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

Wasantha K.D.D. Liyanage, Saman N. Gamage, Lai Xulong, Julia Ellis Burnet

School of Environmental Studies, China University of Geosciences, 388, Lumo Road, Wuhan, Hubei, 430074. P.R. China.
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 plant 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.


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

1. Introduction

Among all the biological resources of Sri Lanka, forests are ecologically remarkable, environmentally indispensible, 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 (Gunatitudeke and Gunatileke, 1990).
Analog forest’s contribution to biodiversity conservation  
Wasantha K.D.D. Liyanage et al.

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 allowed to regenerate into forestland while being 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-foliage, 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-Dediyyagala-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.
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 m² 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 quadrate 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 Manamenda-Ararachchi (1996), Manamenda-Ararachchi and Pethiyagoda (1998), Manamenda-Ararachchi and Pethiyagoda (2005), Meegas-kumbura and Manamenda-Ararachchi (2005); Reptiles: De Silva (1990), Pethiyagoda and Manamenda-Ararachchi, (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.

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

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.

<table>
<thead>
<tr>
<th>Species</th>
<th>Conservation status</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Polypedates longinasus</em></td>
<td>Endangered</td>
</tr>
<tr>
<td><em>Polypedates eques</em></td>
<td>Endangered</td>
</tr>
<tr>
<td><em>Philatus nemus</em></td>
<td>Critically-endangered</td>
</tr>
<tr>
<td><em>Nanophrys ceylonensis</em></td>
<td>Vulnerable</td>
</tr>
<tr>
<td><em>Lepidocephalichthys jonklaasi</em></td>
<td>Endangered</td>
</tr>
<tr>
<td>Sicyopus jonklaasi</td>
<td>Data deficient</td>
</tr>
<tr>
<td><em>Loris tardigradus tardigradus</em></td>
<td>Endangered</td>
</tr>
<tr>
<td><em>Semnopithecus vetellus vetellus</em></td>
<td>Endangered</td>
</tr>
<tr>
<td><em>Macaca sinica aurifrons</em></td>
<td>Vulnerable</td>
</tr>
</tbody>
</table>

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


Earles, R. (2005). Sustainable Agriculture: An Introduction Publication of ATTRA, the National Sustainable Agriculture Information Service. USA.


IUCN (2004) IUCN red list of threatened


threat or promise for biodiversity conservation. *Arborvitae* The IUCN/WWF Forest Conservation Newsletter.


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

<table>
<thead>
<tr>
<th>ORDER: Angiospermae</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Family:</strong> Acanthaceae</td>
</tr>
<tr>
<td>1. <em>Strobilanthes calycina</em></td>
</tr>
<tr>
<td>2. <em>S. cordifolium</em></td>
</tr>
<tr>
<td>3. <em>Asystasia gangetica</em></td>
</tr>
<tr>
<td>4. <em>Justicia adhatoda</em></td>
</tr>
<tr>
<td>5. <em>Ecobolium ligustrinum</em></td>
</tr>
<tr>
<td><strong>Family:</strong> Anacardiaceae</td>
</tr>
<tr>
<td>6. <em>Semecarpus mooni</em></td>
</tr>
<tr>
<td>7. <em>S. nigro-viridis</em></td>
</tr>
<tr>
<td>8. <em>S. subpeltata</em></td>
</tr>
<tr>
<td>9. <em>Mangifera Zeylanica</em></td>
</tr>
<tr>
<td>10. <em>Mangifera indica</em></td>
</tr>
<tr>
<td>11. <em>Campnosperma Zelanica</em></td>
</tr>
<tr>
<td><strong>Family:</strong> Annonaceae</td>
</tr>
<tr>
<td>12. <em>Xylopia championii</em></td>
</tr>
<tr>
<td>13. <em>Cyathocalyx zeylanica</em></td>
</tr>
<tr>
<td>14. <em>X. Parvifolia</em></td>
</tr>
<tr>
<td><strong>Family:</strong> Apocynaceae</td>
</tr>
<tr>
<td>15. <em>Alastonia macrophilla</em></td>
</tr>
<tr>
<td>16. <em>A.Scholaris</em></td>
</tr>
<tr>
<td>17. <em>Pagiantha dichotoma</em></td>
</tr>
<tr>
<td><strong>Family:</strong> Araceae</td>
</tr>
<tr>
<td>18. <em>Pathos scandens</em></td>
</tr>
<tr>
<td><strong>Family:</strong> Asclepiadaceae</td>
</tr>
<tr>
<td>19. <em>Tylophora indica</em></td>
</tr>
<tr>
<td><strong>Family:</strong> Bombacaceae</td>
</tr>
<tr>
<td>20. <em>Bombax ceiba</em></td>
</tr>
<tr>
<td>21. <em>Ceiba pentandra</em></td>
</tr>
<tr>
<td>22. <em>Cullenia zeylanica</em></td>
</tr>
<tr>
<td><strong>Family:</strong> Burseraceae</td>
</tr>
<tr>
<td>23. <em>Canarium zeylanicas</em></td>
</tr>
<tr>
<td><strong>Family:</strong> Campanulaceae</td>
</tr>
<tr>
<td>24. <em>Lobelia nicotinifolia</em></td>
</tr>
<tr>
<td><strong>Family:</strong> Celastraceae</td>
</tr>
<tr>
<td>25. <em>Bhesa zelanica</em></td>
</tr>
<tr>
<td><strong>Family:</strong> Clusiaceae</td>
</tr>
<tr>
<td>26. <em>Calophyllum thwaitesii</em></td>
</tr>
<tr>
<td>27. <em>C. trapazifolium</em></td>
</tr>
<tr>
<td>28. <em>C. bracteatum</em></td>
</tr>
<tr>
<td>29. <em>C. soulatri</em></td>
</tr>
<tr>
<td>30. <em>C. inophyllum</em></td>
</tr>
<tr>
<td>31. <em>Garcinia terpnophylla</em></td>
</tr>
<tr>
<td>32. <em>G. quaesita</em></td>
</tr>
<tr>
<td>33. <em>G. morella</em></td>
</tr>
<tr>
<td><strong>Family:</strong> Combretaceae</td>
</tr>
<tr>
<td>34. <em>Mesua ferrea</em></td>
</tr>
<tr>
<td><strong>Family:</strong> Convolvulaceae</td>
</tr>
<tr>
<td>35. <em>Terminalia bellirica</em></td>
</tr>
<tr>
<td>36. <em>Opeculina tuepethum</em></td>
</tr>
<tr>
<td><strong>Family:</strong> Connaraceae</td>
</tr>
<tr>
<td>37. <em>Ipomoea obscura</em></td>
</tr>
<tr>
<td><strong>Family:</strong> Dioscoreaceae</td>
</tr>
<tr>
<td>38. <em>Roureca minor</em></td>
</tr>
<tr>
<td>39. <em>Dillenia triquetra</em></td>
</tr>
<tr>
<td>40. <em>D. retusa</em></td>
</tr>
<tr>
<td><strong>Family:</strong> Dioscoreaceae</td>
</tr>
<tr>
<td>41. <em>Schumacheria castaneifolia</em></td>
</tr>
<tr>
<td><strong>Family:</strong> Dipterocarpacea</td>
</tr>
<tr>
<td>42. <em>Dioscorea spicata</em></td>
</tr>
<tr>
<td>43. <em>Diptherocapus zelianicas</em></td>
</tr>
<tr>
<td>44. <em>D. hispidus</em></td>
</tr>
<tr>
<td>45. <em>D. gardneri</em></td>
</tr>
<tr>
<td>46. <em>Shorea megistophylla</em></td>
</tr>
<tr>
<td>47. <em>Stemonoporus canaliculatus</em></td>
</tr>
</tbody>
</table>
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. *Erithropermum zeylanicum
67. *Homalium Zeylanicum

Family: Hippocrateaceae

68. Salacia reticulata

Family: Lamiaceae

69. Pogostemon heyneanus

Family: Lauraceae

70. Cinnamomum verum
71. C. dumum
72. Multiflorum
73. Litseifolium
74. L. gardeneri

Family: Leguminosae

75. Adenanthera aeglaoesperma
76. Pongamia pinnata
77. Quassia indica
78. Dalbergia pseudosis
79. Puereria phasioloides

Family: Liliaceae

80. *Sansevieria zelanica

Family: Loganiaceae

81. *Strychnos cinnamomifolia
82. Gaerinera 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 iryaghedhi
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: Olaceae

112. *Olax zeylanica

Family: Oleaceae

113. Olea glandulifera

Family: Orchidaceae
Analog forest’s contribution to biodiversity conservation

Wasantha K.D.D. Liyanage et al.

Family: Palmae
114. *Dendrobium maccarthiae
115. Areca catechu
116. Caryota rivalus
117. *C. zeylanicus
118. C. urens

Family: Pandanaceae
119. *Pandanus thwaitesii
118. *P. Zeylanicus

Family: Passifloraceae
120. Adenia palmate
121. *Adenia fruticosa

Family: Piperaceae
122. Piper sylvestre

Family: Poaceae
123. Ochandra striata
124. Bamboosa varigata

Family: Potamogetonaceae
125. Potamegeton roxburgianus

Family: Rhamnaceae
126. Zizia oenopia

Family: Rutaceae
127. *Zizia oenopia
128. *Hedyotis fruticosa
129. *Muscaenda frondosa
130. *Prunus walkeri

Family: Sapindaceae
131. Harpullia arborescens

Ordered: Gymnospermae
Family: Cyatheaceae
132. Cyathea hookeri
133. Paathara
134. Kekilla

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

Order: Elopiformes
Family: Aplocheilidae
1. Aplocheilus werneri Werner’s killifish

Family: Anguillidae
2. Anguilla icolor Level finned eel

Family: Bagridae
3. Mystus gulio Long whiskered catfish
4. Mystus keletius Yellow catfish

Family: Balitoridae
5. *Schistura notostigma Banded mountain loach
6. *Lepidolephidichthys jenkinsi Jonklas loach
7. Lepidolephidichthys thermalis Common spiny loach

ORDER: Gymnospermae
Family: Zingiberaceae
158. Costus sepii

ORDER: Rubiaceae
159. Seratia pecata

ORDER: Rutaceae
160. Paathara
161. Kekilla
Appendix 3:  List of amphibians observed at BKE (*denotes endemic species)

Order: Apoda
Family: Ichthyophiidae
1. Ichthyophis glutinosus  Common yellow-band cecillian

Order: ANURA
Family: Bufonidae – terrestrial frogs
2. Bufo melanostictus  Common house toad
3. *Bufo atukoralei  Athukorala’s toad
Family: Ranidae – aquatic frogs
4. Rana aurantica  Golden frog
5. R.ana temporalis  Bronzed frog
6. Fejervarya kirthisinghe  Kirtisinghe’s frog
7. Fejervarya limnocharis  Common paddy field frog

Family: Rhacophoridae – arboreal frogs
8. *Polypedates eques  Saddled tree frog
9. *Polypedates cruciger  Common hourglass frog
10. *Polypedates longinasus  Long-snouted tree frog
11. *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 ceylonicus  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
### Appendix 5: List of birds species observed at BKE (*denotes endemic species)

<table>
<thead>
<tr>
<th>Order: Pelicaniformes</th>
<th>19. <em>P. cyanopephala</em></th>
<th>Plum headed parakeet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Family: Phalacrocoracidae</strong></td>
<td>20. <em>Loriculus beryllinus</em></td>
<td>Sri Lankan hanging parrot</td>
</tr>
<tr>
<td>1. <em>Phalacrocorax niger</em></td>
<td>Little cormorant</td>
<td></td>
</tr>
<tr>
<td><strong>Order: Ciconiformes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Family: Ardeidae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. <em>Bubulcus ibis</em></td>
<td>Cattle egret</td>
<td></td>
</tr>
<tr>
<td>3. <em>Egretta garzetta</em></td>
<td>Little egret</td>
<td></td>
</tr>
<tr>
<td>4. <em>Ardea grayii</em></td>
<td>Indian pond heron</td>
<td></td>
</tr>
<tr>
<td><strong>Order: Falconiformes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Family: Accipitridae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. <em>Ictinaetus malayensis</em></td>
<td>Black eagle</td>
<td></td>
</tr>
<tr>
<td>6. <em>Haliastur indus</em></td>
<td>Brahmini kite</td>
<td></td>
</tr>
<tr>
<td>7. <em>Spizaetus cirrhatus</em></td>
<td>Changeable hawk eagle</td>
<td></td>
</tr>
<tr>
<td>8. <em>Spilornis cheela</em></td>
<td>Crested serpent eagle</td>
<td></td>
</tr>
<tr>
<td>9. <em>Accipiter badius</em></td>
<td>Shikra</td>
<td></td>
</tr>
<tr>
<td><strong>Order: Gaviiformes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Family: Phasianidae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. <em>Gallus lafayetti</em></td>
<td>Sri Lankan junglefowl</td>
<td></td>
</tr>
<tr>
<td>11. <em>Galloperdix bicalarata</em></td>
<td>Sri Lankan spurfowl</td>
<td></td>
</tr>
<tr>
<td><strong>Order: Gruiformes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Family: Railidae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. <em>Amaurornis phoenicurus</em></td>
<td>White breasted water hen</td>
<td></td>
</tr>
<tr>
<td><strong>Order: Columbiformes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Family: Columbidae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. <em>Chalcophaps indica</em></td>
<td>Emerald dove</td>
<td></td>
</tr>
<tr>
<td>14. <em>Ducula aenea</em></td>
<td>Green imperial pigeon</td>
<td></td>
</tr>
<tr>
<td>15. <em>Treron bisen</em></td>
<td>Orange breasted green pigeon</td>
<td></td>
</tr>
<tr>
<td>16. <em>T. Pompadora</em></td>
<td>Pompadour green pigeon</td>
<td></td>
</tr>
<tr>
<td>17. <em>Sreptopelia chinensis</em></td>
<td>Spotted dove</td>
<td></td>
</tr>
<tr>
<td><strong>Order: Psittaciformes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Family: Psittacidae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. <em>Psittacula kramer</em></td>
<td>Rose ringed parakeet</td>
<td></td>
</tr>
<tr>
<td><strong>Order: Coraciiformes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Family: Alcedinidae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32. <em>Ceyx erithacus</em></td>
<td>Oriental dwarf kingfisher</td>
<td></td>
</tr>
<tr>
<td>33. <em>Alcedo atthis</em></td>
<td>Common kingfisher</td>
<td></td>
</tr>
<tr>
<td>34. <em>Halcyon smyrnensis</em></td>
<td>White breasted kingfisher</td>
<td></td>
</tr>
<tr>
<td><strong>Family: Meropidae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35. <em>Meros philippinus</em></td>
<td>Blue tailed bee-eater</td>
<td></td>
</tr>
</tbody>
</table>
36. Merops leschenaultia  Chestnutheaded bee-eater
   **Family: Coraciidae**
37. Eurystomus orientalis  Dollar bird
   **Family: Bucerotidae**
38. *Ocyceros gingalensis  Gray hornbill
   **Order: Piciformes**
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**
46. Dendronanthus indicus  forest wagtail
   **Family: Motacillidae**
47. Hirundo daurica  Red rumped swallow
   **Family: Hirundinidae**
48. Pericrocotus flammeus  Scarlet minivet
49. P. cinnamomeus  Small minivet
   **Family: Pycnonotidae**
50. Hypspeps leucocephalus  Black bulbul
51. *Pycnonotus melanicius  Black crested bulbul
52. Pycnonotus cafer  Red vented bulbul
53. Pycnonotus luteolus  White browed bulbul
54. Iole indica  Yellow browed bulbul
   **Family: Pycnonotidae**
55. Lonchura striata  White-rumped Muniya
56. Lonchura punctulata  Scaly-breasted Muniya
   **Family: Pycnonotidae**
57. Chloropsis cochinchinensis  Blue winged leafbird
58. Chloropsis aurifrons  Gold fronted leafbird
59. Aegithina tiphia  Common iora
   **Family: Irenidae**
60. Lanis cristatus cristatus  Brown shrike
   **Family: Laniidae**
61. Muscicapa daurica  Asian brown flycatcher
62. Terpsiphone paradisi  Asian paradise flycatcher
   **Family: Muscicapidae**
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
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
   **Family: Paridae**
74. Pomatorhinus horsfieldii  Scimitar Babbler
75. Parus major  Great tit
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. Zosteropes 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 caerulescens  White bellied drongo
88. Dicrurus paradisius lophorinus  Crested drongo
   **Family: Artamidae**
89. Artamus fuscus  Ashy wood swallow
   **Family: Passeridae**
90. Crocos macroynices  Jungle crow
   **Family: Pteropidae**

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

**Order: Chiroptera**

**Family: Pteropidae**

81
1. Cynopterus sphinx Short-nosed fruit bat
2. Pteropus giganteus Flying fox

Family: Emballonuridae
3. Taphozous melanopogon Black-bearded sheath-tailed bat

Family: Rhinolophidae
4. Rhinolophus rouxi Rufus horseshoe bat
5. Hipposideros lankadiva Great leaf-nosed bat

Family: Vespertilionidae
6. Pipistrellus ceylonicus Kelaart’s pipstrel
7. Kirivoula pictus Painted bat

Order: Primata
Family: Loridae
8. *Loris tardigradus tardigradus S.L. Red slender Loris

Family: Cercopithecidae
9. *Macaca sinica aurifrons Dusky toque macaque
10. *Semnopithecus vetillus vetillus Purple faced leaf monkey

Order: Rodentia
Family: Sciuridae
11. Funambulus palmarum Palm squirrel
12. Funambulus layardi Flame-striped jungle squirrel
13. Funambulus sublineatus Dusky-striped jungle squirrel
14. Ratufa macroura melanochra Black and yellow giant squirrel

Family: Muridae
15. Bandicota indica Malabar bandicoot
16. Mus booduga Field mouse
17. Mus musculus Indian house mouse
18. Rattus rattus Common house rat

Family: Hystricidae
19. Vandeleuria oleracea Long-tailed tree mouse

Family: Pholidota
20. Hystrix indica Porcupine

Family: Leporidae
21. Manis crassicaudata Indian Pangolin

Family: Carnivora
22. Lepus nigriguttatus Black-Napped Hare

Family: Viverridae
23. Viverricula indica Ring-tailed civet
24. Paradoxurus hermaphroditus Palm cat
25. *Paradoxurus zeylonensis Golden palm civet

Family: Herpestidae
26. Herpestes brachyurus Brown mongoose
27. Herpestes smithii Black-tipped mongoose

Family: Felidae
28. Prionailurus rubiginosa Rusty-Spotted Cat
29. Panthera pradus kotiya Leopard
30. Prionailurus viverrinus Fishing cat

Family: Canidae
31. Lutra lutra Otter
32. Canis aureus Jackal

Family: Mustelidae
33. Otter

Family: Suidae
34. Moschiola meminna Mouse deer