BIRD – PLANT ASSOCIATIONS ALONG THE EDGES OF SELECTED FRAGMENTED HABITATS IN SOUTHERN PROVINCE, SRI LANKA

E. Chandana, Nayanathara Weerasinghe

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BIRD – PLANT ASSOCIATIONS ALONG THE EDGES OF SELECTED FRAGMENTED HABITATS IN SOUTHERN PROVINCE, SRI LANKA

M.A.Y.N. WEERASINGHE, E.M.D.V. EKANAYAKE, W.A.K.G. THAKSHILA, T.S.K. DHARMASIRI, N.J. De S. AMARASINGHE and E.P.S. CHANDANA*

Department of Zoology, Faculty of Science, University of Ruhuna, Matara 81000, Sri Lanka

**epschandana@zoo.ruh.ac.lk*

ABSTRACT - Recent development projects taken place all over Sri Lanka seem to cause massive decline in available habitats, habitat fragmentation and edges. Habitat fragmentation and formation of edges threaten survival and reproduction of avifauna. However this has not been widely studied in Sri Lanka. Therefore, the objectives of the present study were to reveal the bird-plant associations in selected fragmented habitats to collect baseline data. Present study has selected edges located at the premises of University of Ruhuna (UP), Matara (5˚56'N 80˚34'E) and Kirala Kele sanctuary (KK), Matara (5˚58' N 80˚32' E) and Baruthakanda (BK) a secondary dry zone bush land (6˚13'N 81˚04' E) situated in Hambantota. Birds, vegetation and bird – plant associations at the study sites were surveyed along transects and established plots (250 m × 25 m) from April- October 2016. Data were analyzed using diversity indices and sites were compared for bird density and plant density using non parametric statistics (Kruskal Wallis Test). Total number of bird species recorded at UP, KK and BK sites were 51, 60 and 59 respectively. Shannon – Wiener diversity was 4.30, 4.25 and 3.63 respectively. Highest mean bird density per unit area was 2101 was observed at BK. Bird and plant densities were significantly different among study sites. (Kruskal Wallis test value – 6.489, P = 0.039). As for the observations in this study, birds used plants mainly for feeding in UP, for nesting and roosting in KK and for resting and nesting in BK indicating the site specificity of the bird-plant associations. As for the comparison with the reference sites, edge specific bird species at UP i.e. Blue – faced Malkoha, Stork – Billed Kingfisher, Yellow – rumped Flycatcher and BK i.e. Bright Green Warbler, Cinereous Tit, Dusky Warbler were recorded.

These data further indicate the specificity of the study edges. Specific bird – plant associations were identified in each study site i.e. Asian Koel – Ahu plant in UP, Red – vented Bulbul and Acacia plant in KK and Purple – rumped Sunbird – Katu Andara plant in BK. These data might be useful in terms of the bird conservation especially in setting priorities.

KEY WORDS : Fragmentation, Bird – Plant associations, Avifauna, University of Ruhuna, Kirala Kele, Baruthakanda

INTRODUCTION

Vegetation potentially influences the distribution of birds in a particular region (Mccollin 1998). It decides the existence of a bird species in a selected area. Birds and plants co – evolved to adapt to one another (Gandhi 2001). There is a symbiotic relationship between birds and plants. Birds depend on plants for feeding, resting, nesting and roosting. Directly or indirectly bird species survival closely depends on the survival of plants.

Birds are also useful indicators of ecosystem health (Gregory *et al.* 2003). Nevertheless bird species diversity and abundance are rapidly declining in all over the world. Climate change including global warming, pollution and habitat destruction including habitat fragmentation are several factors affecting bird species diversity and ecology (Wormworth *et al.* 2016).

As habitat transformation and destruction cause heavy losses of habitats with modern development projects bird species are threatened. Hence in terms of bird conservation and bird-plant associations with reference to habitat conversion, habitat fragmentation and edge effect are widely discussed and researched topics in the world (Murcia 1995). Habitat fragmentation, by definition is the "breaking apart" of continuous habitat (Bennett *et al.* 2010). It can be defined as the replacement of large areas of native habitat by other ecosystems leaving isolated habitat patches, with deleterious consequences for the most of the native biota (Murcia 1995). Habitat fragmentation increases landscape heterogeneity as it forms numerous smaller, isolated patches. Another result of habitat fragmentation is an increase in the amount of edge habitat with the increasing number of smaller patches.

Within avian communities, fragmentation has deleterious effects as it alters the distribution of bird population, the migration among populations or the sizes of local populations (Holsinger 2009). There are many possible effects of habitat fragmentation such as limited geographic range, loss of specific habitat requirements and low population density.

Fragmentation reduces the extent and connectivity of remaining habitats and bird species may or may not be able to persist in those habitats. The conversion of forest to other land – cover types leads to creation of edges (Murcia 1995). An edge is the boundary between two biological communities or two different landscape elements. More fragmented landscapes contain more edge for a given amount of habitat (Fahrig 2009). Edge effects can simply described as the changes in population or community structures that occur at the boundary of two habitats.

Sri Lanka is a tropical island with numerous ecosystems such as forests, wetlands, mountain areas that provide different types of habitats to number of bird species. There are 459 bird species have been recorded at the time of writing. They include in to 253 genera. Number of recorded bird families is 82. Out of them there are 34 endemic species found in the country. It has a high density of endemics when compare to the size of the country. Sri Lanka is a major center for migrant species because of its location in the Indian Ocean. There are large number of migrants (219 species) recorded in Sri Lanka (Wijeyeratne *et al.* 2015).

However, recent development projects taken place all over Sri Lanka including Southern Sri Lanka leads to a massive decline in available habitats for faunal groups including birds. The rapid development which has taken place all over the Southern province might have negatively affected on the natural habitats and their resident species. Habitat fragmentation is one of the major threats that is taken place in these areas. It is becoming an environmentally significant problem as it forms many edges in those fragmented habitats. Therefore this study mainly focused on the current status and the nature and significance of the Bird – Plant associations in the edges of the fragmented habitats.

MATERIALS AND METHODS

Study area

Three study sites were selected namely the premises of University of Ruhuna (UP), Matara (5°56'N 80° 34'E), Kirala Kele sanctuary (KK), Matara (5°58' N 80°32' E) and Baruthakanda (BK), Hambantota (6°13' N 81°04' E).

Edges of the study sites were studied as discussed by Baker et al 2002. The length of the study belts (edges) were 1200 m, 800 m and 400 m at UP, KK and BK respectively. Width of the study belts were 25 m (Baker *et al.* 2002). The first two study sites were located in Matara District (wet zone) where the mean annual temperature is 26.8 C and mean annual rainfall

is 2147 mm (source: Department of Meteorology) and latter site was located in Hambantota District (dry zone) where the mean annual temperature is 28.1 C and mean annual rainfall is 1316 mm (source: Department of Meteorology).

Reference sites were selected at UP and BK to obtain comparative data to identify habitat generalists and specialists as discussed by Carrara et al. 2015. In the KK study site, no reference site was selected as there was no suitable habitat to be selected as a reference site.

Landscape of the study sites

Selected three sites were highly fragmented due to different causes including both natural and human induced factors. Selected study site at the UP is located along the western margin of the university premises. It is mainly fragmented due to the construction of buildings including newly formed building complex of Faculty of Marine Sciences Technology, clearing forest area and adjacent agricultural land. Across the site the vegetation resembles open woodland type (Ashton *et al.* 1997). Reference site in the UP was located inside of the UP. Climate, vegetation type and other conditions in the reference site were same as in the edge site but reference site is non – fragmented.

KK, is a large marshy conserved wetland with an area of 1,800 ha, located 3 km away from Matara city. It comprises marshlands, irrigation canals and mangrove habitats that are best habitats for wetland biodiversity including large number of local and migratory birds and number of plants species. Selected study sites at the KK are fragmented due to the construction of roads, human settlements, urbanization and landfilling. Across the study site in the KK, the vegetation resembles woodland type (Ashton *et al.* 1997).

BK, is a secondary bush land (Ashton *et al.* 1997) where the land is highly fragmented due to commercial – scale solar power stations and construction of southern expressway. The majority of the flora contains bushes and few of isolated large trees. Reference site in the BK is located in the same geographical location that share same climatic condition and vegetation type. However, the reference site is a non – fragmented area.

Bird survey

Field studies were conducted over eight months from April 2016 to October 2016. Data were recorded at the line transect established in the study belt (The line transect method) (Gregory *et al.*, 2004, Baker *et al.* 2002) in regular intervals.

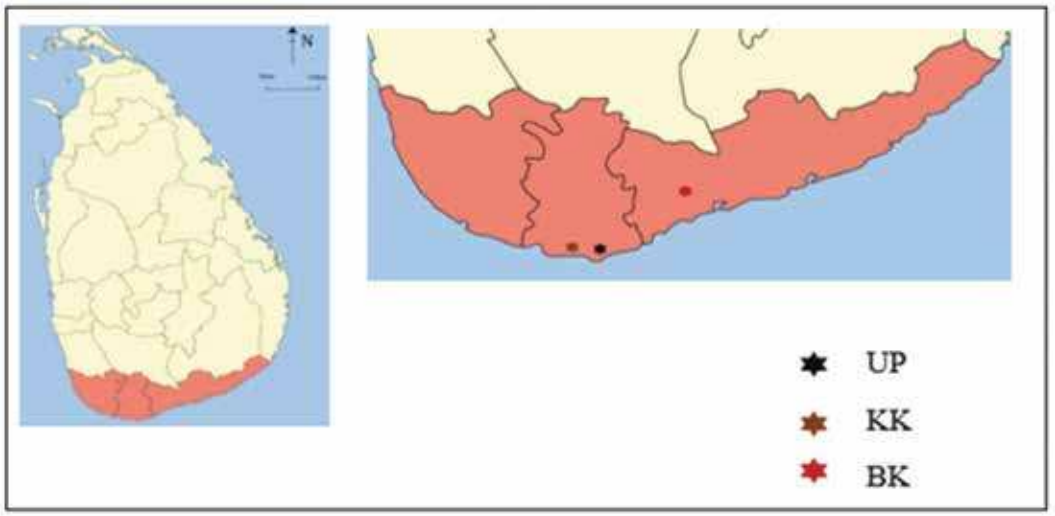


FIGURE 1: Location of the study sites

Bird survey was conducted in the morning (from 6.30 a.m. – 9.30 a.m.) and evening (3.30 p.m. – 6.30 p.m.) for each study site along pre – established study belts. General weather conditions were noted in each field visit (McCollin 1998). Birds were identified and counted while walking along the line transect at a speed of ~ 10m/min. Maximum effort was taken to avoid double counting as indicated by BBIRD protocol (Martin *et al.* 1997). Birds were identified by direct observations and birdcalls and locations were marked by GPS. Standard bird guides were used for identification of birds. (Harrison J.,2014; Kotagama S., 1998; Wijeyrathna G.D.S., 2015). Additionally bird survey was conducted at the plots (three plots ~200 m) established in the study belt of each study site. In the plot study, each plot was observed for 20 min.

Vegetation survey

Plots were established on study belts to sample vegetation (Martin *et al.*, 1997). Within a plot, dominant plant species and co – dominant plant species were identified and counted (Ashton *et al.* 1997, Martin *et al.* 1997).

Bird – plant associations

Bird – Plant associations were observed in field visits. Bird counts were taken and their association with the plant was recorded i.e. feeding, nesting, roosting and resting (Gandhi 2001). Specific assemblages of birds and plants in three study sites were identified. Habitat generalists (Species that use a variety of habitats including both interior and the edge) and habitat specialists (species inhabiting the edge and rarely found in interior habitats) were identified (Carrara *et al.* 2015). The generalists and specialists were also identified based on bird-plant associations through the comparative study. Data were collected in the same manner as followed in the edge habitat. Species with > 75% detections at a particular study site (Interior habitat and edge habitat) were identified as habitat specialists (Baker *et al.* 2002).

Data analysis

Species abundance, species richness, density and species diversity were calculated. (Nur *et al.* 1999). Species richness was calculated by Margalef's index. The diversity was calculated by Shannon – Wiener diversity index. Similarity was compared using Sorenson Similarity Index. Bird densities and plant densities were statistically compared using Non – parametric statistics (Kruskal – Wallis Test) using SPSS software (Version 16.0).

RESULTS

The bird diversity, plant diversity, Bird – Plant associations and species assemblages were different from each study site. During the

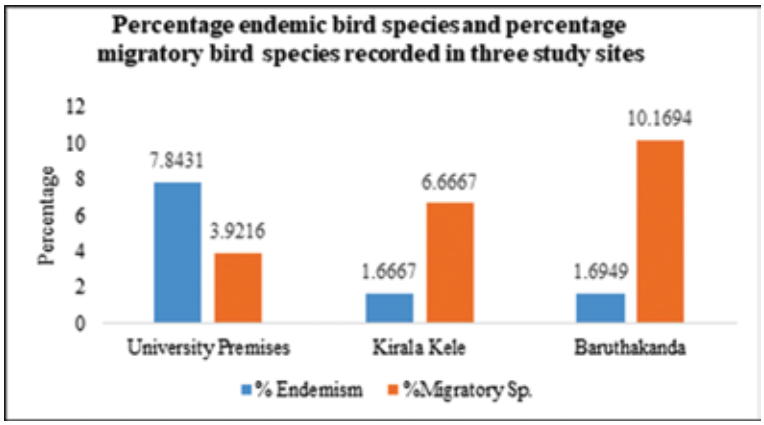


FIGURE 3: Location of the study sites

bird survey, 60 bird species belonging to 37 families were recorded in the KK. 51 bird species belonging to 33 families were recorded in the UP and 59 bird species belonging to 36 families were recorded in the BK. The ecological status of the birds is significant to each study site and there were major four ecological statuses i.e. Resident, Migrant, Endemic and Vagrant. Relatively high number of migratory species were observed in the BK study site when compare to other sites. Highest endemism was observed in the UP.

Species richness and diversity of bird species were highest in the KK (Margalef's species richness index = 17.62 and Shannon – Wiener diversity index = 4.305) when compare with other two sites. However, lowest species richness and diversity of birds were recorded for the BK (Margalef's species richness index = 12.6 and Shannon – Wiener diversity index = 3.6280). Highest similarity was between UP and KK study site (Cj = 2.2424) when compare to the similarity between other study sites. Some bird species were observed in all three study sites i.e. Asian Palm Swift, Barn Swallow, Black – hooded Oriole, Brahminy Kite, Common Mynah, Common Tailor Bird, Flame Minivet, Purple – rumped Sunbird, Red – vented Bulbul, Spotted Dove, White – browed Bulbul etc. Black – headed Cuckooshrike, Black – rumped Flameback, Oriental White – eye, Sri Lanka Grey Hornbill were observed only in the UP.

Black Drongo, Black – headed Ibis, Great Cormorant, Lesser Sand Plover, Lesser Whistling – duck, Painted Stork, Pheasant – tailed Jacana, Pied Kingfisher, Purple Swamphen and Wood Sandpipers were observed only in KK. Some bird species were only observed in BK i.e. Alpine Swift, Ashy Prinia, Barred Buttonquail, Chestnut – headed Bee – eater, Cinereous Tit, Common Iora, Grey – breasted Prinia, Indian Roller, Indian Swiflet, Jerdon's Bushlark, Little Green Bee –eater, Malabar Pied Hornbill, Paddyfield Pipit, Plain Prinia etc.

Mean bird density per ha was highest in the BK when compare to other study sites. According to that comparison, most of the common bird species were highly abundant at the BK study site. Number of frugivorous species such as Green Imperial Pigeons was law while omnivorous species such as common mynah, Red – vented bulbul, White – browed bulbul were relatively high. Meanwhile, there were large amount of insectivorous bird species can found in the BK study site.

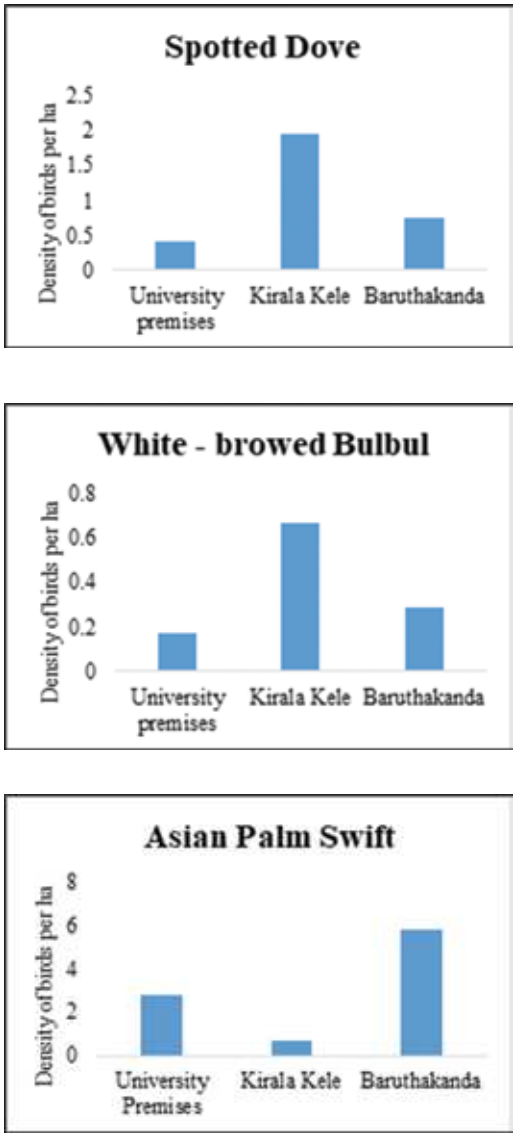
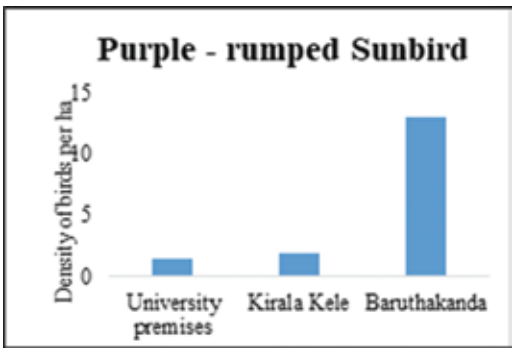
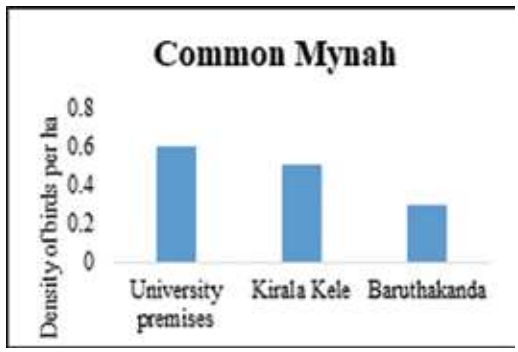
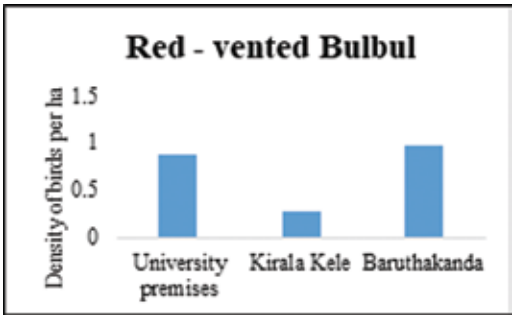
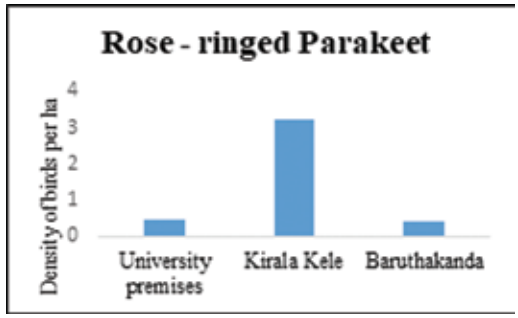


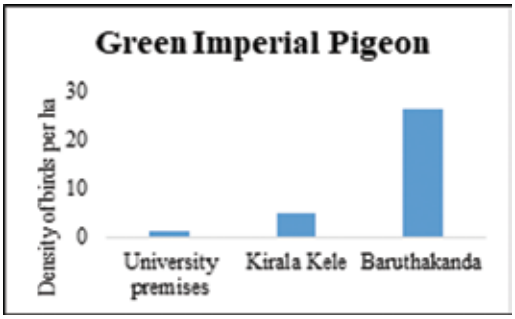
FIGURE 3: Comparison of Density of selected bird species per ha in three study sites

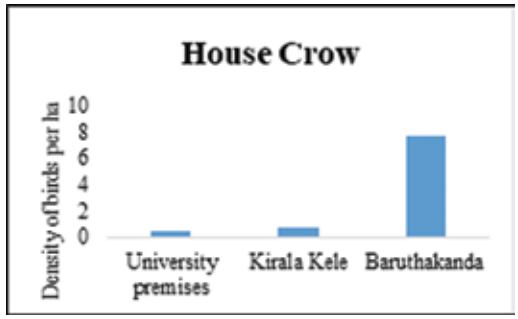


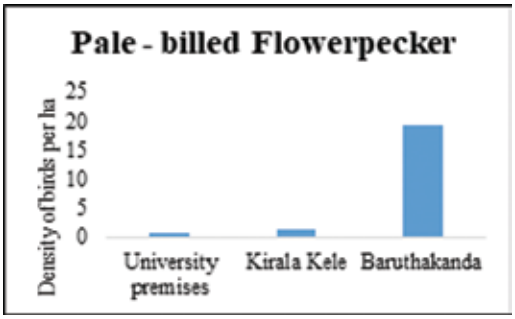












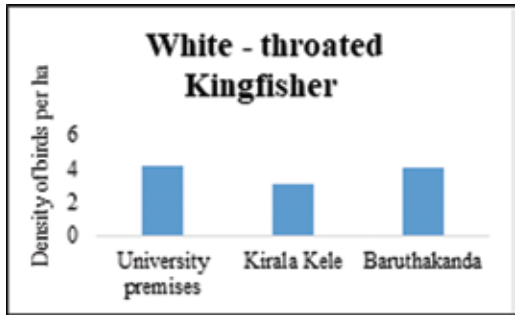
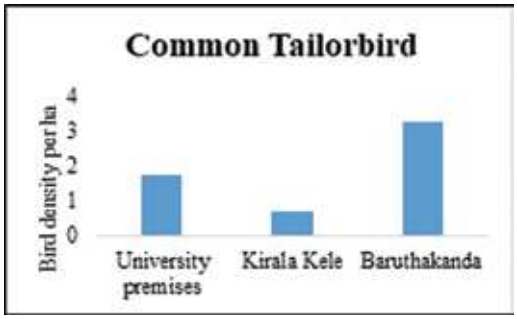


FIGURE 3: Comparison of Density of selected bird species per ha in three study sites (Contd.)



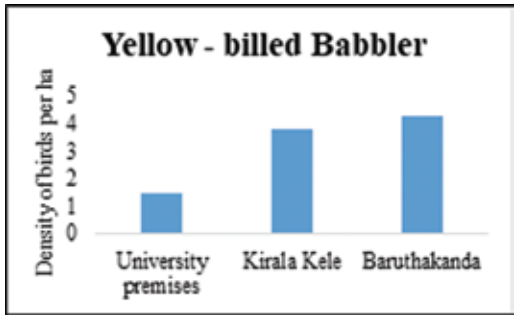


FIGURE 3: Comparison of Density of selected bird species per ha in three study sites (Contd.)

Vegetation is different to each study sites. Mean density of plant species among study sites is compared. Plant density was highest in the KK when compare with other two sites. Bird densities and plant densities were statistically compared using Non – parametric statistics (Kruskal Wallis Test) using SPSS software (Version 16.0). Chi – square value that obtained from Kruskal Wallis Test for both bird density and plant density was 6.489 ± 0.039. Therefore, there was a significant difference of bird density and plant density among three habitats.

There were different types of Bird – Plant associations observed in each study site during the study. Most of these associations were site specific and they were mainly based on the habits of bird species. Most of the bird species used plants for feeding, nesting, roosting and hiding / resting at the day time. Several Bird – Plant associations were identified in both University site and the BK site through the comparative study. Most of these associations were based on the habitat usage of birds with the association of plants. There was a significant association of bird species such as Bulbuls, Orioles, Drongos, Babblers and Doves and the *Acacia auriculiformis* in the KK. In the UP there was a significant association between Koels, Barbets, Fruit Pigeons and parakeets and the *Urostigma benghalense*.

Habitat generalists and habitat specialists were identified through the comparative study between an interior reference site and the edge in the UP. The composition of the plants in the

TABLE 01: Specific Bird – Plant associations in the UP

Bird species	**Plant species**	**Association**	**Frequency of occurrence**
Asian Koel (*Eudynamys scolopacea*)	Ahu (*Morinda citrifolia*)	Feeding, Resting	75.66%
Crimson – fronted Barbet (*Megalaima rubricapilla*)	Attikka (*Ficus racemosa*)	Feeding	80.00%
Brown – headed Barbet (*Megalaima zeylanica*)	Nuga (*Urostigma benghalens*)	Feeding	78.33%
Indian peafowl (*Pavo cristatus*)	Hawari Nuga (*Alstonia macrophylla*)	Roosting	86.67%
Yellow – billed babbler (*Turdoides affinis*)	Wal Beli (*Hibiscus tiliaceus*)	Resting	90.00%

TABLE 02: Specific Bird – Plant associations observed at the KK

Bird species	Plant species	Association	Frequency of occurrence
House Crow (*Corvus splendens*)	Coconut (*Cocos nucifera*)	Nesting	55.55%
Common Mynah (*Acridotheres tristis*)	Coconut (*Cocos nucifera*)	Nesting	66.67%
Purple – rumped Sunbird (*Nectarinia zeylonica*)	Siyambala (*Tamarindus indica*)	Feeding	77.78%
Red – vented Bubul (*Pycnonotus cafer*)	Acacia (*Acacia auriculiformis*)	Feeding	100.00%
Stork - billed Kingfisher (*Pelargopsis capensis*)	Kaha Mara (*Peltophorum pterocarpum*)	Resting	33.33%
Little Cormorant (*Phalacrocorax niger*)	Kirala (*Sonneratia caseolaris*)	Roosting	44.44%
Tri – colored Munia (*Lonchura malacca*)	Illuk (*Imperata cylindrica*)	Feeding	22.22%

TABLE 03: Specific Bird – Plant associations in the BK

Bird species	Plant species	Association	Frequency of occurrence
Purple – rumped Sunbird (*Nectarinia zeylonica*)	Katu Andara (*Prosopsis juliflora*)	Feeding	85.71%
Ashy Prinia (*Prinia socialis*)	Podi Singo Maran (*Chromolena odorata*)	Resting	78.43%
Bright Green Warbler (*Phylloscopus nitidus*)	Mayila (*Bauhinia racemosa*)	Nesting	92.86%

reference site was much similar to the edge. There were about 12 habitat specialists found in the UP while all the others were habitat generalists. *Rhopodytes viridirostris*, *Pelargopsis capensis* and *Ficedula zanthopygia* were found only in the edge of the UP while *Dinopium psarodes*, *Coracina macei*, *Zosterops palpebrosa*, *Pericrocotus flammeus* and *Tockus gingalensis* were observed only in the reference site of the UP.

In the BK there were 8 edge specific birds species i.e. *Phylloscopus nitidus*, *Parus cinereous*, *Phylloscopus fuscatus*, *Prinia hodgsonii*, *Mirafra affinis*, *Anthus rufulus*, *Dumetia hyperythra*, *Picoides mahrattensis* and 6 reference site specific bird species such as *Saxicoloides fulicata*, *Coracina melanoptera*, *Rhopodytes viridirostris*, *Tephrodornis affinis*, *Megalaima haemacephala* and *Upupa epops*.

DISCUSSION

Present study recorded 51 bird species belonging to 34 families including two critically endangered species in national conservation status (IUCN, 2012) and four endemic species in the UP which indicates a relative high diversity. In the reference site (inside) at the UP, 36 bird species were recorded belonging to 25 families. In the KK study site, 60 bird species were recorded belonging to 34 families. There were three near threatened species recorded at KK site. There were large numbers of migrants as well as endemic birds inhabiting in this area (IUCN, 2012). The total number of observed bird species was 59 belonging to 34 families in BK. The present study recorded a critically endangered species, an endangered species, a vulnerable species and two near threatened species in this area (IUCN, 2012).

The number of bird species, as well as their diversity, are strongly positively correlated with aspects of the structural complexity of vegetation (Domokos et al. 2016). Therefore, plant species richness, diversity and density are important factors that correlate with bird diversity and richness. In the UP the number of fruiting plants were comparatively high when compare with two other study sites. Hence large number of frugivorous birds feed in this site. As fruiting plants increased their numbers number of frugivorous birds might have increased in this site. This possibly indicates the positive correlation between the bird diversity and the vegetation.

As for the guidelines indicated by Ashton et al (1997) BK is a secondary bush land where the highest plant species richness was observed. The number of large trees, fruiting trees were relatively low in the Baruthakanda study site when compared to other sites. Number of bush species were relatively high and dominant along this study site. On the other hand, number of frugivorous birds were relatively low in this study site. This might indicate the correlation of fruigivorous bird with the fruiting plants in the study areas.

Plant species richness and density were almost equal in KK and UP. Similarly, bird species richness and diversity were almost equal in KK and UP. These data might indicate possible disturbances in the KK even it is a sanctuary as we expect more bird species in KK site. As for these data UP might be good habitat for bird species indicating the importance of the UP for the well – being and the survival of birds. Plant species richness was highest in BK and plant density was relatively high. Nevertheless, lowest bird diversity was recorded in this site indicating the possible effect of disturbances to the habitat and birds. Bird assemblages in the BK were different from two other study sites.

This might be partly due to both UP and KK study sites are open woodlands while BK is a secondary bushland (Ashton *et al.* 1997). Bird – plant associations are different from each other at all study sites. This indicates the uniqueness of each study site in terms of Bird – Plant Associations.

Majority of birds in the UP fed on plants rather than nesting and roosting. Both resident bird species in the UP and the visitor bird species from the adjacent lands used UP as a feeding ground. The density of frugivorous birds per ha in the UP was relatively high when compared with the other study sites. The reason might be the number of food trees available i.e. *Ficus racemosa* (Attikka), *Lannea coromandelica* (Hik) and *Urostigma benghalens* (Nuga). Importance of plants at UP for feeding should be further studied. However, conditions might not be favourable for nesting as the number of large trees and the density of tree cover was low at UP.

The usage of plants by birds in the KK was different from the UP site. Majority of birds used plants for nesting and roosting. At the same time they used them as a food source. However, the number of fruit trees in the study site was relatively low. There were specific roosting sites in the KK suitable for roosting. In KK, *Sonneratia caseolaris* (Kirala) was occupied by many bird species for roosting at the evening. Most aquatic bird species occupied adjacent marshland area for feeding and nesting. The importance of plants for roosting and nesting at KK should be further studied.

There were large number of insectivorous and omnivorous birds inhabiting the KK.

Mostly these insectivorous species associated with the flowering plants as those flowers might contain large number of different insects. For an example, Red – vented Bulbuls associated with flowers of the Acacia plant.

BK was highly rich with different types of bird species. Majority of them were insectivorous and omnivorous. Most bird species occupied plants for nesting and protection from the direct sunlight. There were relatively low number of fruiting plants in the study site when compare with the UP and KK. It assumed that a bird species is a forest – interior species if it is less abundant or absent in the edges (Brand *et al.* 2001). Species that require forest interior may avoid edges due to altered microclimate, vegetation structure and presence of predators near edges. At the same time there are some species that require edges rather than forest interior sites. However, biotic and abiotic differences between forest interior locations and the edges impact on the species composition depending on their breeding and foraging requirements (Baker 2002).

In the UP the observed number of bird species in the edge site (51 species) was relatively higher than the reference (inside) site (33 species). The edge was comprised with both aquatic and terrestrial bird species. The number of bird species in the edge was high because bird from two adjacent sites (Woodland and agricultural lands) inhabited in the edge. Similarly, in the Baruthakanda study site, the number of recorded bird species in the edge was relatively high (59 species) when compare with the reference site (49 species).

This clearly shows the site specificity of the birds. However, these edge effects remains diffuse and largely site specific (Sisk *et al.* 2002).

Some bird species such as House sparrow were highly associated with human settlements in the BK. On the other hand there were large number of Indian Peafowls were observed in the UP. Red – vented Bulbul was significantly high in the KK and the BK. Birds are good ecological indicators (Gregory *et al.* 2003) that can be used for the identification of the disturbances to the habitat. This significantly increase of selected species might be an indicator for the effect of the fragmentation on the selected ecosystem.

Birds are highly mobile creatures therefore they can move easily from one place to another when the conditions get harsh. Nevertheless the problem is these disturbances negatively influence on the community structure of birds as habitat fragmentation and its consequences lead to limit the territory of the bird species. Nevertheless, less mobile bird species such as Barred Buttonquails prone to high predation within these fragmented areas due the isolation and the limited areas (Murcia 1995).

Recent development projects taken place all over Sri Lanka especially in Southern Sri Lanka lead to a massive decline in available habitats for faunal groups including birds via the process of habitat fragmentation. It is becoming an environmentally significant problem as it forms many edges in those fragmented habitats. Edges are always disturbed and modified for various purposes without considering the conservation implications of these habitats. Nevertheless there were no published reports at the time of writing this report indicating the requirement of model/pilot studies in this field.

The major problem in these study sites is these areas are disturbed and modified for various purposes. Many species require more than one kind of habitat within a life cycle (Fahrig 2009). Nevertheless, with these disturbances it decrease the overall quality of the habitat. Disturbances and the modifications always alter the system that lead to the imbalances in the ecosystem. However, there are large number of birds especially critically endangered, endangered, near threatened and vulnerable bird species found in each study site. It is essential to follow proper conservation and management strategies for conserve these species.

When the conservation and management strategies operate, ecological status of birds, their association of the vegetation and the habitat usage should be taken in to the account. From the conservation dimension, first it has to identify which are the species that need the priority and then to undertake management practices to the benefit of the target species

(McCollin 1998).

Habitat enrichment is one of the best management strategy that can be undertaken. Especially in the UP new plants can be planted such as *Ficus racemosa* (Attikka), *Lannea coromandelica* (Hik), *Urostigma benghalens* (Nuga) and other fruit trees to provide more suitable feeding sites for birds. In the KK, it should take actions to clean polluted areas and should form a proper management system to get the permission to enter the sanctuary. BK where the highest density of birds can be found has to be well conserved while taking the benefits from the land. It can create a barrier zone at the BK and it can enrich by planting different plant species for the benefit of birds. Moreover it can minimize the disturbances and modifications done in the each study site. Meanwhile, it is essential to create an awareness among people about birds and their association with vegetation. Several conservation implications might be arise due to the lack of knowledge of people on this topic. Therefore suitable conservation and management strategies are essentially required for the protection of both birds, plants as well as their relationships.

CONCLUSION

Bird–Plant associations in the fragmented habitat edges in Sri Lanka were not reported in accessible literature. Some observed bird species in this study were totally edge specific. The number of bird species near an edge was comparatively high in some cases as the possible result of the edge effect. Highest number migratory species was observed in the BK while the highest endemism was observed in the UP. KK supports large number of bird species. Majority of birds used UP as a feeding ground, KK as a nesting and roosting site and BK as a resting and nesting site. These data indicate the specialty of habitats in terms of accommodation birds. Edges should be protected and enriched with broader conservation perspective.

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REFERENCES

Ashton, M.S., S. Gunatilleke, N. Zoysa, M.D. Dassanayake, N. Gunatilleke and S. Wijesundera, (1997). *A Field Guide to the Common Trees and Shrubs of Sri Lanka*. WHT Publication (Pvt.) Limited.

Baker, J., K. French, and R. Whelan, (2002). The edge effect and ecotonal species: Bird communities across a natural edge in southeastern Australia. *Research Online*, Retrieved from www.onlinelibrary.wiley.com

Bennett, A.F. and D.A. Saunders, (2010). Habitat fragmentation and landscape change. *Conservation Biology for all*, Oxford University Press, pp. 88 – 106

Brand, L.A. and T.L. George, (2001). Response to passerine birds to forest edge in coast redwood forest edge in coast redwood forest fragments. *The Auk* **118(3):** 678 – 686

Bunyan, M., S. Jose and R. Fletcher, (2012). Edge effects in small forest fragments: Why more is better? *American Journal of Plant Sciences* **3:**869 -878

Carrara, E., V. Arroyo – Rodriguez, J.H. Vega – Rivera, J.E. Schondube, S.M. Freitas and L. Fahrig, (2015). Impacts of landscape composition and configuration on forest specialists and generalists bird species in the fragmented Lacandona rainforest, Mexico. *Biological Conservation* **184:**117 – 126

Domokos, E. and J. Domokos, (2016). Bird communities of different woody vegetation types from the Niraj Valley, Romania. *Turkish Journal of Zoology* **40**

Fahrig, L. (2009). Effects of Habitat Fragmentation on Biodiversity. *Annual Review of Ecology, Evolution and Systematics* **34:**487 - 515

Fairl, J. M., E. Paul, J. Jones, A.B. Clark, A. Davie and G. Kaiser, (2010). Guidelines to the use of wild birds in research (Third Edition). Washington, D.C.: Ornithological Council.

Gandhi, T. (2001). *Birds and Plant Regeneration*, Sangam Book Ltd, India, pp. 1 – 70

Gregory, R.D., D.W. Gibbons and P.F. Donald, (2004). Bird census and survey techniques. *Suther* **02:**17 – 56

Gregory, R.D., D. Noble, R. Field, J. Marchant, M. Raven and D.W. Gibbons, (2003). Using birds as indicators of biodiversity. *Ornis Hungerica*, **12 – 13:** 11 – 24

Harrison, J. (2011). *A field guide to the birds of Sri Lanka (Second Edition)*, Oxford University Press, New York, US. 1 – 186

Herrera, C.M. (1984). A study of avian frugivores, bird – dispersed plants and their interaction in Mediterranean scrubland. *Ecological Monographs* **54(1):** 1 – 23

Holsinger, K.E. (2009). *Habitat Fragmentation*

Ikin, K., P.S. Barton, I.A. Stirnemann, J.R. Stein and D. Michael *et al.* (2014). Multi-Scale Associations between Vegetation Cover and Woodland Bird Communities across a Large Agricultural Region. *PLoS ONE* **9(5):** e97029.

Jayaweera, D.M.A. (1981). *Medicinal Plants (Indigenous and exotic) used in Ceylon* **Part 1 – 5** National Science Council of Sri Lanka, Colombo.

Jones, J. (2001). Habitat selection studies in avian ecology: a critical review. *The Auk* **118(2):**557 - 562

Joshi, K.K., D. Bhatt and A. Thapliyal (2012). Avian diversity and its association with vegetation structure in different elevational zones of Nainital district (Western Himalayan) of Uttarakhand. *International Journal of Biodiversity and Conservation* **4(11):** pp. 364-376

Lindell, C.A., K. Riffell, S.A. Kaiser, A.L. Battin, M.L. Smith, T.D. Sisk (2007). Edge responses of tropical and temperate birds. *The Wilson Journal of Ornithology* **119(2):**205 – 220

Martin, T.E., C. Paine, C.J. Conway, W.M. Hochachka, P. Allen, W. Jenkins, (1997). Breeding Biology Research & Monitoring Database – Montana Coop. *Wildlife Research Unit*. pp. 34 – 49

McCollin, D. (1998). Forest edges and habitat selection in birds: a functional approach

MOE. (2012). The National Red List 2012 of Sri Lanka; Conservation Status of the Fauna and Flora. Ministry of Environment, Colombo, Sri Lanka. pp. 114 – 134

Murcia, C. (1995). Edge effects in fragmented forests: implications for conservation. *Tree* **(10.2):** 58 – 62

Nur, N., S.L. Jones, G.R. Geupel, (1999). Statistical Guide to Data Analysis of Avian Monitoring Programs. *Biological Technical Publication BTP – R6001*

Ralph, C.J. (1985). Habitat Association Patterns of Forest and Steppe Birds of Northern Patagonia, Argentina. *The Condor* **87:**471483

Samarakoon, S.P. (2010). *Hela Flora*. Godage International Publishers.

Samarasekara, W.G.K.H., E.P.S. Chandana and N.J. De S. Amarasinghe, (2013). A note on bird – habitat relationship in Kiara Kele, Sri Lanka. *Taprobanica* **(05)01:** pp. 97 – 98

Sisk, T.D. and J. Battin, (2002). Habitat edges and avian ecology: Geographic patterns and insights for western landscapes. *Studies in Avian Biology* **25:**30 – 48

Whitworth, D., S. Newman, T. Mundkur and P. Harris, (2007). Wild birds and avian influenza: An introduction to applied field research and disease sampling techniques. *FAO Animal Health and Production Manual*, **(5):** 85 – 94

Wijeyeratne, G.S. (2015). *A Naturalist's Guide*

to the Birds of Sri Lanka. John Beaufoy Publishing Ltd, Oxford, England. pp. 16 – 173

Wormworth, J. and K. Mallon, (2016). *Bird Species and Climate Change: The Global Status Report* **Version 1.0**

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