

## **Analog forest's contribution to biodiversity conservation; a biodiversity assessment of an analog forest on a private property in south-western wet zone of Sri Lanka**

<sup>1</sup>Wasantha K.D.D. Liyanage, <sup>2</sup>Saman N. Gamage, <sup>1</sup>Lai Xulong, <sup>1</sup>Julia Ellis Burnet

<sup>1</sup>School of Environmental Studies, China University of Geosciences, 388, Lumo Road, Wuhan, Hubei, 430074, P.R. China.

<sup>2</sup>Department of Zoology, Faculty of Science, University of Colombo, Colombo 03, Sri Lanka

### **Abstract**

Most natural ecosystems in the wet zone are severely fragmented and interspersed between human managed agro ecosystems and home gardens. There is growing evidence that traditional agro-ecosystems contribute to sustain the regional biodiversity of many invertebrate and vertebrate species. Analog forests, as a concept, is accepted by agronomists and conservationists, bringing profits on a long-term, sustainable basis. Bangamukanda Estate is an example of an 18 hectares plantation (tea, rubber and cinnamon) that has been converted into an analog forest. The objective of the study was in assessing the current biodiversity in this 30-year-old analog forest with special reference to vertebrate species and major plants. A total of 197 plants species were recorded of which 63 were endemic to Sri Lanka. A sum of 207 vertebrates species belonging to 79 families were observed during the study period. From those, 48 species were endemic to Sri Lanka. The findings of the survey clearly highlight the contribution of analog forest systems towards sustaining a rich biodiversity. In addition, analog forest systems can be used to link the forest patches in the wet zone. [Journal of American Science 2009:5(2) 69-82] ( ISSN: 1545-1003)

**Key words:** Analog forest, biodiversity, critically endangered, fragmentation

### **1. Introduction**

Among all the biological resources of Sri Lanka, forests are ecologically remarkable, environmentally indispensable, socio-economically invaluable and culturally inseparable from the Sri Lankan traditional way of life (Pemadasa, 1996). From a biological point of view, wet zone forests are more important than others. The lowland wet zone of the island has been identified with highest incidence of biodiversity of Sri Lanka (Pethiyagoda, 1994), and a high percentage of endemism. However, a majority of these species are listed as threatened

(IUCN, 2004). Even though Sri Lanka's biodiversity is thought to be very high, at present only a small fraction of Sri Lanka's biodiversity is known to science (Nekaris *et al.*, 2005). Also, little information is available regarding the affects of habitat disturbance on the fauna of Sri Lanka. Sri Lanka also has one of the densest human populations in Asia; which has resulted in much of its original forests being cleared for settlements, cultivation, and production of timber. Hence, the lowland forests of the wet zone, which harbours 90% of the 830 endemic flowering plants, have suffered the greatest loss (Gunatilleke and Gunatilleke, 1990). A

burgeoning population, demand for subsistence land and a high proportion of endangered and endemic species within the wet zone of Sri Lanka have resulted in its being declared a critically endangered eco-region; designated as one of the world's 11 biodiversity 'hyperhot' hotspots in demand of extensive conservation investment (Brookes *et al.*, 2002; Nekaris *et al.*, 2005).

These wet zone ecosystems harbour a high percentage of endemic and globally threatened species of animals as well. According to the previous studies conducted by Senanayake and Moyle (1981); Erdelen (1989); Kortmulder *et al.* (1990) and Pethiyagoda (1994), 29 endemic fish species are present in this region of which 20 are restricted to this area. Pethiyagoda and Manamendra-Arachchi (1998) and Manamendra-Arachchi and Pethiyagoda (2005) noted that most of Sri Lanka's amphibian fauna is faced with the risk of extinction due to the loss and fragmentation of their habitat as well as habitat quality degradation due to pollution. Many species known from 19th century museum collections are not recorded during present surveys and are probably extinct (Meegaskumbura *et al.*, 2002). Two primate taxa, *Semnopithecus vetulus nester*, and *Loris tardigradus nycticeboides* are endemic to the south-western wet zone forests of Sri Lanka and categorized as a critically endangered species and it's also listed as one of the top 25 endangered primates in the world due to habitat loss (Mittermeir *et al.* 2006). The loss and fragmentation of forest habitats by human land use are recognized as important factors influencing the decline of forest-dependent fauna. Many forest dependant mammal species, other than bats, are particularly sensitive to

habitat loss and fragmentation due to their highly specific habitat requirements, and in many cases they have limited ability to move through and utilize the land use matrix (McAlpine *et al.*, 2006).

In recent decades, sustainable farmers and researchers around the world have responded to the extractive industrial model with ecology based approaches variously called eco-agriculture, agro-forestry or analog forest (Earles, 2005). Non-farmed portions of the mainly agricultural landscapes can provide patches of habitat for forest wildlife and form corridors that connect protected areas and allow species to continue genetic contact with populations as would have occurred if not isolated (Scherr and Shames 2006). There is growing evidence that traditional agro-ecosystems contribute to sustain the regional biodiversity of many invertebrate and vertebrate species (Lawler, 2001).

Vast extents of Sri Lanka's biodiversity rich lands that were transformed into mono-crop plantations during the colonial era are regenerating in many places due to various reasons, both natural and anthropogenic. Bangamukanda Estate is an example of an 18 hectares plantation land (tea, rubber and cinnamon) that has been deliberately reclaimed as an analog forest as a direct result of the far sighted, land use policy of Sri Lanka during 1970 -1977, which introduced crop diversification in uneconomic tea plantations. Bangamukande Estate is situated in Pitigala, Galle, Sri Lanka. The land is formed into an undulating terrain that consists of a series of ridges and valleys with an altitudinal range from 100m to 300m. It has an intricate network of small streams, which drain into the Benthara River. In 1904 ancestors of the

present owner planted agricultural mono-crops such as cinnamon, rubber, and tea. This practice was continuing up to 1973. It was changed in 1973 and 12 hectares of cinnamon and tea land was transferred to analogue forest using a government subsidy, under crop diversification of uneconomic tea lands. The remaining rubber field of 6 hectares is presently been allowed to regenerate into forestland while been cropped (Wimalasuriya, 2006).

Analog forest is a tree-dominated ecosystem that is analogous in structure and function to the original climax and sub-climax community. With time, the natural succession of any undisturbed forest community is to increase in diversity and stability until a highly complex ecosystem or Climax State is reached. When an ecosystem is designed to mimic the indigenous Climax State, the efficiency and dynamics of the natural processes can be replicated; such forests are referred to as analog forests. As well to their ecological distinctiveness, analog forests are considered to provide economic benefits. A wide range of supplies can be produced that may include: fruit, nuts, herbs, cut flowers and cut-foilage, pharmaceuticals and timber. Furthermore, this type of concept can be used to link the fragmented forest patches in the wet zone of Sri Lanka.

Therefore, the main objective of this study was to assess the biodiversity of this analog forest with special reference to the vertebrate fauna and major plant species.

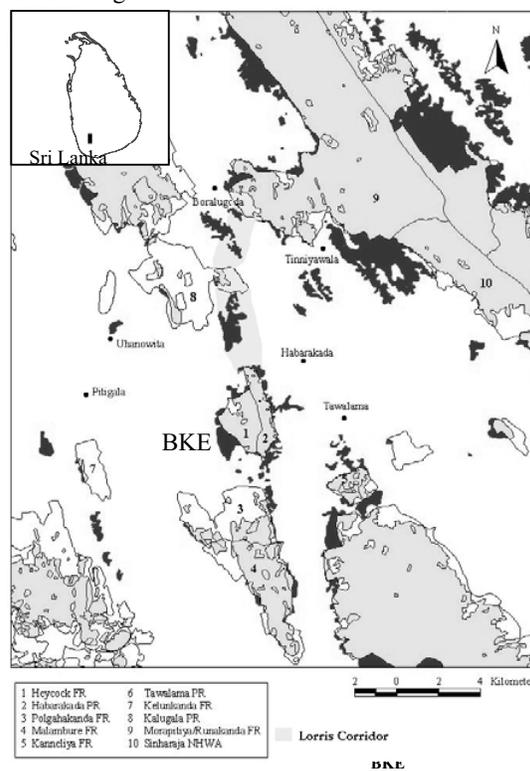
## 2. Materials and methods

Bangamukande Estate (BKE) is situated in Niyagama Divisional Secretate Area in Galle District of Southern Province of Sri Lanka, at 06° 20' 46" N - 080° 16' 26" E, The

average annual rainfall, average temperature and relative humidity are 2300mm, 28°C and 90% respectively. Approximate distances from BKE to the larger forest complexes are as follows:

- To South 4 km Polgahakande-Malabure forest reserve
- To East 1 km Hiniduma forest reserve
- To Southwest 8 km Beraliya forest reserve
- To Southeast 100 m Bangamukanda proposed forest
- To Southeast 8 km Kannaliya-Dediyagala-Nakiyadeniya forest reserve
- To Northeast 12.5 km Sinharaja forest reserve World Heritage site
- To North 11 km Kalugalkande Forest Hermitage and reserve

Figure 1 shows the location of BKE and surrounding forests.



**Figure 1: Location of Bangamukanda Estate (BKE) and surrounding Forests**

Surveys were carried out dividing BKE into 4 plots, in relationship to different levels of regeneration. Vegetation sampling used the Quadrant method; in addition each quadrant of 400 m<sup>2</sup> was subdivided into 25 grids of 4m x 4m quadrants. Within each quadrat, all plants equal to and above 1 m in height and 2 cm in girth size were listed. Individuals with (CBH)>10cm were measured and recorded as trees. Vines occurring on trees were described qualitatively.

Different methodologies were used to assess the vertebrate fauna in BKE, including systematic line transect surveys of primates, recording of the presence of animal species whenever they were seen, and a trapping regime for rodents (Shermann traps), arboreal rodents (Chardonnet traps) and slender lorises (live mammal traps). Invertebrates were excluded from the survey and fish were only sampled at two sites. Amphibians, many of which occur in the treetops and reptiles were only sampled opportunistically. The following methods were applied for sampling different taxa:

### **2.1 Herpetofauna**

Quadrat sampling was the main method used for herpetofauna. It involves placing small quadrates at randomly selected sites within a habitat and thoroughly searching these squares for presence of herpetofauna (Heinen, 1992). A total of 18 quadrates (8 x 8 m) were placed at randomly selected points of each study site. When placing quadrates, areas with a deep slope or areas adjacent to tree-fall gaps were omitted. A polythene fence (45cm height) was placed along the sides of the quadrat to prevent animals from escaping. At least two people were engaged in all sampling sessions. Sampling involved sorting through

all leaf litter in the plot, tree trunks, branches, under stones and logs (Heinen, 1992). In addition, fixed line transects were also used to assess the herpetofauna.

### **2.2 Avifauna and Mammals**

A fixed line transect method was used to assess avifaunal and mammal richness of the study site (Sutherland, 1996). Day and night surveys were conducted between August 2003 and April 2006. Field observation was carried out at 6.30 am to 9.00 am and 4.00 pm to 6.00 pm. Furthermore, night observations were carried out between 7.00 pm to 10 pm and 2.00 am to 6.00 am. Headlamps were used to spot animals at night and red lights were used to prevent the animals from being frightened. Nocturnal animals were identified according to colour, size and shape of eye shine and eye movement. Transects were surveyed by one or two people at a speed of 0.5 to 1 km/hr, depending on time of the day at which survey was conducted (day or night) and depending on the terrain and weather conditions.

### **2.3 Identification**

Vertebrates species were identified using the most recent taxonomic keys or guides available such as; Freshwater fish: Pethiyagoda (1991), Pethiyagoda (1998); Amphibians: Dutta and Manamendra-Aarachchi (1996), Manamendra-Aarachchi and Pethiyagoda (1998), Manamendra-Aarachchi and Pethiyagoda (2005), Meegas-kumbura and Manamendra-Aarachchi (2005); Reptiles: De Silva (1990), Pethiyagoda and Manamendra-Aarachchi, (1998); Birds: Henry (1978), Kotagama and Fernando (1993); Mammals: Phillips (1980), Corbet and Hill (1992), Groves (2001). Furthermore, Bambaradeniya eds. (2006) was used for

confirmation of nomenclature.

### 3. Results

A total of 197 plants species were recorded (Appendix 1) of which 63 (39%) were endemic while 75 species are used for medicinal purposes. From animal species recorded (Appendix 2-6), 207 vertebrates species belonging to 79 families were observed from which 48 species are endemic

to Sri Lanka (table 1). The species list is composed of amphibians (17 species), snakes (25 species), tetra pods reptiles (17 species), fish (23 species), birds (90 species) and mammals (34 species). Fresh water fish had the highest number of endemism (48%). The overall endemism was also high (23%).

**Table 1:** Recorded number of vertebrate species, families and endemism % in the each group during the study period.

Taxa	No. of Species	No. of families	No. of spp. Endemic & %
<b>Plants</b>	<b>197</b>	<b>63</b>	<b>63 (39%)</b>
Fish	23	8	11 (48%)
Amphibians	17	4	7 (24%)
Snakes	25	5	6 (24%)
Tetrapod Reptiles	17	5	7 (41%)
Birds	90	39	12 (13%)
Mammals	34	18	5 (15%)
<b>Total Vertebrates</b>	<b>207</b>	<b>79</b>	<b>48 (23%)</b>

Table 2 shows the conservation status of several threatened species found in the study site of which two were vulnerable, five were endangered, one was critically endangered and one was data deficient. This critically endangered frog (*Philatus nemus*) is a newly described species and previously it was only found in Hiniduma forest reserve of Sri Lanka.

**Table 2:** Conservation statuses of some threaten species, which were found in Bangamukanda Estate.

Species	Conservation status
<i>Polypedates longinasus</i>	Endangered
<i>Polypedates eques</i>	Endangered
<i>Philatus nemus</i>	Critically- Endangered
<i>Nanophrys ceylonensis</i>	Vulnerable
<i>Lepidocephalichthys jonklaasi</i>	Endangered
<i>Sicyopus jonkalaasi</i>	Data deficient
<i>Loris tardigradus tardigradus</i>	Endangered
<i>Semnopithecus vetullus vetullus</i>	Endangered
<i>Macaca sinica aurifrons</i>	Vulnerable

### 4. Discussion

The results indicate that the BKE analog forest is an agro-ecosystem that sustains a high species richness of plants and vertebrate fauna. A variety of methods targeting different groups enabled the documentation of BKE biodiversity as expressed in terms of species richness. The total vertebrate richness shows the BKE maintains high species diversity. In addition to the species richness, the study site is providing niches for a large number of endemic vertebrates. The results clearly show that agro-forestry systems are closer to natural conditions in maintaining high biodiversity. Furthermore, the study site is providing niches for 9 globally threatened species of which one is critically endangered. This clearly shows the importance of this ecosystem. Most birds and mammals species used the estate as a

temporary refugia or feeding area, while they move from one forest patch to another. Thus, these results demonstrate the advantages of using such type of systems for connecting forest patches in the country.

##### 5. Conclusion

According to the results can conclude the analog forest systems are sustaining high level of vertebrate diversity and endemism. As a concept, the analog forestry systems are biodynamic and environmentally friendly (Earles, 2005). The results were agreed to this concept. The findings of the survey clearly highlight the contribution of the analog forest systems towards sustaining a rich biodiversity. Further, such agro-ecosystems can be used to link the forest patches in the area.

##### Acknowledgements

We wish to acknowledge Mr. Sunil Wimalasuriya and members of LORRIS (Land Owners Restore Rainforests In Sri Lanka) and BEOG (Bangamukande Environmental Observation Group) for invaluable assistance provided in the field. We thank the Chinese Scholarship Council for granting a scholarship and other facilities. Also a word of gratitude goes to the International corporation office of the China University of Geosciences for all the care and advice.

##### References

- Bambaradeniya, C.N.B. (Edited). (2006). Fauna of Sri Lanka: status of Taxonomy, Research & Conservation. The World Conservation Union, Colombo, Sri Lanka & Government of Sri Lanka. Viii + 308pp.
- Brookes, T.M., Mittermeier, R.A., Mittermeier, C.G., Da Fonseca, G.A.B., Rylands, A.B., Konstant, W.R., Flick, P., Pilgrim, J., Oldfield, S., Magin, G. & Hilton-Taylor, C. (2002) Habitat loss and extinction in the hotspots of biodiversity. *Conservation Biology*. 16(4): 909-923.
- Corbert, G.B. & Hill, J.E. (1992). Mammals of the Indomalayan Region: A systematic Review. *Oxford University, Oxford, UK*.
- De Silva A. (1990). Colour Guide to the Snakes of Sri Lanka. *R & A Publishing Ltd., Avon, England*, 130pp.
- Dutta, S.K., & Manamendra-Arachchi, K. (1996). The Amphibian fauna of Sri Lanka. *Wildlife Heritage trust of Sri Lanka, Colombo*, 280pp.
- Dutta, S.K., & Manamendra-Arachchi, K. (1996) The Amphibian fauna of Sri Lanka. *Wildlife Heritage Trust of Sri Lanka, Colombo*. 280 P.
- Earles, R. (2005). *Sustainable Agriculture: An Introduction* Publication of ATTRA, the National Sustainable Agriculture Information Service. USA.
- Erdelen, W. (1989) Aspects of the biogeography of Sri Lanka. *Forschungee Aug. Ceylon*. 3: 73-100.
- Groves, P.C. (2001). *Primate Taxonomy*. Smithsonian Institution Press, Washington D.C.
- Gunatilleke, I.A.U.N. and Gunatilleke, C.V.S. (1990). Distribution of floristic richness and its conservation in Sri Lanka. *Conservation Biology*, 4(1): 21-30.
- Henry, G.M. (1971). A guide to the Birds of Ceylon (Sri Lanka) with 30 half-tone plates of which 27 are coloured and 136 black and white drawings. (2nd edition). *K.V.G. de Silva & Sons, Kandy, Ceylon (Sri Lanka)*. 457pp.
- Heinen, J.H. (1992). Comparisons of the leaf litter herpetofauna in abandoned cacao plantations and primary rain forest in Costa Rica: some implications for faunal restoration. *Biotropica* 24(3): 431-439.
- IUCN (2004) IUCN red list of threatened

- species, 2004. <http://www.iucn.org>
- Kortmulder, K., Padmanadhan K.G. & de Silva, S.S. (1990). Pattern of distribution and endemism in some cyprinid fishes, as determined by the geomorphology of South-west Sri Lanka and soth Kerala (India). *Ichthyol. Explor. Freshwater*. 1(2): 97-112.
- Kotagama, S.W. & Fernando, P. (1992). A field guide to the birds of Sri Lanka. *Wildlife Heritage Trust of Sri Lanka, Colombo 8, Srilanka*. 226pp.
- Lawler, S. P. (2001). Rice fields as temporary wetlands: A review. *Israel J. of Zoology*, 47 (3), 513-528.
- Manamendra-Arachchi, K., & Pethiyagoda, R. (1998). A synopsis of Sri Lankan Bufonidae (Amphibia: Anura) with discription of new species. *J. South Asian Nat. Hist.*, 3(1), 213-247.
- Manamendra-Arachchi, K., & Pethiyagoda, R. (2005). The Sri Lankan shrub-frogs of Genus *Philautus* Gistel., 1848 (Ranidae: Rhacophorinae), with discription of 27 new species. *The Raffles Bulletin of Zoology*, Supplement No. 12: 163-303.
- McAlpine, C.A., Rhodessa, J.R., Callaghanc, J.G., Bowena, M.E., Lunneyd, D., Mitchellc, D.L., Pullara, D.V. & Possingham, H.P. (2006) The importance of forest area and configuration relative to local habitat factors for conserving forest mammals: A case study of koalas in Queensland, Australia. *Biological Conservation* 132: 153-165.
- Meegaskumbura, M., Bossuyt, F., Pethiyagoda, R., Manamendra-Arachchi, K., Bahir, M., Milinkovitch, M.C., & Schneider, C.J. (2002) Sri Lanka: An Amphibian Hot Spot. *The Ecology*.
- Meegaskumbura, M., & Manamendra-Arachchi, K. (2005). Description of eight new species of shrub frogs (Ranidae: Rhacophorinae: *Philautus*) From Sri Lanka. *The Raffles Bulletin of Zoology*, Supplement No. 12: 305-338.
- Mittermeier, R.A., Valladares-Pádua, C., Rylands, A.B., Eudey, A.A., Butynski, T.M., Ganzhorn, J.U., Kormos, R., Aguiar, J.M., and Walker, S. (2006). Primates in Peril: The World's 25 Most Endangered Primates, 2004–2006. *Primate Conservation*. 20: 1–28
- Nekaris, K.A.I., Liyanage, W.K.D.D. & Gamage, S.N. (2005) Influence of forest structure and floristic composition on population density of the red Slender Loris (*Loris tardigradus tardigradus*) in Masmullah proposed forest reserve, Sri Lanka. *Mammalia*. 69(2): 201-210.
- Pemadasa, M.A. (1996) The green mantle of Sri Lanka. *National Library Services Board, Sri Lanka*. 242 P.
- Pethiyagoda, R. (1991) Fresh water fishes of Sri Lanka. *Wildlife Heritage Trust of Sri Lanka*. 362p
- Pethiyagoda, R. (1994) Threats to the indigenous fresh water fishes of Sri Lanka & remarks on their conservation. *Hydrobiologia*. 285: 189-201.
- Pethiyagoda, R. (1998). *Freshwater fishes of Sri Lanka*. Wildlife Heritage Trust, Colombo. xiv+362pp.
- Pethiyagoda, R. & Manamendra-Arachchi, K. (1998) Evaluating Sri Lanka's amphibian diversity. *Occasional Papers, Wildlife Heritage Trust, Colombo*. 2:1-12.
- Pillips, W.A.A. (1981). Manual of the Mamals of Sri Lanka. *Wildlife and Nature Protection Society of Ceylon (Sri Lanka)*. Colombo. Vol. I, II, & III.
- Scherr, S.J. & Shames, S. (2006). Agriculture: a

- threat or promise for biodiversity conservation. *Arborvitae* The IUCN/WWF Forest Conservation Newsletter.
- Senanayake, F.R., & Moyle, P.B. (1981) Conservation of freshwater fishes of Sri Lanka. *Biological Conservation*. 22: 181-195.
- Sutherland, J.W. (1996). Ecological census techniques. *Cambridge University Press.UK*. 336pp.
- Wimalasuriya, S.H. (2006) Resurrecting Razed Rainforests. *Part 1*. Wimalasuriya Property Developers, Colombo, Sri Lanka. 35 pp.

**Appendix 1: List of plants species observed at BKE** (\*denotes endemic species)

**ORDER: Angiospermae**

**Family: Acanthaceae**

1. *Strobilanthes calycina*
2. *S. cordifolium*
3. *Asystasia gangetica*
4. *Justicia adhatoda*
5. *Ecobolium ligustrinum*

**Family: Anacardiaceae**

6. *Semecarpus mooni*
7. \**S. nigro-viridis*
8. \**S. subpeltata*
9. \**Mangifera Zeylanica*
10. *Mangifera indica*
11. \**Camposperma Zelanica*

**Family: Annonaceae**

12. \**Xylopia championii*
13. \**Cyathocalyx zeylanica*
14. *X. Parvifolia*

**Family: Apocynaceae**

15. *Alastonia macrophilla*
16. *A.Scholaris*
17. *Pagiantha dichotoma*

**Family: Araceae**

18. *Pathos scandens*

**Family: Asclepiadaceae**

19. *Tylophora indica*

**Family: Bombacaceae**

20. *Bombax ceiba*
21. *Ceiba pentandra*
22. \**Cullenia zeylanica*

**Family: Burseraceae**

23. \**Canarium zelanicas*

**Family: Campanulaceae**

24. *Lobelia nicotifolia*

**Family: Celastraceae**

25. \**Bhesa zelanica*

**Family: Clusiaceae**

26. *Calophyllum thwaitesii*
27. *C. trapazifolium*
28. *C. bracteatum*
29. *C. soulattri*
30. *C. inophyllum*
31. *Garcinia terpnophylla*
32. *G. quaesita*
33. *G. morella*
34. *Mesua ferrea*

**Family: Combretaceae**

35. *Terminalia bellirica*

**Family: Convolvulaceae**

36. *Operculina tuepethum*
37. *Ipomoea obscura*

**Family: Connaraceae**

38. *Rourea minor*

**Family: Dilleniaceae**

39. *Dillenia triquetra*
40. \**D. retusa*
41. *Schumacheria castaneifolia*

**Family: Dioscoreaceae**

42. *Dioscorea spicata*

**Family: Dipterocarpaceae**

43. \**Diptherocapus zelanicas*
44. *D. hispidus*
45. *D. gardneri*
46. *Shorea megistophylla*
47. *Stemonoporus canaliculatus*

48. *Vateria copallifera*
- Family: Ebanaceae**
49. *Diospyros atrata*
50. *D. quaesita*
- Family: Elaeocarpaceae**
51. *Elaeocarpus subvillosus*
- Family: Euphorbiaceae**
52. *Bridelia retusa*
53. \**B. moonii*
54. *P. indicus*
55. *Croton officinalis*
56. *Chaetocarpus castanocarpus*
57. \**Fahrenheitia zelanicas*
58. *Macaranga peltata*
59. *Digina*
60. *Hevea braziliensis*
61. *Aporosa cardiosperma*
- Family: Fabaceae**
62. *Albizia falcataria*
63. *Pericopsis mooniana*
64. *Humboldtia laurifolia*
- Family: Flacourtiaceae**
65. \**Scolopia schreberi*
66. \**Erithrospermum zeylanicum*
67. \**Homalium Zeylanicum*
- Family: Hippocrateaceae**
68. *Salacia reticulata*
- Family: Lamiaceae**
69. *Pogostemon heyneanus*
- Family: Lauraceae**
70. *Cinnamomum verum*
71. *C. dubium*
72. *Multiflorum*
73. *Litseifolium*
74. *L. gardeneri*
- Family: Leguminosae**
75. *Adenanthera aglaosperma*
76. *Pongamia pinnata*
77. *Quassia inidica*
78. *Dalbergia pseudosis*
79. *Puereria phasiolooides*
- Family: Liliaceae**
80. \**Sansevieria zelanica*
- Family: Loganiaceae**
81. \**Strychnos cinnamomifolia*
82. *Gaerineria vaginans*
- Family: Melastomataceae**
83. \**Axinandra zeylanica*
84. \**Osbeckia octandra*
85. *O. aspera*
86. *Melastoma malabathricum*
87. *Lijndenia capitellata*
- Family: Meliaceae**
88. \**Dysoxylum championii*
89. *Swinitenia macrophylla*
90. *Toona sinensis*
- Family: Menispermaceae**
91. *Coscinium fenestratum*
92. *Tinospora malabarica*
93. *Cyclea burmanni*
- Family: Minomiaceae**
94. *Hortonia floribunda*
- Family: Moraceae**
95. \**Artocarpus nobilis*
96. *A. heterophyllus*
97. *A. altilis*
98. *Ficus elastica*
99. *F. hispida*
100. *F. nervosa*
101. *F. fergusonii*
102. *F. tsiela*
- Family: Myristicaceae**
103. \**Horsfieldia iryagedhi*
104. *H. iriya*
105. \**Myristica dactyloides*
- Family: Myrtaceae**
106. *Syzygium firmum*
107. *S. opperculatum*
108. \**S. makul*
109. *S. aromaticum*
- Family: Ochnaceae**
110. \**Ochnaceae jabotapita*
111. *O. lanceolata*
- Family: Olacaceae**
112. \**Olax zeylanica*
- Family: Oleaceae**
113. *Olea glandulifera*
- Family: Orchidaceae**

114. *Dendrobium maccarthiae*
- Family: Palmae**
115. *Areca catechu*
116. *Caryota rivalus*
117. \**C. zeylanicus*
118. *C. urenus*
- Family: Pandanaceae**
120. *Pandanus thwaitesii*
121. \**P. Zeylanicus*
- Family: Passifloraceae**
122. *Adenia palmate*
- Family: Piperaceae**
123. *Piper sylvestre*
- Family: Poaceae**
124. *Ochalandra stridula*
125. *Bamboosa valgaris*
- Family: Potamogetonaceae**
126. *Potamogeton roxburgianus*
- Family: Rhamnaceae**
127. *Ziziphus oenoplia*
- Family: Rhizophoraceae**
128. *Anisophyllea cinnamomoides*
129. *Carallia brachiata*
- Family: Rosaceae**
130. *Gaertnera vaginans*
131. *Hedyotis fruticosa*
132. *Mussaenda frondosa*
133. \**Prunus walkeri*
- Family: Rubiaceae**
134. *Canthium dicocum*
135. *Ophiorrhiza mungos*
- Family: Rutaceae**
136. \**Micromelum minutum*
137. *Acrenychia pedunculata*
138. *Euodia lunuankenda*
- Family: Sapindaceae**
139. *Harpullia arborea*
140. *Filicium decipiens*
141. *Dimocarpus longan*
142. *Nephelium lappaceum*
- Family: Sapotaceae**
143. *Isonandra compta*
- Family: Simaroubaceae**
144. *Quassia indica*
- Family: Smilacaceae**
145. \**Smilax zelanica*
- Family: Staphyleaceae**
146. *Turpinia malabarica*
- Family: Symplocaceae**
147. *Symplocos cochinchinensis*
- Family: Theaceae**
148. *Camellia sinensis*
- Family: Thymelaeaceae**
149. *Gyrinops walla*
- Family: Tiliaceae**
150. *Berrya cordifolia*
151. *Microcos paniculata*
152. *Grewia orientalis*
- Family: Verbenaceae**
153. *Tectona grandis*
154. *Vitex pinnata*
155. *Lantana camara*
156. *Clerodendrum infortunatum*
- Family: Vitaceae**
157. *Seratia pecata*
- Family: Zingiberaceae**
158. *Costus sepicious*
- ORDER: Gymnospermae**
- Family: Cyatheaceae**
159. *Cyathea hookeri*
160. Paathara
161. Kekilla

**Appendix 2: List of fresh water fish observed at BKE** (\*denotes endemic species)

**Order: Elopiformes**

**Family: Aplocheilidae**

1. *Aplocheilus wernerii* Werner's killifish

**Family: Anguillidae**

2. *Anguillaicolor* Level finned eel

**Family: Bagridae**

3. *Mystus gulio* Long whiskered catfish

4. *Mystus keletius* Yellow catfish

**Family: Balitoridae**

5. \**Schistura notostigma* Banded mountain loach

**Family: Cobitidae**

6. \**Lepidocephalichthys jonklaasi* Jonklas loach

7. *Lepidocephalichthys thermalis* Common spiny loach

Marsland Press

Journal of American Science 2009:5(2) 69-82

- |                                    |                     |                                      |                          |
|------------------------------------|---------------------|--------------------------------------|--------------------------|
| 8. <i>Danio malabaricus</i>        | Giant danio         | 18. <i>*Rasboroides vaterifloris</i> | Golden rasbora           |
| 9. <i>Esmos thermoicos</i>         | Flying barb         | <b>Family: Gobiidae</b>              |                          |
| 10. <i>*Garra ceylonensis</i>      | Stone sucker        | 19. <i>Awaous melanocephalus</i>     | Scribbled goby           |
| 11. <i>Puntius amphibious</i>      | Scarlet-banded barb | 20. <i>*Sicyopus jonkalaasi</i>      | Lipstick goby            |
| 12. <i>Puntius bimaculatus</i>     | Redside barb        | <b>Family: Belontiidae</b>           |                          |
| 13. <i>*Puntius cumingii</i>       | Cuming's barb       | 21. <i>*Belontia signata</i>         | Comb-tail                |
| 14. <i>*Puntius nigrofasciatus</i> | Black ruby barb     | <b>Family: Channidae</b>             |                          |
| 15. <i>*Puntus sinhala</i>         | Filamented barb     | 22. <i>Channa gachua</i>             | Brown snakehead          |
| 16. <i>*Puntius tittaya</i>        | Cherry barb         | 23. <i>*Channa orientalis</i>        | Smoothbreasted snakehead |
| 17. <i>Rasbora daniconius</i>      | Striped rasbora     |                                      |                          |

**Appendix 3: List of amphibians observed at BKE** (\*denotes endemic species)

**Order: Apoda**

**Family: Ichthyophiidae**

1. *Ichthyophis glutinosus* Common yellow-band cecilian

**Order: ANURA**

**Family: Bufonidae – terrestrial frogs**

2. *Bufo melanostictus* Common house toad  
3. *\*Bufo atukoralei* Athukorala's toad

**Family: Ranidae – aquatic frogs**

4. *Rana aurantiaca* Golden frog  
5. *R.ana temporalis* Bronzed frog  
6. *Fejervarya kirthisinghe* Kirtisinghe's frog  
7. *Fejervarya limnocharis* Common paddy field frog

8. *Hoplobatrachus crassus* Jerdon's bull frog  
9. *Nanophrys ceylonensis* Sri Lankan rock frog  
10. *\*Lankanectus corrugatus* Corrugated water frog  
11. *Euphlyctis hexadactylus* Indian green frog  
12. *Euphlyctis cyanophlyctis* Skipper frog
- Family: Rhacophoridae – arboreal frogs**
13. *\*Polypedates eques* Saddled tree frog  
14. *\*Polypedates cruciger* Common hourglass treefrog  
15. *\*Polipedates longinasus* Long-snouted tree frog  
16. *\*Philatus. foliicola* Anthropogenic shrub frog  
17. *\*Philatus. nemus* Southern shrub frog

**Appendix 4: List of reptiles observed at BKE**

**Order: Serpentes**

**Family: Boidea**

1. *Python molurus* Rock python

**Family: Elapidae**

2. *Naja naja naja* Indian cobra  
3. *\*Bungarus ceylonicus* Ceylon krait

**Family: Colubridae**

4. *\*Xenochrophis asperrimus* Checkered keel back  
5. *Xenochrophis piscator* Checkered keel back  
6. *\*Baloniphis ceylonensis* Sri Lankan Keelback  
7. *\*Aspidura brachyorrhos* Boie's roughside  
8. *Amphiesma stolata* Buff-stripped keel back  
9. *Oligodon sublineatus* Streaked Kukri Snake  
10. *Ahaetulla nasutus* Green vine snake  
11. *Boiga ceylonensis* Sri Lanka cat snake  
12. *Boiga forsteni* Forsten's catsnake  
13. *Chrysopelea ornata* Gold & black tree snake

14. *Dendrelaphis bifrenalis* Bronze back  
15. *Dendrelaphis tristis* Common bronze back  
16. *Dryocalamus nympha* Bridal snake  
17. *Coelognathus helena* Trinket snake  
18. *Lycodon aulicus* Wolf snake  
19. *Lycodon striatus* Shaw's wolf snake  
20. *Ptyas mucosus maximus* Rat snake  
21. *Oligodon arnensis* Common kukri

**Family: Uropeltidae**

22. *\*Cylindrophis maculata* Pipe snake

**Family: Viperidae**

23. *Hypnale hypnale* Hump-nosed viper  
24. *\*Trimeresurus trigonocephalus* Green pit viper  
25. *Daboia russellii* Russell's viper

**Order: Sauria****Family: Agamidae**

1. *Calotes calotes* Green garden lizard  
 2. *Calotes versicolor* house lizard  
 3. \**Calotes liolepis* Whistling lizard  
 4. \**Ceratophora aspera* Rough-horn lizard  
 5. \**Otocryptis wiegmanni* Kangaroo lizard  
 6. \**Lyriocephalus scutatus* Hump-nosed lizard

**Family: Scincidae**

7. *Mabuya carinata* Rat snake skink  
 8. \**Nessia burtoni* Three-toe snakeskink  
 9. \**Lankascincus fallax* Common Lanka skink

10. \**Lankascincus gansi* Gans's lanka skink

**Family: Varanidae**

11. *Varanus bengalensis* Land monitor  
 12. *Varanus salvator* Water monitor

**Family: Gekkonidae**

13. *Cnemaspis podihuna* Small Day Gecko  
 14. *Hemidactylus frenatus* Asian House Gecko  
 15. *Hemidactylus brooki* Brooke's House Gecko  
 16. *Gehyra mutilata* Four-clawed Gecko

**Family: Trionychidae**

17. *Lissemys punctata* Flapshell turtle

**Appendix 5: List of birds species observed at BKE** (\*denotes endemic species)**Order: Pelicaniformes****Family: Phalacrocoracidae**

1. *Phalacrocorax niger* Little cormorant

**Order: Ciconiformes****Family: Ardeidae**

2. *Bubulcus ibis* Cattle egret  
 3. *Egretta garsetta* Little egret  
 4. *Ardeola grayii* Indian pond heron

**Order: Falconiformes****Family: Accipitridae**

5. *Ictinaetus malayensis* Black eagle  
 6. *Haliastur indus* Brahmini kite  
 7. *Spizaetus cirrhatus* Changeable hawk eagle  
 8. *Spilornis cheela* Crested serpent eagle  
 9. *Accipiter bandius* Shikra

**Order: Galiformes****Family: Phasianidae**

10. \**Gallus lafayetii* Sri Lankan junglefowl  
 11. \**Galloperdix bicalcarata* Sri Lankan spurfowl

**Order: Gruiformes****Family: Rallidae**

12. *Amaurornis phoenicurus* White breasted water hen

**Order: Columbiformes****Family: Columbidae**

13. *Chalcophaps indica* Emerald dove  
 14. *Ducula aenea* Green imperial pigeon  
 15. *Treron bisenta* Orange breasted green pigeon  
 16. *T. Pompadora* Pompadour green pigeon  
 17. *Streptopelia chinensis* Spotted dove

**Order: Psittaciformes****Family: Psittacidae**

18. *Psittacula krameri* Rose ringed parakeet

19. *P. cyanocephala* Plum headed parakeet

20. \**Loriculus beryllinus* Sri Lankan hanging parrot

**Order: Cuculiformes****Family: Cuculidae**

21. *Eudynamis scolopacea* Asian Koel  
 22. *Centropus sinensis* Greater coucal  
 23. \**C. chlororhynchus* Green billed coucal

**Order: Strigiformes****Family: Tytonidae**

24. *Bubo nipelensis* Spot bellied eagle owl  
 25. \**Glaucidium castanontum* Chestnut backed owl

**Family: Strigidae**

26. *Strix letogrammica* Brown wood owl  
 27. *Ketupa zelanica* Brown fish owl

**Order: Caprimulgiformes****Family: Podargidae**

28. *Batrachostomus moniliger* Frog mouth

**Order: Apodiformes****Family: Apodidae**

29. *Cypsiurus balasiensis* Asian palm swift

**Family: Hemiprocnidae**

30. *Hemiproctne coronata* Crested tree swift

**Order: Trogoniformes****Family: Trogonidae**

31. *Harpactes faciatus* Malabar trogon

**Order: Coraciformes****Family: Alcedinidae**

32. *Ceyx erithacus* Oriental dwarf kingfisher  
 33. *Alcedo atthis* Common kingfisher  
 34. *Halcyon smyrnensis* White breasted kingfisher

**Family: Meropidae**

35. *Merops philippinus* Blue tailed bee-eater

Marsland Press

Journal of American Science 2009:5(2) 69-82

36. *Merops leschenaultia* Chestnutheaded bee-eater

**Family: Coraciidae**

37. *Eurystomus orientalis* Dollar bird

**Family: Bucerotidae**

38. *\*Ocyrceros gingalensis* Gray hornbill

**Order: Piciformes**

**Family: Capitonidae**

39. *Megalaima zelanica* Brown headed barbet

40. *\*M. rubricapilla* Crimson fronted barbet

41. *\*M. flavifrons* Yellow fronted barbet

**Family: Picidae**

42. *Chrysocolaptes lucidus* Greater flamback

43. *Pitta brachyura* Indian pitta

44. *Dendrocopos nanus* Pigmy woodpecker

45. *Dinopium benghalense* Red backed woodpecker

**Order: Passeriformes**

**Family: Motacillidae**

46. *Dendronantus indicus* forest wagtail

**Family: Hirundinidae**

47. *Hirundo daurica* Red rumped swallow

**Family: Campephagidae**

48. *Pericrocotus flammeus* Scarlet minivet

49. *P. cinnamomeus* Small minivet

**Family: Pycnonotidae**

50. *Hypspetes leucocephalus* Black bulbul

51. *\*Pycnonotus melanicterus* Black crested bulbul

52. *Pycnonotus cafer* Red vented bulbul

53. *Pycnonotus luteolus* White browed bulbul

54. *Iole indica* Yellow browed bulbul

**Family: Passeridae**

55. *Lonchura striata* White-rumped Munia

56. *Lonchura punctulata* Scaly-breasted Munia

**Family: Irenidae**

57. *Chloropsis cochinchinensis* Blue winged leafbird

58. *Chloropsis aurifrons* Gold fronted leafbird

59. *Aegithina tiphia* Common iora

**Family: Laniidae**

60. *Lanius cristatus cristatus* Brown shrike

**Family: Muscicapidae**

61. *Muscicapa daurica* Asian brown flycatcher

62. *Terpsiphone paradisi* Asian paradise flycatcher

63. *Hypothymis azurea* Black-naped Monarch

64. *Copsychus saularis* Oriental magpie robin

65. *Cyornis tickelliae* Tickell's blue flycatcher

**Family: Rhipiduridae**

66. *Rhipidura aureola* White browed fantail

**Family: Sittidae**

67. *Sitta frontalis* Velvet fronted nuthatch

**Family: Silviidae**

68. *Orthotomus sutorius* Common tailerbird

69. *Phylloscopus trochiloides* Greenish tree warbler

70. *P. magnirostris* Large-billed leaf warbler

71. *Turdoides affinis* Yellow billed babbler

72. *Rhopocichla atriceps* Dark fronted babbler

73. *\*Pellorneum fuscocapillum* Brown capped babbler

74. *Pomatorhinus horsfieldii* Scimitar Babbler

**Family: Paridae**

75. *Parus major* Great tit

**Family: Dicaeidae**

76. *Zosterops palpebrosa* Oriental white-eye

77. *\*Dicaeum vincens* Legge's flowerpecker

78. *Dicaeum erythrorhynchos* Small flowerpecker

**Family: Nectarinidae**

79. *Nectarinia zeylanica* Purple rumped sunbird

80. *Nectarinia lotenia* Long billed sunbird

81. *Nectarinia asiatica* Purple sunbird

**Family: Zosteropidae**

82. *Zosterops palpebrosus* Small white-eye

**Family: Sturnidae**

83. *Acridotheres tristis* Common myna

84. *Gracula religiosa* Hill myna

85. *\*G. ptilogenys* Sri Lankan myna

**Family: Oriolidae**

86. *Oriolus xanthornus* Black headed oriel

**Family: Dicruridae**

87. *Dicrurus caeruleus* White bellied drongo

88. *Dicrurus paradisius lophorhinus* Crested drongo

**Family: Artamidae**

89. *Artamus fuscus* Ashy wood swallow

**Family: Corvidae**

90. *Crocoros macrohynches* Jungle crow

**Appendix 6: List of mammals observed at BKE (\*denotes endemic species)**

**Order: Chiroptera**

**Family: Pteropidae**

Analog forest's contribution to biodiversity conservation		Wasantha K.D.D. Liyanage et al.	
1. <i>Cynopterus sphinx</i>	Short-nosed fruit bat	19. <i>Vandeleuria oleracea</i>	Long-tailed tree mouse
2. <i>Pteropus giganteus</i>	Flying fox	<b>Family: Hystricidae</b>	
<b>Family: Emballonuridae</b>		20. <i>Hystrix indica</i>	Porcupine
3. <i>Taphozous melanopogon</i>	Black-bearded sheath-tailed bat	<b>Order: Pholidota</b>	
<b>Family: Rhinolophidae</b>		<b>Family: Manidae</b>	
4. <i>Rhinolophus rouxi</i>	Rufus horseshoe bat	21. <i>Manis crassicaudata</i>	Indian Pangolin
5. <i>Hipposideros lankadiva</i>	Great leaf-nosed bat	<b>Order: Lagomorpha</b>	
<b>Family: Vespertilionidae</b>		<b>Family: Leporidae</b>	
6. <i>Pipistrellus ceylonicus</i>	Kelaart's pipistrel	22. <i>Lepus nigricollis</i>	Black-Napped Hare
7. <i>Kirivoula pictus</i>	Painted bat	<b>Order: Carnivora</b>	
<b>Order: Primata</b>		<b>Family: Viverridae</b>	
<b>Family: Loridae</b>		23. <i>Viverricula indica</i>	Ring-tailed civet
8. * <i>Loris tardigradus tardigradus</i>	S.L.Red slender Loris	24. <i>Paradoxurus hermaphroditus</i>	Palm cat
<b>Family: Cercopithecidae</b>		25. * <i>Paradoxurus zeylonensis</i>	Golden palm civet
9. * <i>Macaca sinica aurifrons</i>	Dusky toque macaque	<b>Family: Herpestidae</b>	
10. * <i>Semnopithecus vetullus vetullus</i>	Purple faced leaf monkey	26. <i>Herpestes brachyurus</i>	Brown mongoose
<b>Order: Rodentia</b>		27. <i>Herpestes smithii</i>	Black-tipped mongoose
<b>Family: Sciuridae</b>		<b>Family: Felidae</b>	
11. <i>Funambulus palmarum</i>	Palm squirrel	28. <i>Prionailurus rubiginosa</i>	Rusty-Spotted Cat
12. <i>Funambulus layardi</i>	Flame-striped jungle squirrel	29. <i>Panthera pardus kotiya</i>	Leopard
13. <i>Funambulus sublineatus</i>	Dusky-striped jungle squirrel	30. <i>Prionailurus viverrinus</i>	Fishing cat
14. <i>Ratufa macroura melanochra</i>	Black and yellow giant squirrel	<b>Family: Mustelidae</b>	
<b>Family: Muridae</b>		31. <i>Lutra lutra</i>	Otter
15. <i>Bandicota indica</i>	Malabar bandicoot	<b>Family: Canidae</b>	
16. <i>Mus booduga</i>	Field mouse	32. <i>Canis aureus</i>	Jackal
17. <i>Mus musculus</i>	Indian house mouse	<b>Order: Artiodactyla</b>	
18. <i>Rattus rattus</i>	Common house rat	<b>Family: Suidae</b>	
		33. <i>Sus scrofa</i>	Wild boar
		<b>Family: Tragulidae</b>	
		34. <i>Moschiola meminna</i>	Mouse deer

---