is lacking. It is important to note that several species fall into two or more categories. For example *Gelochelidon nilotica* is represented by both resident and (winter) migrant populations and *S. anaethetus* which is largely a passage migrant, is also considered by some authors to be a winter visitor and recent reports indicate that small numbers may breed on islets off Mannar. This raises the question as to whether a small resident breeding population of the species occurs in Sri Lanka. Where the specified status of a species is in some doubt, it is indicated in the checklist by a mark of interrogation (?) following the presumed status. It is relevant to point out that Sri Lanka has no endemic seabird species. It is inevitable that as more data becomes available the status of many species discussed here will be clarified and the checklist will require to be amended accordingly.

Several seabird species from the Antarctic and sub-Antarctic regions visit Sri Lanka. These include *Catharacta lonnbergi*, *C. maccormicki* and *Oceanites oceanicus.* Another southern seabird Pterodroma mollis recorded recently from Sri Lanka, was the first of its species to be recorded from the tropical Indian Ocean. Another of its congeners from the sub-Antarctic regions *P. lessonii* was the first of the species to be recorded from any tropical ocean.

Conservation issues

Sri Lanka's seabirds are subject to many threats, actual and potential. Many birds are accidentally entangled and drowned in fishing nets. Among the species so affected for which information is available are Sterna bergii and Sula leucogaster. Seabirds are sometimes foul-hooked on trolling lines, here again Sula species appear to be among the victims. A major setback to some species of breeding terns (which are ground nesters), is the loss of breeding habitat due to the littoral regions of lagoons in which they nest, being converted into ponds for shrimp farming or into evaporation pans for salt production. Habitat degradation has increased considerably in the last two decades. Larus brunnicephalus and occasionally other wintering gulls are captured for food in a few northern villages. Reports indicate that at present this appears to be carried out on a relatively limited scale. The data relating to the effects of marine pollution on seabirds is virtually non-existent and the extent of actual or potential threats is therefore unknown.

Issues related to taxonomy

The taxonomy of offshore birds has undergone considerable revision in recent years. Regrettably in some instances this has not clarified matters, as an element of disagreement exists among the different authorities. A source of some confusion is the *Larus argentatus / L. cachinnans / L. fuscus / L. heuglini* group. These have been considered by some authors as individual species in their own right, others consolidate them into two (or more) species, a minority consider them to be conspecific, while some authorities treat them as sub-species. Since each one has at some time been recorded from Sri Lanka and the taxonomy continues to remain rather confused, we provisionally treat these as separate species, realizing clearly that this treatment may be subject to revision in the light of new information. This also illustrates a major drawback to workers in Sri Lanka where a lack of specimens for comparative study and limited access to literature often proves to be a serious handicap.

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Appendix 1: Checklist of Sea Birds of Sri Lanka

ORDER CICONIIFORMES

Family Laridae

1. *Catharacta lonnbergi* Mathews, 1941.
   Brown Skua. (S) — Ll
2. *C. maccormicki* (Saunders, 1893)
   South Polar Skua. (U) — L3
3. *Stercorarius pomarinus* (Temminck, 1815)
   Pomarine Jaeger. (S) — Ll
4. *S. parasiticus* (Linnaeus, 1758)
   Parasitic Jaeger. (U) — L3
5. *Larus hemprichii* (Bruch, 1853)
   Sooty Gull. (U) — L3
6. *L. heuglini* Bree, 1876
   Heuglin's Gull (I) — Ll
7. *L. argentatus* Pontoppidan, 1763
   Herring Gull (W?) — L3
8. *L. cachinnans* Pallas, 1811
   Sooty Gull. (U) — L2
9. *L. fuscus* Linnaeus, 1758
   Lesser Black-backed Gull. (I) — L3
10. *L. ichthyaetus* Pallas, 1773
    Pallas's Gull. (W) — Ll
11. *L. brunnicephalus* Jerdon, 1840
    Brown-headed Gull. (W) — Ll
12. *L. ridibundus* Linnaeus, 1766
    Black-headed Gull. (W) — L3
13. *L. genei* Breme, 1839
    Slender-billed Gull. (U) — L3
14. *Gelochelidon nilotica (*Gmelin, 1789)
    Gull-billed Tern. (W/R?) — Ll
15. *Sterna caspia* (Pallas, 1770)
    Caspian Tern. (R/W) — Ll
16. *S. bengalensis* Lesson, 1831
    Lesser Crested Tern. (W) — Ll
17. *S. bergii* Lesson, 1831
    Great Crested Tern. (R) — Ll
18. *S. sandvicensis* Latham, 1787
    Sandwich Tern. (W) — Ll
19. *S. dougallii* Montagu, 1813
    Roseate Tern. (S/R) — Ll
20. *S. sumatrana* Raffles, 1822
    Black-naped Tern. (U) — L3

21. *S. hirundo* Linnaeus, 1758
Common Tern. (W/R) Ll

22. *S. albifrons* Pallas, 1764
Little Tern. (R) Ll

23. *S. saundersi* Hume, 1877
Saunders's Tern. (R) Ll

24. *S. repressa* Hartert, 1916
White-cheeked Tern (U) L3

25. *S. anaethetus* Scopoli, 1786
Bridled Tern. (PM/W?/R?) Ll

26. *S. fuscata* Linnaeus, 1766
Sooty Tern. (PM) Ll

27. *Chlidonias hybridus* (Pallas, 1811)
Whiskered Tern. (W) Ll

28. *C. leucopterus* (Temminck, 1815)
White-winged Tern. (W) Ll

29. *C. niger* (Linnaeus, 1758)
Black Tern. (W?) L3

30. *Anous stolidus* (linnaeus, 1758)
Brown Noddy. (S) Ll

31. *A. minutus* (Boie, 1844)
Black Noddy. (U) L3

32. *A. tenuirostris* (Temminck, 1823)
Lesser Noddy. (I) Ll

Family Phaethontidae

33. *Phaethon aetherus* Linnaeus, 1758
Red-billed Tropicbird. (S) Ll

34. *P. lepturus* Daudin, 1802
White-tailed Tropicbird. (I) Ll

Family Sulidae

35. *Sula dactylatra* Lesson, 1831
Masked Booby. (U) Ll

36. *S. sula* (Linnaeus. 1766)
Red-footed Booby. (U) Ll

37. *S. leucogaster* (Boddaert. 1783)
Brown Booby. (I) Ll

Family Fregatidae

38. *Fregata minor* (Gmelin, 1789)
Great Frigatebird. (I) Ll

39. *F. ariel* (Gray, 1845)
Lesser Frigatebird. (I) Ll

40. *F. andrewsi* Mathews. 1914
Christmas Island Frigatebird. (U) L3

FAMILY PROCELLARIIDAE

41. *Daption capense* (Linnaeus. 1758)
Cape Petrel (U). Ll

42. *Pterodroma baraui* (Jouanin, 1964)
Barau's Petrel. (U) L3

43. *P. lessonii* (Garnot. 1826)
White-headed Petrel. (U) L3

44 *P. mollis* (Gould. 1844)
Soft-plumaged Petrel. (U) L3

45. *Bulweria bulwerii* (Jardine & Selby. 1828)
Bulwer's Petrel. (U) L3

46. *B. fallax* Jouanin, 1955
Jouanin's Petrel. (U) Ll

47. *Calonectris leucomelas* (Temminck, 1835)
Streaked Shearwater. (U) Ll

48. *Puffinus pacificus* (Gmelin. 1789)
Wedge-tailed Shearwater. (I) Ll

49. *P. carneipes* Gould, 1844
Flesh-footed Shearwater. (PM) Ll

50. *P. griseus* (Gmelin, 1789)
Sooty Shearwater. (U) L3

51. *P. tenuirostris* (Temminck. 1835)
Short-tailed Shearwater. (U) Ll

52. *P. Iherminieri* Lesson, 1839
Audubon's Shearwater. (U). L3

53. *Oceanites oceanicus* (Kuhl, 1820)
Wilson's Storm-petrel. (S) Ll

54. *Oceanodroma monorhis* (Swinhoe, 1867)
Swinhoe's Storm-petrel. (U) Ll

The Fauna of Sri Lanka (2006): 294-301

Taxonomy and Status of the Sharks and Rays of Sri Lanka

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Abstract

This paper presents checklists, for the 61 species of sharks and 31 species of rays found both in the territorial waters and exclusive economic zones belonging to Sri Lanka. Conservation concerns have arisen primarily from the fact that most selachians are rather slow breeders, and as such are very easily affected by a variety of natural and anthropogenic threats, including intense fishing. To implement successful conservation initiatives further research will be required for threat analysis on a species by species basis. Furthermore the author describes some of the existing taxonomic issues faced by selachian biologists in Sri Lanka.

Key words: *Sharks, Rays, Skates, Conservation*

Background

Sharks have been relatively neglected by Sri Lanka's naturalists, possibly on account of the difficulties inherent in identifying many species, as well as the paucity of accessible literature. Until recently the taxonomy was also in a rather confused state.

Various authors have from time-to-time attempted to catalogue the Sri Lanka sharks. Mendis (1954) listed 15 species, which included a doubtful species - Lamna spallanzani. In his list of 22 species Munroe (1955) included *Lamna spallanzani* and listed *Nebrius ferrugineus* twice, once under its correct taxon and again under a synonym, hence the actual number was 20 species. De Silva (1988) listed 44 confirmed and 11 unconfirmed species in his checklist. Several of these unconfirmed species have subsequently been recorded in Sri Lankan waters. Amarasooriya and Dayaratne (1994) listed 44 species from the west and south-western coasts. De Bruin, Russel and Bogusch (1994) included 43 species as being of interest to the marine fisheries industry. In a more recent paper, De Silva (1995) has listed 51 species. Weerakkody and Fernando (2000) added a single species *Centrophorus squamosus* and also proposed the acceptance of *Isistius braziliensis* on a provisional basis. The latter species is excluded from the checklist as evidence for its occurrence in Sri Lanka waters is circumstantial. It is relevant to note that a few species of sharks caught extra-territorially are sometimes unloaded in Sri Lankan ports. Care was taken therefore to ensure that such species were not inadvertently included in the Sri Lanka checklist.

Sri Lanka's skates and rays have received considerably less attention than their relatives the sharks. Munroe (1955) included 29 species. De Bruin, Russel and Bogusch (1994) accepted 30 and also updated the taxonomy.

Species richness of sharks and rays

The present paper accepts 61 species of sharks belonging to 5 orders and 17 families (Appendix 1). These comprise the currently known shark species from both the territorial waters of Sri Lanka and the exclusive economic zone. Since Jonklaas first reported *Notorhynchus cepedianus* in the 1970's (De Silva, 1995) there have been no further records of the species. There have also been no records of *Carcharodon carcharias* and *Sphyrna mokarran* since they were first documented a few decades ago. Compagno (in litt. 1989) clarified that *C. carcharias* is primarily a temperate zone species which seldom enters the tropics. The paucity of records for *S. mokarran* however has no ready explanation. Other species for which there are relatively few recent records include *Carcharhinus amboinensis*, *C. plumbeus*, *Odontaspis noronhai*, *O. ferox*, *Negaprion brevirostris*, *Hexanchus griseus* and *Lamiopsis temmincki*.

The skates and rays documented from Sri Lanka waters include a total of 31 species from four orders and nine families (Appendix 2). However, this is an under-representation of the true species richness, as many species of rays remain to be documented from Sri Lanka's waters. This is a lacuna that future workers could fill.

Conservation issues

Most selachians are rather slow breeders. They take a long time to attain sexual maturity, have long gestation periods and produce relatively few young. For example in two of the more prolific breeders *Prionace glauca* and *Galeocerdo cuvier* sexual maturity takes approximately four to five years and litters vary from 4 to 135 for the former and 10 to 82 for the latter. The gestation periods for these species vary from 9 to 12 months. Many other species however are less fecund; Eugomphodus taurus produces only two young at a time. *Carcharhinus wheeleri* and *Triaenodon obesus* have litters of from one to five. In comparison bony fish produce several tens of thousands of eggs at a time and a few species produce as many as a million. It is clear therefore that selachian populations, on account of their slow reproductive rate, can easily be adversely affected by a variety of threats both natural and those resulting from human intervention.

Intensive fishing activity using modern equipment, coupled with the proliferation of large-scale fisheries has resulted in greatly increased catches. Sharks are particularly affected as their flesh has recently become more acceptable as a source of protein. Many sharks are captured as by-catch, by fishing gear set for other species. The very large demand for shark fins has resulted in the cruel and wasteful practice of "finning". Pelagic species like *Caraharhinus falciformis, C. longimanus,* the three Alpoias species, *Sphyrna zygaena, S. lewini* etc. are taken in large numbers. Many of these are slow breeders, hence it is not clear how much longer these (and other pelagic species) can survive in commercially viable populations. Some reef sharks have declined in numbers in recent years. For example Stegostoma fasciatum, which was never very abundant, has all but disappeared from many of its former haunts. *Nebrius ferrugineus* and *Triaenodon obesus,* both largely nocturnal species, have also decreased in numbers although reasons for this are difficult to determine. The skates and rays are mainly taken by artisan fisheries, hence they appear to have fared somewhat better, although once again precise data is lacking. In addition to direct impact of the fisheries industry, there is the potentially adverse effect of marine pollution on selachians, although precise data relating to the Sri Lanka condition is not available. Due to the lack of data it is not possible to determine the exact status of many of the species in the checklist and whether any are at risk. There is an urgent need therefore for threat-evaluation on a species-by-species basis.

Taxonomic issues

The taxonomic validity of *Eugomphodus tricuspidatus* (included by De Bruin et al., 1994), needs to be re-evaluated. The status of the species described as *Lamna spallanzani* and *Carcharhinus menisorrah,* recorded by many earlier writers as being present in Sri Lanka waters, as well as the two *Gymnura* species periodically reported from our seas need to be reconsidered. In the past most small manta rays were ascribed to *Mobula diabolus* which is no longer thought to occur in Sri Lanka waters. Whether this species is actually present along with its large relative *Manta birostris,* as anecdotal evidence suggests, is a matter for future research to clarify. This highlights a problem faced by selachian biologists in Sri Lanka, viz. the lack of specimens for comparative studies and the restricted access to literature: a problem faced by many workers in developing countries.

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Appendix 1: Checklist of shark species recorded from the territorial waters of Sri Lanka

ORDER HEXANCHIFORMES

Family Hexanchidae

1. *Hexanchus griseus* (Bonaterre, 1788). B1untnose sixgill shark.
2. *Notorynchus cepedianus* (Peron, 1907). Broadnose sevengill shark.

ORDER SQUALIFORMES

Family Echinorhinidae

3. *Echinorhinus brucus* (Bonaterre, 1788). Bramble shark.

Family Squalidae

4. *Centrophorus squamosus* (Bonaterre, 1788). Leaf scale gulper shark.
5. *Centroscyllium ornatum* (Alcock, 1889). Ornate dogfish.
6. *Dalatias licha* (Bonnaterra, 1788). Kitefin shark.

ORDER ORECTOLOBIFORMES

Family Hemiscylliidae

7. *Chiloscyllium griseum* (Muller & Henle, 1838). Grey bambooshark.
8. *C. indicum* (Gmelin, 1789). Slender bamboo shark.
9. *C. plagiosum* (Bennet, 1830). Whitespotted bamboo shark.

Family Stegostomatidae

10. *Stegostoma fasciatum* (Hermann, 1783). Zebra shark.

Family Ginglymostomatidae

11. *Nebrius ferrugineus (*Lesson, 1830). Tawny nurse shark.

Family Rhiniodontidae

12. *Rhiniodon typus* (Smith, 1828). Whale shark.

ORDER LAMNIFORMES

Family Alpoiidae

13. *Alopias vulpinus* (Bonnaterre, 1788). Thresher shark.
14. *A. superciliosus* (Lowe, 1839). Bigeye thresher shark.
15. *A. pelagicus* (Nakamura, 1935). Pelagic thresher shark.

Family Odontaspididae

16. *Odontaspis noronhai* (Maul, 1955). Bigeye sandtiger.
17. *O. ferox* (Risso,1810). Smalltooth sandtiger.
18. *Eugomphodus taurus* (Rafinesque, 1810). Sandtiger shark.

Family Pseudocarchariidae

19. *Pseudocarcharias kamoharai* (Matsubara, 1936). Crocodile shark.

Family Lamnidae

20. *Carcharodon carcharias* (Linnaeus, 1758). Great white shark.
21. *Isurus oxyrinchus* (Rafinesque, 1809). Shortfin mako shark.
22. *I. paucus* (Guitart Manday, 1966). Longfin mako.

ORDER CARCHARHINIFORMES

Family Scyliorhinidae

23. *Atelomycterus marmoratus* (Bennet, 1830). Coral catshark.
24. *Halaelurus hispidus* (Alcock, 1891). Bristly catshark.

Family Proscylliidae

25. *Eridacnis radcliffei* (Smith, 1913) Pygmy ribbontail catshark.

Family Triakidae

26. *Mustelus manazo* (Bleeker, 1854). Starspotted smoothhound.
27. *M. mosis* (Hemprich & Ehrenberg, 1899). Arabian smoothhound.

Family Hemigaleidae

28. *Chaenogaleus macrostorna* (Bleeker, 1852). Hooktooth shark.
29. *Hemigaleus microstorna* Bleeker, 1852. Sicklefin weasel shark.
30. *Hemipristis elongatus* (Klunzinger, 1871). Snaggletooth shark.

Family Carcharhinidae

31. *Carcharhinus albimarginatus* (Ruppel, 1837). Silvertip shark.
32. *C. altimus* (Springer, 1950). Bignose shark.
33. *C. amblyrhynchoides* (Whitley, 1934). Graceful shark.
34. *C. amblyrhynchos* (Bleeker, 1856). Grey reef shark.
35. *C. amboinensis* (Muller & Henle, 1839). Pigeye shark.
36. *C. brevipinna* (Muller & Henle, 1839). Spinner shark.
37. *C. dussumieri* (Valenceiennes, 1839). Whitecheek shark.
38. *C. falciformis* (Bibron, 1839). Silky shark.
39. *C. hemiodon* (Valenciennes, 1839). Pondicherry shark.
40. *C. limbatus* (Valenciennes, 1839). Blacktip shark.
41. *C. 1ongimanus* (Poey. 1861). Oceanic whitetip shark.
42. *C. macloti* (Muller & Hen1e, 1839). Hardnose shark.
43. *C. melanopterus* (Quoy & Gaimard, 1824). Blacktip reef shark.
44. *C. plumbeus* (Nardo, 1827). Sandbar shark.
45. *C. sealei* (Pietschmann, 1916). Blackspot shark.
46. *C. sorrah* (Valenciennes. 1830). spot-tai1 shark.
47. *C. wheeleri* (Garrick, 1982) .Blacktail reef shark.

48. *Galeocerdo cuvier* (Peron & Lesuer, 1822). Tiger shark.
49. *Lamiopsis temmincki* (Muller & Henlei. 1839). Broadfin shark.
50. *Loxodon macrorhinus* (Muller. Hen1e. 1839). Sliteye shark.
51. *Negaprion acutidens* (Ruppell, 1837). Sicklefin lemon shark.
52. *N. brevirostris* (Poey. 1868). Lemon shark.
53. *Prionace glauca* (Linnaeus, 1758). Blue shark.
54. *Rhizoprionodon acutus* (Ruppell, 1837) .Milk shark.
55. *R. oligolinx* Springer. 1964. Grey sharpnose shark.
56. *Scoliodon laticaudus* Muller & Henle, 1838. Spadenose shark.
57. *Triaenodon obesus* (Ruppell, 1837). Whitetip reef shark.

Family Sphyrnidae

58. *Eusphyra blochii* (Cuvier. 1817). Winghead.
59. *Sphyrna lewini* (Griffith & Smith, 1834). Scalloped hammerhead.
60. *S. mokarran* (Ruppell. 1837). Great hammerhead.
61. *S. zygaena* (Linnaeus. 1757). Smooth hammerhead.

Appendix 2: Checklist of skates and rays recorded from the territorial waters of Sri Lanka

ORDER PRISTIFORMES

Family Pristidae

1. *Anoxypristis cuspidatus* (Latham, 1794). Narrow sawfish.
2. *Pristis microdon* Latham, 1794. Largetooth sawfish.
3. *P. zijsron* Bleeker, 1851. Longcomb sawfish.

ORDER TORPEDINIFORMES

Family Narcinidae

4. *Narke dipterygia* (Bloch & Schneider, 1801). Numb fish.
5. *N. brunnea* Annandale, 1909. Brown electric ray.
6. *N. timlei* (Bloch & Schneider, 1801). Spotted electric ray.

ORDER RAJIFORMES

Family Rhinobatidae

7. *Rhina ancylostoma* Bloch & Schneider, 1801. Shark ray.
8. *Rhinobatos annandale*i Norman, 1926. Annandale's guitarfish.
9. *R. granulatus* Cuvier, 1829. Granulated guitarfish
10. *Rhynchobatus djiddensis* (Forsskal, 1775). Whitespotted guitarfish.

Family Rajidae

11. *Raja mamillidens* Alcock, 1889. Prickly skate.

ORDER MYLIOBATIFORMES

Family Dasyatididae

12. *Dasyatis kuhlii* (Muller & Henle, 1841). Bluespotted stingray.
13. *D. marginatus* (Blyth, 1860). Blackedged stingray.
14. *D. pastinacus* (Linnaeus, 1758). Stingray.
15. *D. zugei* (Muller & Henle, 1841). Pale-edged stingray.
16. *Himantura bleekeri* (Blyth, 1860). Whiptail stingray.
17. *H. gerrardi* (Gray, 1851). Sharpnose stingray.
18. *H. imbricatus* (Bloch & Schheider, 1801). Scaly stingray.
19. *H. uarnak* (Forsksk.al, 1775). Honeycomb stingray.
20. *Pastinachus sephen* (Forsskal, 1775). Cowtail stingray.
21. *Taeniura lymma* (Forsskal, 1775). Bluespotted ribbon ray.
22. *T. meyeni* Muller & Henle, 1841. Blotched fantail ray.
23. *Urogymnus asperrimus* (Bloch & Schneider, 1801). Porcupine ray.

Family Gymnuridae

24. *Gymnura poecilura* (Shaw, 1804). Butterfly ray.

Family Myliobatididae

25. *Aetobatus narinari* (Euphrasen, 1790). Spotted eagle ray.
26. *Aetomylaeus maculatus* (Gray, 1834). Mottled eagle ray.
27. *A. nichofii* (Bloch & Schneider, 1801). Banded eagle ray.

Family Rhinopteridae

28. *Rhinoptera adspersa* (Muller & Henle, 1841). Rough cownose ray.
29. *R. javenica* (Muller & Henle, 1841). Javanese cownose ray.

Family Mobulidae

30. *Mobula eregoodootenkee* (Cuvier, 1829). Lesser devil ray.
31. *M. kuhlii* (Valenciennes, 1841). Pygmy devil ray.

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Taxonomy and Current Status of Marine Mammals in Sri Lanka

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Abstract

Based on published literature and the current state of knowledge, 28 species of marine mammals have been identified in Sri Lanka's waters. Of these, 27 species - under two sub-orders and five families - belong to the order Cetacea, and one species belongs to the order Sirenia. Cetacean taxonomy is still evolving globally and the ecological needs and parameters for many of these species have not yet been defined clearly. Even in the 2002 IUCN Red List of Threatened Species the majority of even common species of small cetaceans are still listed as data deficient or not assessed. Although there has been a long-term research focus on many terrestrial mammal species, dedicated long-term research on marine mammals in Sri Lanka is lacking. As a result, there are many research gaps in relation to this faunal group and our knowledge on population trends, distribution and species and/or populations at risk is still very meager. As a group, marine mammals also face many threats as a result of human activities in both near-shore and offshore marine areas.

Key words: *Marine mammals, Taxonomy, Issues, Ecology, Gaps*

Introduction

Sri Lanka's territorial waters are rich in marine mammal fauna with high species richness and year-round abundance. However, present knowledge about this diverse segment of mammalian fauna is still very limited due to a lack of dedicated research on the subject. In scientific literature, there are records of stranded whales and museum specimens from as far back as the 1889 (Fernando, 1912; Deraniyagala, 1960). In the mid-20th century, interactions with fisheries are mentioned for the first time (Lantz and Gunasekera, 1955). Although travelers and historians have referred to whales in the waters around the island as far back as the 14th century, the first scientific records of live cetaceans are documented only after about 1980. Research carried out in the last two decades has resulted in most of what is known about species diversity, threats and conservation issues of Sri Lankan cetaceans. The occurrence and hunting of the dugong in Sri Lanka's waters appears in the literature in the late 19th century (Haley, 1884; Nevill 1885), but there has been very little recent work done on this globally threatened species.

Taxonomic classification for species in Sri lanka's waters

Based on current taxonomy, 28 species of marine mammals within the two Orders of Cetacea and Sirenia have been recorded from the waters around Sri Lanka (Table 1 below). This species list is based on specimens obtained from strandings on the coastline (Deraniyagala, 1948, 1960, 1963, 1965b; Leatherwood and Reeves, 1989, Ilangakoon, 2002), specimens from the fisheries bycatch and direct take (Prematunga et. al., 1985; Leatherwood and Reeves 1989; Leatherwood, 1990, Dayaratna and Joseph, 1993; Ilangakoon, 1997, 2002; Ilangakoon et. al., 2000a, 200b) and sightings from offshore surveys (Leatherwood et. al. 1984; Alling, 1986; Alling et. al., 1991; Ilangakoon, 2000b, 2002; Anonymous, 2003). The list is by no means complete as a new species for our waters - Blainville's beaked whale *(Mesoplodon densirostris)* - was identified as recently as 2002 (Ilangakoon, 2002; Ilangakoon and Perera, 2002).

Of the total of 28 species, 27 belong to the Order Cetacea, and are placed within the two Suborders Mysticeti and Odontoceti, and come under the six families of Balaenopteridae, Physeteridae, Kogiidae, Ziphiidae, Delphinidae and Phocoenidae. The single species in the Order Sirenia is the Dugong *(Dugong dugon)*, belonging to the family Dugongidae.

Table 1: Taxonomic Classification of Species in Sri Lanka's Waters

Order	**Suborder**	**Family**	**No. of Genera**	**No. of Species**
Cetacea	Mysticeti	Balaenopteridae	2	5
	Odontoceti	Physeteridae	1	1
		Kogiidae	1	2
		Ziphiidae	3	4
		Delphinidae	12	14
		Phocoenidae	1	1
Sirenia	-	Dugongidae	1	1
Total			**21**	**28**

Issues pertaining to taxonomy and ecology

In a global context, the taxonomy of cetaceans is still evolving and species are being split and lumped based on new advances in molecular biological research; new species are also being added based on discoveries from expanding field research. A good example of splitting is Bryde's whale *(Balaenoptera edeni)*. This species is being currently split into two species based on genetic differences and skull morphometrics (Wada et. al., 2003). Once the original type specimen is re-examined, these two new species will very likely be named *B. edeni* and *B. brydii*. However, the problem of field discrimination of these two species is yet to be resolved, because they are outwardly similar in appearance and are not geographically isolated, occurring side by side. [This has been empirically proven in in the waters off Thailand where both are present (personal communication S. Chantrapornsyl)]. In Sri Lanka's waters, what was originally named *B. edeni* is common, but recent evidence indicates that both species may occur here as well.

In contrast, the rough-toothed dolphin *(Steno bredanensis*, found in Sri Lankan waters, was placed originally in a separate family called the Stenidae. However, a captive specimen in a dolphinarium in Hawaii bred successfully with a common bottlenose dolphin *(Tursiops truncatus)* and produced a calf that lived for four years (Leatherwood and Reeves, 1982). As a result of this, and similar observations from the wild, this species was moved to the family Delphinidae. Meanwhile new species of cetaceans are also still being discovered in little studied families such as the Ziphiidae. For example, the Pygmy beaked-whale *(Mesoplodon peruvianus)* was discovered in the South Pacific Ocean and named as recently as 1991.

Ecology

The ecological needs of many of the species occurring in Sri Lanka's waters are not defined clearly or even known at present. However, what is known is that the great diversity of species in the waters around the island inhabit all available niches in both coastal and offshore waters with a few even entering coastal lagoons (Ilangakoon, unpublished data).

Research gaps

There has been little dedicated, long-term research on marine mammals in Sri Lanka. This is mostly a result of a lack of both financial resources (since research at sea is costly) and trained personnel to carry out the work. Whatever studies have been carried out have been short-term projects, when funds became available and through the use of platforms of opportunity despite he unavailability of a dedicated research vessel. Therefore, marine mammal research has been discontinuous and as a result, what we know about Sri Lankan marine mammals is still very incomplete.

- We do not know which species/population are particularly at risk in Sri Lanka.
- We still know little about distribution, migration patterns, population trends or species/populations at particular risk.
- No molecular biological work has been conducted to assess stock affinities or population structure of any species in our waters.
- Because species identification has been based largely on external morphology, there is a need for trained marine mammal taxonomists in the country.
- Even less is known about the dugong population in the waters of the Gulf of Mannar because little focused research has been carried out for decades.

Threats and conservation issues

Marine mammals face a multitude of threats due to various human activities. In Sri Lanka's waters, the principle threat is the fisheries industry, because it causes both direct and indirect mortality of small cetaceans and dugongs in large numbers each year (Ilangakoon, 1989, 1997, 2002; Ilangakoon et. al. 2000a, 2000b). For small cetaceans, accidental bycatch in commonly used synthetic gillnets is a major problem. This causes the death, by drowning, of thousands of animals. Although direct hunting is not as widespread as bycatch in Sri Lanka, in certain areas the use of hand-held harpoons to kill small cetaceans does take place (Ilangakoon 1997, 2002; Ilangakoon et. al., 2000a). Within the past two decades, this practice has spread to new areas and the numbers being killed annually in this way continue to increase (Ilangakoon et. al., 2000a; Ilangakoon, 2002). Dugongs too are often caught accidentally in nets and are also hunted deliberately whenever sighted by fishermen.

Although increased shipping traffic is a threat that affects all marine mammals, it much more of a direct threat to large whales in the waters around the island. Recently, there has been evidence that several large whales have been killed in our waters due to ship strikes (Ilangakoon, unpublished data). Increased shipping also causes increased marine pollution (both acoustic and chemical) as well as the likelihood of oil spills, which that can be extremely detrimental to marine mammals. Habitat destruction in the form of pollution of coastal waters - through land-based and marine-based sources - also poses a threat to marine mammals which have a restricted habitat or specialized ecological needs such as the dugong and coastal dolphins. For instance, based on current research the range of the small cetacean Indo-pacific humpback dolphin *(Sousa chinensis)* in Sri Lanka's waters appears to be restricted to a small nearshore area off the north-west of the island (Ilangakoon, unpublished data). Disturbance or pollution of their habitat can become a threat to the very existence of this population and its long-term viability. However, because detailed long-term research on this species and therefore sound scientific data are lacking, it is not possible to formulate or enforce any protective measures based on sound scientific data.

Another conservation issue that affects the marine mammals of Sri Lanka is that marine protected areas (MPA's) are not given priority in the protected area system of the country (Ilangakoon, 2001). To date only four MPA's have been declared in the waters around the island and both have been declared with the aim of protecting coral reefs. Even in these two marine protected areas, enforcement and management are almost non-existent. Some marine mammal species, such as the vulnerable dugong with its specialized ecological needs and restricted habitat, would indubitably benefit from well-managed protected areas declared specifically for its protection. However, protection of marine mammals has been given priority or even taken into consideration when marine protected areas have been declared in Sri Lanka.

Nature tourism, although not yet a threat to marine mammals in Sri Lanka, is potential threat. This could become a major problem to marine mammals, as there are no regulations in place to control or monitor such activities in this country. Even if regulations were put in place through the law, enforcement would be very difficult at sea due to the same constraints that cause the lack of enforcement in MPA's. In many parts of the world today, where whale and dolphin watching is a well-developed part of the tourist industry, adverse impacts - especially on species and populations inhabiting coastal waters - have become proven (Constantine et. al., 2004; Lusseau, 2003). Such adverse impacts occurred even where strict regulations are in place (Garrod and Fennel, 2004).

From an international perspective, of the species in Sri Lanka's waters, the 2002 IUCN Red List of Threatened Species lists two as endangered and three as vulnerable. Another seven are listed as low risk, but of these six are conservation dependent and one is near threatened (Table 2, below). However, the most for Sri Lankan marine mammals is that, of the rest, 11 are listed as data deficient, while five are not listed at all.

Table 2: Status of Species in Sri Lanka's Waters According to IUCN Red List

Order	Suborder	Family	IUCN 2002 Red List Categories					
			CR	EN	VU	LR	DD	NL*
Cetacea	Mysticeti	Balaenopteridae	-	2	1	1nt	1	-
	Odontoceti	Physeteridae	-	-	1	-	-	-
		Kogiidae	-	-	-	-	-	2
		Ziphiidae	-	-	-	1cd	3	-
		Delphinidae	-	-	-	5cd	6	3
		Phocoenidae	-	-	-	-	1	-
Sirenia	-	Dugongidae	-	-	1	-	-	-
Total			**0**	**2**	**3**	**7**	**11**	**5**

CR: Critically Endangered; EN: Endangered; Vu: Vulnerable; Low Risk: LR; DD: Data Deficient; NL: notlisted; nt: Near threatened; cd: Conservation dependent

Conclusions

It is important to recognize that much more research is necessary before a clear understanding of the marine mammal fauna in the waters around Sri Lanka can be obtained. This also means that there is an urgent need for the allocation of resources for the specific study of marine mammals in Sri Lanka. As marine mammals, except for a few species, are largely transient animals, with some species undertaking long annual migrations, it is important that links for research and conservation are forged and collaborations established with other regional countries and organizations. These linkages will also help fill resource gaps through the use of platforms of opportunity, such as shared use of research vessels from both outside and within the region.

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Appendix 1: Checklist of Marine Mammals Recorded in Sri Lanka's Waters

ORDER CETACEA

SUB-ORDER MYSTICETI

FAMILY: BALAENOPTERIDAE

Blue Whale (*Balaenoptera musculus*)
Fin Whale (*Balaenoptera physalus*)
Bryde's Whale (*Balaenoptera edeni*)
Minke Whale (*Balaenoptera acutorostrata*)
Humpback Whale (*Megaptera novaeangliae*)

SUB-ORDER ODONTOCETI

FAMILY: PHYSETERIDAE

Sperm Whale (*Physeter macrocephalus*)

FAMILY: KOGIIDAE

Pygmy Sperm Whale (*Kogia breviceps*)
Dwarf Sperm Whale (*Kogia sima*)

FAMILY: ZIPHIIDAE

Cuvier's Beaked Whale (*Ziphius cavirostris*)
Ginkgo-toothed Beaked Whale (*Mesoplodon ginkgodens*)
Blainville's Beaked Whale (*Mesoplodon densirostris*)
Southern Bottlenose Whale (*Hyperoodon planifrons*)

FAMILY: DELPHINIDAE

Killer Whale (*Orcinus orca*)
False Killer Whale (*Pseudorca crassidens*)
Pygmy Killer Whale (*Feresa attenuata*)
Melon-headed Whale (*Peponocephala electra*)
Short-finned Pilot Whale (*Globicephala macrohynchus*)
Risso's Dolphin (*Grampus griseus*)
Rough-toothed Dolphin (*Steno bredanensis*)
Indo-Pacific Humpback Dolphin (*Sousa chinensis*)
Common Bottlenose Dolphin (*Tursiops truncatus*)
Common Dolphin (*Delphinus delphis*)
Fraser's Dolphin (*Lagenodelphis hosei*)
Long-snouted Spinner Dolphin (*Stenella longirostris*)
Pantropical Spotted Dolphin (*Stenella attenuata*)
Striped Dolphin (*Stenella coeruleoalba*)

FAMILY: PHOCOENIDAE

Finless Porpoise (*Neophocaena phocaenoides*)

ORDER SIRENIA

FAMILY: DUGONGIDAE

Dugong (*Dugong dugong*)