CONSERVATION OVERVIEW OF HERPETOFAUNA OF SINHARAJA MAN AND BIOSPHERE RESERVE OF SRI LANKA

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Abstract

Sinharaja Man and Biosphere (MAB) Reserve is one of the largest intact rainforest in the southwestern lowlands of Sri Lanka, which is known to be rich in reptile and amphibian diversity. This reserve is a refuge for many taxa of point endemism concerning herpetofauna. Consequently, the Sri Lankan government along with the UNESCO has given a top level of conservation status for Sinharaja forest by nominating it not only as an international MAB reserve but also as a world heritage site. Despite the high priority given to the forest in terms of legislation, the reserve is facing threats due to various human activities, chiefly habitat disturbances. In fact the herpetofaunal diversity in disturbed areas is significantly lower than in the undisturbed areas. This paper investigates the threats encountered by the herpetofauna in the Sinharaja MAB reserve and discusses the management and conservation approaches that would contribute towards the well being of herpetofaunal communities of the reserve.

Keywords

Conservation overview, herpetofauna, Sinharaja, Sri Lanka

Western Ghats of India and southwestern Sri Lanka constitute one of the 34 biodiversity hotspots (Mittermeier *et al.*, 2004). This not only reflects the exceptionally high degree of endemism and diversity, but also the alarming degree of threat facing the biota. It is also significant that Sri Lanka and the Western Ghats harbour the greatest density of human population among the 25 biodiversity hotspots and record a population growth rate higher than the world average (Cincotta *et al.*, 2000). Biodiversity and endemism on the herpetofauna of Sri Lanka is remarkable: 140 species of amphibians (Meegaskumbura *et al.* 2002; Pethiyagoda & Manamendra-Arachchi, 1998b), 87 species of tetrapod reptiles and 97 species of serpentinoid reptiles, have been recorded in the island (Das & De Silva, 2005). Considering endemism within the herpetofaunal taxa, of the 140 species of amphibians, 103 species are endemic to the country (74 percent). Of the 184 species of reptiles recorded on the island, 93 species are endemic (53 percent of the tetrapod reptiles and 54 percent of the serpentinoid reptiles), to the island (Das & De Silva, 2005). The majority of these endemics are concentrated in the southwestern region (low country wet zone and central highlands) of the country (Evans, 1981; Gunathilleke & Gunathilleke, 1991; Senanayake, 1980).

Among tropical rainforests of Sri Lanka, Sinharaja Man and Biosphere reserve is one of the largest intact rainforests (11331ha) in the southwestern lowland wet zone of the island (Surasinghe & Wijesinghe, 2005a,b). Sinharaja forest provides shelter for a large spectrum of endemic herpetofauna, some of which are point endemics, e.g., *Ceratophora karu*, *Ceratophora erdeleni*, *Calotes desilvai*, *Cyrtodactylus cracens* (Batuwita & Bahir, 2005; Bahir & Maduwage, 2005; Bahir & Surasinghe, 2005; Pethiyagoda & Manamendra-Arachchi, 1998a). In Sinharaja MAB reserve, around 27 species of amphibians and around 48 species of reptiles are recorded, among which 19 species of amphibians and more than 24 species of reptiles are endemic (IUCN, 1993; Kotagama, 1985; Kotagama *et al.*, 1986; Wijesinghe & Dayawansa, 2002). Before declaration as an international MAB reserve in 1978, the Sinharaja forest was subjected to a six-year (1972-78) mechanized logging operation. This was followed by the inclusion of the forest in UNESCO's World Heritage list in 1990 (UNESCO, 1990). The growing recognition of the unique biodiversity of the Sinharaja forest prompted the government of Sri Lanka to declare the forest as a National Wilderness Area under the forest department in 1988. Sadly, however, much of the forest has been encroached upon and Sinharaja today is much reduced from its original extent (IUCN, 1993).

Due to various activities of the inhabitants of the villages in close proximity to the forest, such as resource extraction, forest clearance and cultivation, the reserve is facing a significant degree of disturbances that adversely affect the forest species, especially herpetofauna that are known to be highly sensitive to habitat alterations (Surasinghe, 2004).

The conservation issues identified through literature survey and direct observations as well as investigations carried in and around the Sinharaja MAB reserve are described below.

Implications for conservation

Most of the herpetofauna discovered in Sinharaja MAB reserve, particularly the endemics, are forest dwellers (Surasinghe & Wijesinghe, 2005). Therefore, if the forest is continuously disturbed due to human activities, this might reduce the available habitats for such species. Such disturbances are mainly attributed to the adjoining villages of the forests. There are about 30 villages around the boundary of the Sinharaja reserve (IUCN, 1993). The main form of livelihood of these villagers is agriculture, which takes a variety of forms such as the cultivation of economic crops (mainly tea as well as rubber and cardamom), paddy farming, in a few instances animal husbandry and very infrequent instances of *chena* cultivation (Anon., 1989). Most of the cultivation plots and human settlements are located quite close to the forest boundary. It is also observed that villagers who live adjoining the forest boundary encroach the forest proper, mainly for cultivation. The main reason for this is the absence

Manuscript 1484; © ZOO; Date of publication 21 December 2006
Received 24 December 2005; Revised received 08 June 2006;
Finally accepted 27 October 2006

of a properly demarcated forest boundary (IUCN, 1993). Such situations will yield adverse consequences of edge effects, leading to further degradation of the forest patch and troubling the endemic herpetofauna occupying the core-forest (Sumner *et al*., 1999). Sometimes, such settlements and cultivated plots are located inside the boundary. Since the herpetofaunal diversity is quite low in anthropogenic habitats (Erdelen, 1988), destroying the forest vegetation for cultivation within the forest can be extremely harmful to the core-forest herpetofauna (Fox *et al*., 1998). In addition to agriculture the villagers are engaged in the extraction of non-woody resources, which are also known to deter the endemic herpetofauna (Ramirez-Marcial *et al*., 2001). For example, kitul tapping and the collection of medicinal plants, rattan, wild mushrooms, wild cardamom, resins and honey are frequently carried out by the villagers (Anon., 1989).

A conservation issue that arises in the eastern section of the reserve, which is a sub-montane rainforest is gem mining. Mining has a profound effect on the diversity of endemic amphibians. The species richness of endemic amphibians is significantly low in the gem pitted sub-montane areas of Sinharaja compared with areas not subjected to gem mining Wijesinghe & Dayawansa (2002).

An important implication about the Sinharaja forest is mechanized logging that was carried out in the past. As stated previously, an area of 2025ha was logged for two years, nearly two decades ago. Although the selectively logged forest regions have successfully regained secondary growth, such secondary forests seem to house a lower species richness and abundance of reptiles and amphibians. Furthermore, the skid trails, through which the lumber was transported is virtually devoid of agamid lizards (Surasinghe & Wijesinghe, 2005a,b).

It is seen that highly disturbed opened areas outside forest boundary (basically the land areas subjected to complete logging and abandoned plantations/estates) are rapidly colonized by the invasive fern *Drycanopteris linearis*. This fern is also seen to colonize open areas inside the forest. For instance, skid trail margins, areas degraded with land slides and large tree fall gaps close to skid trails are occupied by this fern. In such areas growth of forest tree species are inhibited. Hence, the natural regeneration process does not occur in such areas. A similar situation is observed in the eastern sub-montane section of the reserve, where the abandoned tea and cardamom cultivated lands which were earlier sub-montane rainforests, have now grown into sub-montane grasslands (Pethiyagoda & Manamendra-Arachchi, 1998a). If so, the endemic forest species that are considered as habitat specialists requiring special ecological conditions found within forest habitats will not be able to survive since the disturbance will completely alter their environment (Graham, 2002). It was observed that only a very few endemic reptiles and amphibians, for instance, *Otocryptis wiegmanni* and *Philautus folicola* survive in the open habitats. Even these species were found in significantly low abundance (Surasinghe & Wijesinghe, 2005a).

In addition, it was seen that the non-endemic amphibian and reptile species inhabit open areas outside and within the forest. If the core-forest is encroached upon, then such village species will, undoubtedly, invade the cleared areas of the forest and will compete with the endemics confined to the forest. It is reported that endemics are inferior competitors and might face displacement in the presence of such invasive non-endemic species (Wijesinghe & Dayawansa, 2002). Forest clearance might also expose endemic agamids to predators such as non-endemic village serpents, birds and domestic animals such as fowls, cats and dogs who may have access to the forest through the newly cleared areas.

A limitation in the case of Sinharaja is the lack of a suitable link between the main forest (MAB reserve) and the adjacent small forest patches. Around Sinharaja, in most areas, the intervening land between the forest and surrounding forest patches consists of human settlements, road constructions and plantation areas such as paddy fields, tea estates, cardamom cultivations, *chena* cultivations as well as significantly large areas of abandoned plantations (IUCN, 1993). Such areas impede the movement of herpetofauna from one forest patch to another (Wickramasinghe & Somaweera, 2004). Natural habitat links that facilitate dispersal of individuals are essential for the survival of reptiles and amphibians as it facilitates inter-breeding of meta-populations. Under the current situation, the reptile and amphibian populations in different forest fragments are virtually isolated. Most of the forest patches are quite small in area, thus may not even support a minimum viable pupation. Thus, the presence of natural corridors is necessary for long term viability of such herpetofauna populations (Anon., 2004).

Previous studies have shown that the endemic herpetofauna usually have small population sizes. This factor combined with the inability to interbreed due to lack of habitat links between suitable forest patches may hinder the possibility of enhancing their genetic diversity (Cunningham & Martiz, 1998).

According to current rules and regulations, the ancient families surrounding the Sinharaja MAB reserve are allowed to live in the buffer zone. They are allowed to extract resources, like firewood, poles and other non-woody resources which if not controlled, may have drastic consequences through over exploitation of forest resources (De Zoysa & Raheem, 1990).

The application of pesticides and inorganic fertilizers in paddy fields, tea plantations and vegetable plots specially in the periphery of the forest and around the buffer zone may adversely affect insect populations within the forest causing the reduction in the prey population for reptiles and amphibians. Besides, the use of agro-chemicals can cause direct toxicity and therefore have lethal effects on herpetofauna (Somaweera, 2001). Deformities in herpetofauna have been noted as a result of pesticide use around natural habitats. Ground dwelling and fossorial herpetofauna occupying the forest periphery can get destroyed by the operation of machinery and by manual field preparation activities (Bambaradeniya, 2001; Bishop & Gendron, 1998).

Recommendations

Strict protection of the remaining forest habitats is essential for the existence of herpetofaunal species. Further encroachments must be prevented. Although the forest boundary is documented, the physical demarcation of the

boundary by means of concrete posts or fences should be carried out immediately. Additionally, systematic patrolling of areas within and around the forest should be carried out. The authorities responsible for safeguarding the forest must ensure that rules and regulations are adhered to and encroachers and harvesters should be subjected to heavy fines or alternatively face criminal charges.

It is recommended that degraded lands closer to the periphery of the forest, both state owned and private owned, which were earlier under tea plantations, paddy and *chena* cultivations and other forms of agriculture, be reclaimed and restored. Thereafter, these lands can be incorporated into the forest proper, preferably as a part of the buffer zone. In the process of restoration, it must be recognized that these land areas are highly degraded and may hence require soil conservation measures. Replanting these areas with fast growing forest tree species should also be considered. The areas that are invaded by the fern *Drycranopteris linearis* and other invasive plants should be completely cleared of these weeds and replanted with a combination of fast growing forest tree species. All these restoration processes require close and constant monitoring in order to prevent invasions and reoccurrence of invasions. The areas colonized by invasive plants, although cleared might be reinvaded and hence continuous removal must be carried out.

Pinus if grown on slopes and abandoned agricultural lands can be subjected to further degradation and erosion. Therefore, soil conservation measures have to be frequently and continuously applied. The proper development of the soil profile in the degraded lands is a must for the regeneration of forest vegetation. The establishment of natural vegetation in degraded lands in close resemblance to the virgin rainforests is imperative for the colonization of the herpetofaunal communities.

Special attention must be paid to the *Pinus* plantations. At the moment the *Pinus* plantations are less heterogeneous in terms of floral diversity and hence, poor in habitat quality. Apart from *Pinus* trees which account for a majority of the large trees, only a few forest tree species have grown there. Indigenous forest species should be introduced to the well-established *Pinus* plantations. Subsequently, after the forest species are established, the *Pinus* trees can be gradually removed.

Preventing further degradation and destruction of buffer zone habitats is also recommended. According to current rules and regulations, the local people with a longstanding hold on forestlands are permitted to live within the buffer zone. Further, these local inhabitants are permitted to maintain cultivations and to extract resources from the buffer zone (IUCN, 1993). Permitting such practices will certainly create disturbances in the forest ecosystem. Therefore, these regulations must be subjected to amendments and close monitoring of such activities must be carried out by the relevant authorities.

Establishment and maintenance of natural corridors to facilitate connectivity between forest patches seems particularly essential in the case of the wet zone forests of Sri Lanka which have undergone severe fragmentation. Most rainforest patches are reduced to areas of less than 100ha (IUCN, 1995). By linking the Sinharaja MAB reserve with other adjoining forests like Dellewa, Delwala, Diyadawa and Morapitiya, the entire forest complex will be extensive and will provide adequate space and resources for herpetofauna. It will also promote inter-breeding among meta populations (Mac Donald *et al*., in press).

Promoting research activities that focus on aspects of population dynamics, distribution and ecology of herpetofaunal groups is vital for conservation of these populations. Studies assessing the distribution and abundances of herpetofauna must be carried out at regular intervals to determine the well being of those species. The populations of threatened herpetofauna should be continuously monitored, particularly in the face of habitat loss and fragmentation. These research activities should be carried out through collaborative participation of schools, universities, NGOs, and other state sector organizations like the Forest Department and the Department of Wildlife Conservation.

Awareness programmes should be carried out to educate the general public and to instill in them the value of safeguarding biodiversity. Such educational programmes should primarily target the villagers living around the Sinharaja reserve. The local people, i.e., the stakeholders of the forest should be encouraged to adopt eco-friendly agricultural practices. Local farmers and the estate owners should be encouraged to use organic fertilizers and biological pesticides, and strict instructions should be given regarding the recommended dosages of agro-chemicals. Moreover, local people should be encouraged to grow medicinal plants, kitul trees, rattan in their home gardens so that they need not to come to the forest to extract them. Besides, eco-tourism can be introduced to these local communities as an alternative livelihood which would generate a high income that would complement the traditional practices.

In all conservation activities wherever possible, it is advised that a participationary approach be adopted, where the conservation approaches would consider the socio-economical status of the local inhabitants and attempt to practically involve the local people in management and sustainable utilization of forest and wildlife resources (IUCN, 1991).

In the face of rapidly dwindling natural forests and the resulting threats to biota, it might be important to protect wild species under *ex situ* conservation. Among herpetofauna, the lizards (Suborder: Sauria) and amphibians are not subjected to *ex situ* conservation in Sri Lanka. It is therefore suggested that these species, specially the endemics, are an important component of biodiversity that should be conserved in zoological gardens or other such institutions. According to de Silva & Walker (1998), agamid lizards like *Lyriocephalus scutatus* and *Ceratophora* spp. can be easily bred in captivity. Furthermore, these captive bred lizard species can be reintroduced to the wild following the guidelines of the Reintroduction Specialist Group of IUCN/SSC. These collections would also serve as a means of educating the general public and at the same time provide wild stocks for re-introduction purposes.

References

Anonymous (1989). *Socio-economic reports for nine villages around Sinharaja Forest*. **Forest Department,** Ministry of Environment and Natural Resources, Colombo.

Anonymous (2004). *Best Management Practices for Amphibians and Reptiles in Urban and Rural Environments in British Columbia*. Ministry of Water, Land and Air Protection Ecosystem Standards and Planning Biodiversity Branch, British Columbia. **Biolinx Environmental Research Ltd & E. Wind Consulting.**

Bahir, M.M. & K.P. Maduwage (2005). *Calotes desilvai*, a new agamid lizard from Morningside Forest, Sri Lanka. *The Raffles Bulletin of Zoology* 12: 381-392.

Bahir, M.M. & T.D. Surasinghe (2005). A conservation assessment of the Sri Lankan Agamidae (Reptilia: Sauria). *The Raffles Bulletin of Zoology* 12: 407-412.

Bahir, M.M., M. Meegaskumbura, K. Manamendra-Arachchi, C.J. Schneider & R. Pethiyagoda (2005). Reproduction and terrestrial direct development in Sri Lankan Shrub frogs (Ranidae: Racophorinae: *Philautus*). *Raffles Bulletin of Zoology* 12: 339-350.

Bambaradeniya, C.N.B. (2001). Rice fields: An important man made habitat for amphibians. *Lyriocephalus* 4: 57-64.

Batuwita, S. & M.M. Bahir (2005). Description of five new species of *Crytodactylus* (Reptilia: Gekkonidae) From Sri Lanka. *The Raffles Bulletin of Zoology* 12: 351-380.

Bishop, C.A. & A.D. Gendron (1998). Reptiles and amphibians shy and sensitive vertebrates of the great lake basin and St. Lowrance river. *Environmental monitoring and assessment* 53: 225-244.

Cincotta, R.P., J. Wisnewski & R. Engleman (2000). Human populations in the biodiversity hotspots. *Nature* 404: 990-992.

Cunningham, M. & C. Martiz (1998). Genetic effects of forest fragmentation on a rainforest restricted lizard (Scincidae: *Cypetoscinus queensalandiae*). *Biological Conservation* 83: 19-30.

Das, I. & A. De Silva (2005). *A Photographic Guide to Snakes and Other Reptiles of Sri Lanka*. New Holland Publishers, UK.

De Silva, A. & B. Walker (1998). Saving Sri Lanka's living heritage. *Biologist* 45(2): 71-75.

De Zoysa, N. & R. Raheam (1990). *Sinharaja: A Rainforest in Sri Lanka*. March for conservation, Colombo.

Erdelen, W. (1988). Population dynamics and dispersal in three species of agamid lizards in Sri Lanka: *Calotes Calotes C. Versicolor and C. Nigrilabris*. *Journal of herpetology* 22(1): 42-52.

Evans, D. (1981). Threatened Freshwater Fish of Sri Lanka. *Extract from Red Data Book (Pisces)*. IUCN Conservation monitory Center, Cambridge.

Fox, B.J., J.E. Taylor, M.D. Fox & C. Williams (1998). Vegetation changes across edges of rainforest remnants. *Forest Ecology and Management* 173(1-3): 11-24.

Graham, K.L. (2002). Human influences on forest wildlife habitats, pp.63-90. In: *Southern Forest Resource Assessment*. David N. and J.G. Greis (eds.). Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station.

Gunathilleke, C.V.S. & I.A.U.N. Gunathilleke (1991). Threatened woody endemics of the wet lowlands of Sri Lanka and their conservation. *Biological conservation* 55: 386-396.

Gunathilleke, I.A.U.N. & C.V.S. Gunathilleke (1990). Floristic richness in Sri Lanka. *Conservation Biology* 4(1): 21-31.

IUCN (1991). *Caring for The Earth - A Strategy for Sustainable Living*. IUCN, Gland, Switzerland.

IUCN (1993). *Sinharaja Management Plan*. IUCN, Sri Lanka.

IUCN (1995). *Preliminary Analysis of Biodiversity within Sri Lanka's Wet Zonal Forests*. IUCN, Sri Lanka, Colombo.

Kotagama, S.W. (1985). Fauna of wet zone. *Sri Lanka Forester* 17: 37-41.

Kotagama, S.W., P.B. Karunarathna, A. Nandaraja, N.D. De Zoysa & V. Kulasekera (1986). Faunal studies in the Sinharaja rainforest. iii. Composition and diversity of small natural fauna, pp.134-135. Proceedings of the 42nd Annual Sessions of the Sri Lanka Association for the Advancement of Science.

MacDonald, S.E., B. Eaton, C.S. Machtans, C. Paszkowski, S. Hannon & S. Boutin (in press). Is forest close to lakes ecologically unique? Analysis of vegetation, small mammals, amphibians, and songbirds. *Forest Ecology and Management*.

Meegaskumbura, M., F. Bossuyt, R. Pethiyagoda, K. Manamendra-Arachchi, M. Bahir, M.C. Milinkovitch & C.J. Schneider (2002). Sri Lanka: An amphibian hot spot. *Science* 298: 397.

Mittermeier, R.A., P.R. Gil, M. Hoffmann, J. Pilgrim, J.P.T. Brooks, C.G. Mittermeier, J. Lamoreux & G.A.B. da Fonseca (2004). *Hotspots Revisited: Earth's Biologically Richest and most Endangered Terrestrial Ecoregions*. CEMEX, 392pp.

Pethiyagoda, R. & K. Manamendra-Arachchi (1998a). A revision of endemic Sri Lankan agamid lizard gums *Ceratophara* gray 1835, with description of two new species. *Journal of South Asian Naturalist* 3(1): 1-50.

Pethiyagoda, R. & K. Manamendra-Arachchi (1998b). Evaluating Sri Lanka's amphibian diversity. *Occasional papers of the wildlife heritage trust* 2.

Ramirez-Marcial, N., M. Gonzalez-Espinosa & G. Williams-Linera, (2001). Anthropogenic disturbances and tree diversity in Montane Rainforests in Chaipas, Maxico. *Forest Ecology and Managment* 154: 311-326.

Senanayake, F.R. (1980). Biogeography and ecology of the inland fishes of Sri Lanka. PhD dissertation. University of California, Davis, California.

Somaweera, R. (2001). Biodiversity survey on the herpetofauna of the Manikdena archeological site, Dambulla, Sri Lanka. *Abstracts of the young environment symposium. University of Sri Jayawardenapura and Young Biologists' Association of Sri Lanka*.

Sumner, J., C. Martz & R. Shine (1999). Shrinking forests shrinks skinks: morphological changes in response to rainforest fragmentation in the prickly forest skink. *Biological conservation* 91: 159-161.

Surasinghe, T.D. (2004). Distribution and habitat selection of agamid lizards in the Sinharaja man and biosphere reserve. BSc thesis, University of Colombo, Sri Lanka.

Surasinghe, T.D. & M.R. Wijesinghe (2005a). Habitat associations of the four endemic agamid lizards in the Sinharaja Man and Biosphere Reserve. *Proceedings of the 25th annual sessions of Institute of Biology, Sri Lanka*.

Surasinghe, T.D. & M.R. Wijesinghe (2005b). Influences of habitat disturbances on agamid lizards. Evidence from studying along a disturbance gradient in Sinharaja. *Lyriocephalus Special issue June 2005*, 06: in press.

UNESCO (1990). The world heritage - a legacy for all. UNESCO, Paris.

Wickramasinghe, M. & R. Somaweera (2004). Distribution and current status of the endemic geckos of Sri Lanka. *Gekko*, 03: 1-13.

Wijesinghe, M.R. & P.N. Dayawansa (2002). The amphibian fauna at two altitudes in the Sinharaja rainforest, Sri Lanka. *Herpetological Journal* 12: 175-178.