JEB
Journal of Environmental Biology

Journal Home page : www.jeb.co.in
E-mail : editor@jeb.co.in

ISSN: 0254-8704 (Print)
ISSN: 2394-0379 (Online)
CODEN: JEBIDP

# Effects of logging and recovery process on avian richness and diversity in hill dipterocarp tropical rainforest-Malaysia

**Mohamed Zakaria Husin* and Muhammad Nawaz Rajpar**

Department of Recreation and Ecotourism, Faculty of Forestry, Universiti Putra Malaysia-43400, Serdang, Selangor Darul Ehsan, Malaysia

*Corresponding Authors Email : mzakaria@upm.edu.my

## Abstract

The effects of logging and recovery process on avian richness and diversity was compared in recently logged and thirty year post-harvested hill dipterocarp tropical rainforest, using mist-netting method. A total of 803 bird individuals representing 86 bird species and 29 families (i.e. 37.90% from recently logged forest and 62.10% from thirty year post-harvested forest) were captured from October 2010 to September, 2012. Twenty one bird species were commonly captured from both types of forests, 37 bird species were caught only in thirty year post-harvested forest and 28 bird species were caught only from recently logged forest. *Arachnothera longirostra* – Little Spiderhunter, *Malacopteron magnum* – Rufous-crowned Babbler, *Alophoixus phaeocephalus* – Yellow-bellied Bulbul and *Meiglyptes tukki* – Buff-necked Woodpecker were the most abundant four bird species in the thirty year post-harvested forest. On the contrary, seven bird species i.e., *Trichastoma rostratum* – White-chested Babbler, *Lacedo pulchella* – Banded Kingfisher, *Picus miniaceus* – Banded Woodpecker, *Enicurus ruficapillus* – Chestnut-naped Forktail, *Anthreptes simplex* – Plain Sunbird, *Muscicapella hodgsoni* – Pygmy Blue Flycatcher and *Otus rufescens* – Reddish Scope Owl were considered as the rarest (i.e. each represented only 0.12%). Likewise, *A. longirostra*, *Pycnonotus erythropthalmos* – Spectacled Bulbul, *P. simplex* – Cream-vented Bulbul and *Merops viridis* – Blue-throated Bee-eater were the most dominant and *Copsychus malabaricus* – White-rumped Shama *Eurylaimus javanicus* – Banded Broadbill *Ixos malaccensis* – Streaked Bulbul and *Harpactes diardii* – Diard's Trogon (each 0.12%) were the rarest bird species in recently logged forest. CAP analysis indicated that avian species in thirty year post-harvested forest were more diverse and evenly distributed than recently logged forest. However, recently logged forest was rich in bird species than thirty year post-harvested forest. The results revealed that logging and retrieval process affect bird species richness and diversity. However, bird species may respond differently from habitat to habitat i.e., forest logging causes disturbance of some avian species while recovery process may replace the loss of vegetation and harbour a wide array of avian species richness and diversity.

**Publication Info**

*Paper received:*
24 June 2013

*Revised received:*
28 October 2013

*Re-revised received:*
18 June 2014

*Accepted:*
22 September 2014

**Key words**

Birds, Dipterocarp, Logging, Mist-nets, Post-harvesting, Rainforest



## Introduction

The areas of highlands; largely dominated by overshadowing trees from the Dipterocarpaceae family called 'Hill Dipterocarp Forests are distributed on dry land just above sea level upto an altitude of approximately 900 m (WWF, 2013). The significant feature of hill dipterocarp forest is the presence of Seraya (*Shorea sp.*) large size trees which most frequently grow on hill ridges with prolific undergrowth of *Eugeisonna tristis* (Bertam palm) and *Oncosperma horridum* (Thorny palm tree). These forests are most diverse in vegetation structure and composition which support a diversity of wildlife species, directly or indirectly depending on the forests for survival. A wide array of avian species utilize these unique forests to perform multiple actions.

The dipterocarp tropical rainforests are 30 million years old forest of Asia and most productive (FAO, 2001; Raunter *et al.*, 2002). They formed the cradle of life on earth and support a substantial proportion of the world's biodiversity (Myers *et al*., 2000; Kettle, 2010). The Asian dipterocarp forest can be divided into two zones: the moist tropical forest and dry tropical forest (Collins *et al*., 1991). Malaysia is blessed with 1641.0 million ha (Peninsular Malaysia; 5.38 mh, Sabah; 3.83 mh and Sarawak; 7.20 mh) of dipterocarp tropical rainforest. Dipterocarp tropical rainforest is divided into two categories Hill Dipterocarp tropical rainforest and Lowland Dipterocarp tropical rainforest. These forests have been declared as permanent forest reserve and are vital economic as well as ecologically important to the country.

In Malaysia these forests are managed by Selective Logging Management System (SMS), in which selected tree species above 50 cm dbh had been felled to reduced the impact of logging and the rest are left to form the next cut in 30 years (Tang, 1987; Sheil and van Heist, 2000; Jennings *et al*., 2001). In addition, few mother trees *i.e.*, advanced relicts has been left to provide a sufficient seed and to enhance the seedling regeneration (Appanah and Weinland, 1990). SMS is least detrimental to wildlife species in tropical forests (Grove, 2002; Meijaard and Sheil, 2008) and is considered as more flexible management system to maintain highly variable forest in the hilly terrain (Appanah, 1998), to ensure the forest renewal and obtained yield on sustainable basis. These forests have been protected under National Forestry Act (1984).

Despite their richness in faunal diversity, these forests are being destroyed and degraded at an alarming rate due to anthropogenic activities such as urbanization and conversion into agricultural fields, which cause fragmentation and isolation (Fitzherbert *et al*., 2008; Clark *et al*., 2009; Edwards *et al*., 2011). It has been reported that approximately 50% of tropical forest areas of Southeast Asia have been degraded or are lost due to human intervention such as logging, urbanization, conversion into agricultural fields (Laurance, 1999; DeFries *et al*., 2005; Wright, 2005). The habitat loss and degradation have a serious affect on wildlife species (Koh *et al*., 2004; Cardillo *et al*., 2005). Forest logging directly or indirectly reduces the habitat suitability of forest fauna (Potts, 2011) such as butterflies, fish, and mammals (Brooke *et al*., 2003), birds (Sehgal, 2010) and monkeys (Collins, 2008). Due to logging, the forest becomes fragmented, more irregular and isolated, which affects distribution, richness and diversity of avian species.

Information regarding the effect of forest logging and recovery process on wildlife species is not sufficient and to understand the effects is needed more investigation . Hence, the avian richness and diversity in recently logged and thirty year post-harvested hill dipterocarp rainforest was studied so that the effects of logging and recovery process on avian richness and diversity can be understood and important steps could be taken for future direction and conservation activities.

## Materials and Methods

**Study area :** The Berkelah Hill Dipterocarp Rainforest Reserve Maran, examined in this study, is located between 2° 57' 43" N, 101° 41' 47" E in Phang Darul Makumar (Fig. 1). This hill dipterocarp rainforest consists of a mixture of undisturbed primary forest and different aged post-harvested forests. Recently logged forest and thirty year post-harvested forest in this forest reserve was selected to examine the effect of logging and recovery on avian richness and diversity after logging. Because, the habitat structure and composition of recently logged and thirty years recovered forest provide information on the effects of logging and recovery on avian species composition and structure (Johns, 1986; Samejima *et al*., 2012). The other reason for selecting these two habitats was forest variation in vegetation composition and structures such as recently logged hill dipterocarp rainforest was dominated with woody vegetation having less than 14 cm dbh such as young seedlings of dipterocarp trees and shrubs; where as thirty year post-harvested hill dipterocarp rainforest was dominated by mature trees (having diameter 30-60 cm dbh and around 85.0% canopy cover) and shrubs. The variation in vegetation cover, species composition and structure created different microhabitat which attracted a variety of avian species.

**Bird survey :** Bird species were caught with ten mist-nets (14 x 4 m with 3 pockets) at 86 sampling sites in both the forests (*i.e.*, 43 sampling sites in recently logged and 43 sampling sites in thirty year post-harvested hill dipterocarp rainforest). The netting was done for a total of 3,096 hrs or 258 days (129 days or 1548 hrs in recently logged and 129 days or 1548 hrs in thirty year post-harvested forest) from October 2010 to September, 2012. The nets were stretched between two bamboo poles and poles were fixed into soil and the lower end of the net was kept on the ground to capture all types of birds at different locations. These were opened during 07:00-19:00 hrs, monitored hourly and placed for

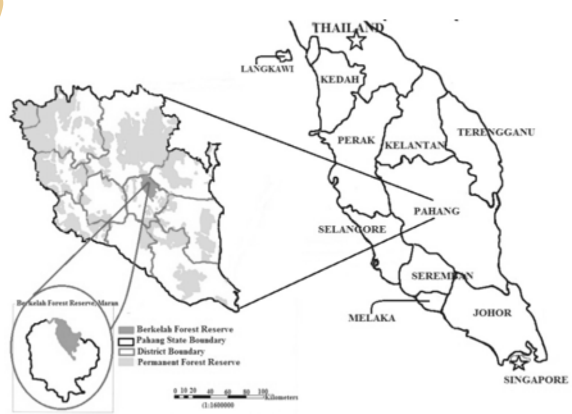


**Fig. 1 :** Location map of Berkelah Forest Reserve Maran, Pahang, Malaysia

three days on the same sampling site and then transferred to the new site. Three days netting was sufficient to capture most of the birds as after three days, birds may become familiar with the mist nets (Robbins *et al*., 1992). Each individual bird was tagged with a numbered aluminium ring on the right tarsus and photographed before the release (Robson, 2002).

**Data analysis**

**Relative abundance (%) :** Relative abundance refers to the number of individuals of a particular species as percent of the total capture in both areas. It was estimated for each species using average detection values calculated by dividing total number of species sighted in both forests. However, recaptured bird individuals were not included in the analysis to obtain reliable results and avoid the bias. The relative abundance (%) of bird species was estimated using the following expression: Relative abundance = n/N x 100

Where: n is the number of a particular captured bird species while N is the total number captured bird species.

**Bird diversity indices :** Diversity indices are major aspects of species structure in an avian community because it indicates the importance of particular dwelling forest habitat for different bird species. Species diversity is an index that measures species variation in a community and incorporates not only the numbers of species in an area but also takes into account species relative abundance. Therefore, the index provides more information about community composition such as rarity and commonness of a bird species in a community. These indices are used to understand the habitat's preferences by avian species. Avian species diversity, species richness and species evenness in the study areas, was analyzed using Community Analysis Package Software (CAP, Version 4.0) (Henderson and Seaby, 2007).

Shannon's diversity index: $H = -\Sigma (n_i/n) \ln (n_i/n)$

Where: $n_i = \Sigma$ individuals of species *i*, and $n = \Sigma$ individuals of all species.

Species richness is the number of different species in a given area. It also provides information on homogeneity and rarity of species. Margalef's richness index: $R = S\text{-}1/\ln(n)$

Where: $S = \Sigma$ species in plot; $n = \Sigma$ individuals of all species.

Evenness is a measure of relative abundance of different species of a particular area.

## Results and Discussion

A total of 803 bird individuals were captured using mist-netting (i.e. 37.90% from recently logged forest and thirty year post-harvested hill dipterocarp rainforest; 62.10%), representing 86 bird species and 29 families. In comparison, 21 bird species were commonly captured from both forest types, 37 bird species were caught in thirty year post-harvested forest which were absent in recently logged forest. Likewise, 28 bird species were detected in recently logged forest but were absent in thirty year old logged forest.

Mist-netting method captured a total of 499 bird individuals of 58 species belonging to 20 families in thirty year post-harvested forest. *Arachnothera longirostra* – Little Spiderhunter, *Malacopteron magnum* – Rufous-crowned Babbler, *Alophoixus phaeocephalus* – Yellow-bellied Bulbul and *Meiglyptes tukki* – Buff-necked Woodpecker were four most abundant bird species. On the contrary, seven bird species i.e., *Trichastoma rostratum* – White-chested Babbler, *Lacedo pulchella* – Banded Kingfisher, *Picus miniaceus* – Banded Woodpecker, *Enicurus ruficapillus* – Chestnut-naped Forktail, *Anthreptes simplex* – Plain Sunbird, *Muscicapella hodgsoni* – Pygmy Blue Flycatcher and *Otus rufescens* – Reddish Scope Owl were rare (*i.e.,* each represented only 0.12%) in thirty year post-harvested forest (Table 1).

A total of 304 bird individuals of 49 species representing 21 families were captured through mist-nets in recently logged forest. *Arachnothera longirostra* – Little Spiderhunter, *Pycnonotus erythropthalmos* – Spectacled Bulbul, *Pycnonotus simplex* – Cream-vented Bulbul and *Merops viridis* – Blue-throated Bee-eater were most dominant; while four species *i.e., Copsychus malabaricus* – White-rumped Shama *Eurylaimus javanicus* – Banded Broadbill *Ixos malaccensis* – Streaked Bulbul and *Harpactes diardii* – Diard's Trogon (each 0.12%) were rare in recently logged forest (Table 1).

A total of 29 families were recorded in recently logged and thirty year post-harvested forest. Out of these, 21 families were detected in recently logged forest while 20 families were sampled from thirty year post-harvested forest. Pycnonotidae (10.46%), Nectariniidae (5.60%) and Timaliidae (5.35%) were three most dominant families and Trogonidae was the rarest family (i.e., 0.12%) in recently logged forest based on the number of bird individual catches. Likewise, Timaliidae (17.93%), Nectariniidae (14.07%) and Pycnonotidae (7.72%) were three most common families with highest relative abundance in thirty year post-harvested forest. In comparison, thirteen families *i.e.,* Turdidae, Corvidae, Rhipuduridae, Eurylaimidae, Meropidae, Dicaeidae, Pittidae, Podargidae, Oriolidae, Trogonidae, Irenidae, Ramphastidae and Strigidae (each 0.12%) were rare in thirty year post-harvested forest. Eight avian families were absent in recently logged forest and nine bird families were absent in thirty year post-harvested forest (Table 2).

Community Analysis Package (PCA) Version 4.0 used to determine the avian diversity indices of recently logged and thirty year post-harvested hill dipterocarp rainforest at Berkelah Reserve. CAP analysis indicated that thirty year post-harvested

**Table 1 :** Bird species composition with relative abundance in recently logged and thirty year post-harvested hill dipterocarp rainforest at Berkelah Reserve Maran, Phang Selangor–Malaysia.

| Family | Scientific Name | Common name | Recently logged forest no of captures | % | Thirty year old logged forest no of captures | % |
|---|---|---|---|---|---|---|
| Nectariniidae | *Arachnothera longirostra* | Little Spiderhunter | 28 | 3.49 | 94 | 11.71 |
| Timaliidae | *Malacopteron magnum* | Rufous-crowned Babbler | 11 | 1.37 | 55 | 6.85 |
| Pycnonotidae | *Alophoixus phaeocephalus* | Yellow-bellied Bulbul | 4 | 0.50 | 32 | 3.99 |
| Picidae | *Meiglyptes tukki* | Buff-necked Woodpecker | 7 | 0.87 | 31 | 3.87 |
| Timaliidae | *Stachyris poliocephala* | Grey-headed Babbler | 0 | 0 | 28 | 3.50 |
| Alcedinidae | *Ceyx rufidorsa* | Rufous-backed Kingfisher | 0 | 0 | 20 | 2.50 |
| Muscicapidae | *Philentoma pyrhoptera* | Rufous-winged Philentoma | 4 | 0.50 | 17 | 2.12 |
| Nectariniidae | *Hypogramma hypogrammicum* | Purple-naped Sunbird | 0 | 0 | 14 | 1.75 |
| Timaliidae | *Stachyris erythroptera* | Chestnut-winged Babbler | 6 | 0.75 | 13 | 1.63 |
| Muscicapidae | *Copsychus malabaricus* | White-rumped Shama | 1 | 0.12 | 13 | 1.63 |
| Timaliidae | *Stachyris nigricollis* | Black-throated Babbler | 0 | 0 | 13 | 1.63 |
| Turdidae | *Luscinia cyne* | Siberian Blue Robin | 4 | 0.50 | 11 | 1.37 |
| Monarchidae | *Terpsiphone paradisi* | Asian Paradise Flycatcher | 0 | 0 | 11 | 1.37 |
| Timaliidae | *Trichastoma bicolor* | Ferruginous Babbler | 0 | 0 | 10 | 1.25 |
| Pycnonotidae | *Alophoixus ochraceus* | Ochraceous Bulbul | 2 | 0.25 | 9 | 1.12 |
| Timaliidae | *Stachyris maculata* | Chestnut-rumped Babbler | 0 | 0 | 8 | 1.00 |
| Pycnonotidae | *Tricholestes criniger* | Hairy-backed Bulbul | 4 | 0.50 | 7 | 0.87 |
| Alcedinidae | *Alcedo atthis* | Common Kingfisher | 0 | 0 | 7 | 0.87 |
| Alcedinidae | *Ceyx erithaca* | Black-backed Kingfisher | 0 | 0 | 6 | 0.75 |
| Monarchidae | *Hypothymis azurea* | Black-naped Monarch | 0 | 0 | 5 | 0.63 |
| Corvidae | *Platylophus galericulatus* | Crested Jay | 0 | 0 | 5 | 0.63 |
| Timaliidae | *Malacopteron magnirostre* | Moustached Babbler | 0 | 0 | 5 | 0.63 |
| Rhipuduridae | *Rhipidura perlata* | Spotted Fantail | 0 | 0 | 5 | 0.63 |
| Eurylaimidae | *Eurylaimus javanicus* | Banded Broadbill | 1 | 0.12 | 4 | 0.50 |
| Pycnonotidae | *Ixos malaccensis* | Streaked Bulbul | 1 | 0.12 | 4 | 0.50 |
| Timaliidae | *Pellorneum capistratum* | Black-capped Babbler | 0 | 0 | 4 | 0.50 |
| Muscicapidae | *Rhinomyias umbratilis* | Grey-chested Jungle Flycatcher | 0 | 0 | 4 | 0.50 |
| Picidae | *Blythipicus rubiginosus* | Maroon Woodpecker | 0 | 0 | 4 | 0.50 |
| Pycnonotidae | *Pycnonotus erythropthalmos* | Spectacled Bulbul | 22 | 2.74 | 3 | 0.37 |
| Meropidae | *Merops viridis* | Blue-throated Bee-eater | 19 | 2.37 | 3 | 0.37 |
| Pycnonotidae | *Pycnonotus bruuneus* | Redeye Bulbul | 13 | 1.62 | 3 | 0.37 |
| Pittidae | *Pitta guajana* | Banded Pitta | 0 | 0 | 3 | 0.37 |
| Dicaeidae | *Prionochilus percussus* | Crimson-breasted Flowerpecker | 0 | 0 | 3 | 0.37 |
| Podargidae | *Batrachostomus stellatus* | Gould's Frogmouth | 0 | 0 | 3 | 0.37 |
| Picidae | *Sasia abnormis* | Rufous Piculet | 0 | 0 | 3 | 0.37 |
| Timaliidae | *Malacocincla malaccensis* | Short-tailed Babbler | 0 | 0 | 3 | 0.37 |
| Pycnonotidae | *Pycnonotus simplex* | Cream-vented Bulbul | 22 | 2.75 | 2 | 0.25 |
| Nectariniidae | *Archnothera modesta* | Grey-breasted Spiderhunter | 11 | 1.37 | 2 | 0.25 |
| Alcedinidae | *Alcedo meninting* | Blue-eared Kingfisher | 9 | 1.12 | 2 | 0.25 |
| Oriolidae | *Oriolus xanthonotus* | Dark-throated Oriole | 4 | 0.50 | 2 | 0.25 |
| Timaliidae | *Malaconcincla sepiaria* | Horsfield's Babbler | 2 | 0.25 | 2 | 0.25 |
| Irenidae | *Irena puella* | Asian Fairy-bluebird | 0 | 0 | 2 | 0.25 |
| Pycnonotidae | *Pycnonotus melanoleucos* | Black-and-white Bulbul | 0 | 0 | 2 | 0.25 |
| Alcedinidae | *Alcedo euryzona* | Blue-banded Kingfisher | 0 | 0 | 2 | 0.25 |
| Ramphastidae | *Calormphus fuliginosus* | Brown Barbet | 0 | 0 | 2 | 0.25 |
| Picidae | *Picus mentalis* | Checker-throated Woodpecker | 0 | 0 | 2 | 0.25 |
| Trogonidae | *Harpactes orrhophaeus* | Cinnamon-rumped Trogon | 0 | 0 | 2 | 0.25 |
| Timaliidae | *Malacopteron affine* | Sooty-capped Babbler | 0 | 0 | 2 | 0.25 |
| Nectariniidae | *Arachnothera magna* | Streaked Spiderhunter | 0 | 0 | 2 | 0.25 |
| Muscicapidae | *Eumyias thalassinus* | Verditer Flycatcher | 0 | 0 | 2 | 0.25 |
| Timaliidae | *Trichastoma rostratum* | White-chested Babbler | 3 | 0.37 | 1 | 0.12 |
| Alcedinidae | *Lacedo pulchella* | Banded Kingfisher | 0 | 0 | 1 | 0.12 |
| Picidae | *Picus miniaceus* | Banded Woodpecker | 0 | 0 | 1 | 0.12 |
| Muscicapidae | *Enicurus ruficapillus* | Chestnut-naped Forktail | 0 | 0 | 1 | 0.12 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Nectariniidae | *Anthreptes simplex* | Plain Sunbird | 0 | 0 | 1 | 0.12 |
| Muscicapidae | *Muscicapella hodgsoni* | Pygmy Blue Flycatcher | 0 | 0 | 1 | 0.12 |
| Strigidae | *Otus rufescens* | Reddish Scope Owl | 0 | 0 | 1 | 0.12 |
| Muscicapidae | *Ficedula zanthopygia* | Yellow-rumped Flycatcher | 0 | 0 | 1 | 0 |
| Timaliidae | *Malacopteron cinereum* | Scaly-crowned Babbler | 16 | 1.99 | 0 | 0 |
| Cisticolidae | *Orthotomus atrogularis* | Dark-necked Tailorbird | 9 | 1.12 | 0 | 0 |
| Turdidae | *Copsychus saularis* | Oriental Magpie Robin | 9 | 1.12 | 0 | 0 |
| Eurylaimidae | *Cymbirhynchus macrorhynchos* | Black-and-red Broadbill | 8 | 1.00 | 0 | 0 |
| Cuculidae | *Cacomantis merulinus* | Plaintive Cuckoo | 8 | 1.00 | 0 | 0 |
| Laniidae | *Lanius cristatus* | Brown Shrike | 7 | 0.87 | 0 | 0 |
| Hirundinidae | *Hirundo rustica* | Barn Swallow | 6 | 0.75 | 0 | 0 |
| Nectariniidae | *Arachnothera flavigaster* | Spectacled Spiderhunter | 6 | 0.75 | 0 | 0 |
| Pycnonotidae | *Pycnonotus finalysoni* | Stripe-throated Bulbul | 6 | 0.75 | 0 | 0 |
| Aegithinidae | *Aegithina viridissima* | Green Iora | 5 | 0.63 | 0 | 0 |
| Laniidae | *Lanius tigrinus* | Tiger Shrike | 5 | 0.63 | 0 | 0 |
| Muscicapidae | *Muscicapa dauurica* | Asian Brown Flycatcher | 4 | 0.50 | 0 | 0 |
| Campephagidae | *Hemipus hirundinaceus* | Black-winged Flycatcher Shrike | 4 | 0.50 | 0 | 0 |
| Pycnonotidae | *Pycnonotus eutilotus* | Puff-backed Bulbul | 4 | 0.50 | 0 | 0 |
| Chloropseidae | *Chloropsis cochinchinensis* | Blue-winged Leafbird | 3 | 0.37 | 0 | 0 |
| Timaliidae | *Macronus ptilosus* | Fluffy-backed Tit-Babbler | 3 | 0.37 | 0 | 0 |
| Falconidae | *Microhierax fringillarius* | Black-thighed Falconet | 2 | 0.25 | 0 | 0 |
| Pycnonotidae | *Iole olivacea* | Buff-vented Bulbul | 2 | 0.25 | 0 | 0 |
| Eurylaimidae | *Calyptomena viridis* | Green Broadbill | 2 | 0.25 | 0 | 0 |
| Pycnonotidae | *Pycnonotus cyaniventris* | Grey-bellied Bulbul | 2 | 0.25 | 0 | 0 |
| Chloropseidae | *Chloropsis cyanopogon* | Lesser Green Leafbird | 2 | 0.25 | 0 | 0 |
| Muscicapidae | *Ficedula mugimaki* | Mugimaki Flycatcher | 2 | 0.25 | 0 | 0 |
| Pycnonotidae | *Pycnonotus plumosus* | Olive-winged Bulbul | 2 | 0.25 | 0 | 0 |
| Dicaeidae | *Dicaeum trignostigma* | Orange-bellied Flowerpecker | 2 | 0.25 | 0 | 0 |
| Timaliidae | *Macronus gularis* | Pin-striped Tit-Babbler | 2 | 0.25 | 0 | 0 |
| Cisticolidae | *Prinia rufescens* | Rufescent Prinia | 2 | 0.25 | 0 | 0 |
| Estrildidae | *Lonchura leucogastra* | White-bellied Munia | 2 | 0.25 | 0 | 0 |
| Trogonidae | *Harpactes diardii* | Diard's Trogon | 1 | 0.12 | 0 | 0 |
| | | **Total** | **304** | | **499** | |

forest was more diverse and evenly distributed with avian species as compared to recently logged forest. However, later was rich in bird species than thirty year post-harvested forest (Table 3).

Birds are bio-indicators of forest ecosystem health as they are conspicuous and easy to study and are closely associated with vegetation diversity and richness. The recording of 58 bird species in the thirty year post-harvested hill dipterocarp forest and 49 bird species in recently logged forest indicated that birds may exploit all types of vegetated areas and forest logging effects on avian distribution, richness and diversity. Difference in avian species is due to variation in vegetation structure and composition. The heterogeneity of vegetation effects avian communities by providing food, habitat and shelter (Belisle *et al*., 2001). Marquez *et al.* (2004) stated that avian richness is associated with the distribution and diversity of food resources. The results of this study showed that habitat preference in bird species may vary depending on foraging behaviour, food selection and niches, as some birds occupy canopy to prey on flies and also forage on fruits, while others select understorey to hunt on caterpillars and worms, some select ground cover to feed on beetles, worms and grass seeds, some select forest edges, some inhabit riparian vegetation such as streams and river side while others prey on flying insects through sallying and catch their prey on wing.

Recording of higher species diversity and richness in thirty year post-harvested hill dipterocarp forest indicated that after logging, recovery process may effect avian distribution and diversity. Recovery process replaces the loss of vegetation and harbours a wide array of avian species richness and diversity that can accommodate higher avian richness and diversity (Ellwood *et al*., 2002; Ellwood and Foster, 2004). This might be due to availability of heterogeneous vegetation layers which provide shelter from predators and harsh weather and also provide suitable foraging, perching and nesting sites for a variety of bird species. During thirty year recovery process many plant species were matured and started bearing flowers and fruits which attract highest number of insects (bees, wasps, butterflies, moths, beetles and flies), a major dietary components of avian species. Flowers and fruits also attract variety of insects, which too are major diet of insect and fruit eating bird species. Silva and Brandao (2010) reported that invertebrate density is strongly associated with vegetation structure, leaf litter and may vary at

**Table 2 :** List of bird families based on the number of bird individuals captured through mist-nets in recently logged and thirty year post-harvested hill dipterocarp rainforest at Berkelah Reserve Maran, Phang Selangor-Malaysia

| Family | Recently logged forest | | Thirty year post-harvested forest | |
|---|---|---|---|---|
| | No of capture individual | % | No of capture individual | % |
| Pycnonotidae | 84 | 10.46 | 62 | 7.72 |
| Nectariniidae | 45 | 5.60 | 113 | 14.07 |
| Timaliidae | 43 | 5.35 | 144 | 17.93 |
| Meropidae | 19 | 2.37 | 3 | 0.37 |
| Turdidae | 13 | 1.63 | 11 | 1.37 |
| Laniidae | 12 | 1.49 | 0 | 0 |
| Cisticolidae | 11 | 1.37 | 0 | 0 |
| Eurylaimidae | 11 | 1.37 | 4 | 0.50 |
| Muscicapidae | 11 | 1.37 | 39 | 4.86 |
| Alcedinidae | 9 | 1.12 | 38 | 4.73 |
| Cuculidae | 8 | 1.00 | 0 | 0 |
| Picidae | 7 | 0.87 | 41 | 5.11 |
| Hirundinidae | 6 | 0.75 | 0 | 0 |
| Aegithinidae | 5 | 0.63 | 0 | 0 |
| Chloropseidae | 5 | 0.63 | 0 | 0 |
| Campephagidae | 4 | 0.50 | 0 | 0 |
| Oriolidae | 4 | 0.50 | 2 | 0.25 |
| Dicaeidae | 2 | 0.25 | 3 | 0.37 |
| Estrildidae | 2 | 0.25 | 0 | 0 |
| Falconidae | 2 | 0.25 | 0 | 0 |
| Trogonidae | 1 | 0.12 | 2 | 0.25 |
| Corvidae | 0 | 0 | 5 | 0.63 |
| Irenidae | 0 | 0 | 2 | 0.25 |
| Monarchidae | 0 | 0 | 16 | 1.99 |
| Pittidae | 0 | 0 | 3 | 0.37 |
| Podargidae | 0 | 0 | 3 | 0.37 |
| Ramphastidae | 0 | 0 | 2 | 0.25 |
| Rhipuduridae | 0 | 0 | 5 | 0.63 |
| Strigidae | 0 | 0 | 1 | 0.12 |
| Total | **304** | | **499** | |

**Table 3** : Diversity indices of bird species in recently logged and thirty year post-harvested hill dipterocarp rainforest at Berkelah Reserve Maran, Phang Selangor–Malaysia

| Index | Recently logged forest | Thirty year post-harvested forest |
|---|---|---|
| Fisher's Alpha | 16.52 | 16.98 |
| Margalef's Richness index $R_1$ | 8.40 | 9.81 |
| McIntosh Evenness index E | 0.93 | 0.85 |

spatial scales of a few meters. Likewise, Peters *et al.* (2013) also reported that invertebrate communities of the tropical rain forest were highly diverse in a diversity of vegetation.

The recordings of 21 common bird species in both habitats, demonstrated that forest logging didn't affect all avian species. Likewise recording of 37 bird species only in thirty year post-harvested hill dipterocarp forest, revealed that few bird species extensively depended on dense vegetation and avoid utilizing open canopy forested areas. Similarly 28 bird species, captured, only in recent logged forest, highlighted that these bird species preferred open area devoid of vegetation or scattered trees and avoided using dense forest for foraging, perching and shelter. This might be that selective logging may increase habitat heterogeneity (Thiollay, 1992; Davis *et al*., 2001) that offers diverse resources for them. This indicated that bird species responded differently to logging, however, the effect of logging varied from species to species and habitat to habitat. Forest logging results in opening of areas (Johns, 1988) which led to increase in temperature and decrease in relative humidity (Jackson *et al*., 2002). Bird species inhabiting open areas indicated higher resilience to disturbance and bird species utilizing thirty year old logged forest showed less resilience to disturbance and sensitiveness to disturbance. Bird richness and diversity increased with recovery after logging because tree diversity and richness affected food availability and accessibility, which ultimately influenced bird distribution and diversity.

The findings of this study showed that habitat selection among bird species varied and bird species responded differently to logging and recovery process. The effects of forest logging and recovery process varied from species to species and habitat to habitat depending on the logging system, time period and stages of recovery process.

## References


Appanah, S.: Management of Natural forest. In: A Review of Dipterocarp Taxonomy, Ecology and Silviculture (Eds.: S. Appanah and J.M. Turnbull). *Centre Int. For. Res., Bogor, Indonesia*. pp. 223 (1998).

Appanah, S. and J.M. Turnbull: A Review of Dipterocarps Taxonomy, Ecology and Silviculture. *Center Int. For. Res., Bogor, Indonesia*. pp. 223 (1998).

Appanah, S. and G. Weinland: Will the management of hill dipterocarp forests, stand up? *J. Tropi. For. Sci.*, **3**, 140–158 (1990).

Bélisle, M., A. Desrochers and M.J. Fortin: Influence of forest cover on the movements of forest birds: A homing experiment. *Ecol.*, **82**, 1893–1904 (2001).

Brook, B.W., N.S. Sodhi and P.K.L. Ng: Catastrophic extinctions follow deforestation in Singapore. *Nature*, **424**, 420-426 (2003).

Cardillo, M., G.M. Mace, K.E. Jones, J. Bielby, O.R.P. Bininda Edmonds, W. Sechrest, C.D.L. Orme and A. Purvis: Multiple causes of high extinction risk in large mammal species. *Science*, **309**, 1239–1241 (2005).

Clark, C.J., J.R. Poulsen, R. Malonga and P.W. Elkan: Logging concessions can extend the conservation estate for central African tropical forests. *Conser. Biol.*, **23**, 1281–1293 (2009).

Collins, A.C.: The taxonomic status of spider monkeys in the twenty-first century. *In:* Spider Monkeys: Behavior, Ecology and Evolution of the Genus Ateles (Eds. Campbell, C.J.). Cambridge University Press, New York, USA. pp. 50–78 (2008).

Collins, N.M., J.A. Sayer and T.C. Whitmore: The Conservation Atlas of

Tropical Forests: Asia and the Pacific. MacMillan, UK (1991).

Davis, A.J., J.D. Holloway, H. Huijbergts, J. Krikken, A.H. Krik-Spriggs, and S.L. Sutton: Dung beetles as indicators of change in the forests of northern Borneo. *J. App. Ecol.*, **38**, 593–616 (2001).

DeFries, R., A. Hansen, A.C. Newton and M.C. Hansen: Increasing isolation of protected areas in tropical forests over the past twenty years. *Ecolo. Appli.*, **15**, 19–26 (2005).

Edwards, D.P., T.H. Larsen, T.D.S. Docherty, F.A. Ansell, W.W. Hsu, M.A. Derhé, K.C. Hamer and D.S. Wilcove: Degraded lands worth protecting: The biological importance of Southeast Asia's repeatedly logged forests. *Proc. Roy. Soc. B.,* **278,** 82–90 (2011).

Ellwood, M.D.F. and W.A. Foster: Doubling the estimate of invertebrate biomass in a rainforest canopy. *Nature*, **429,** 549–551 (2004).

Ellwood, M.D.F., D.T. Jones, and W.A. Foster: Canopy ferns in lowland dipterocarp forest support a prolific abundance of ants, termites, and other invertebrates. *Biotropica*, **34**, 575–583 (2002).

FAO.: State of the World's Forests. Rome, Italy: FAO (2001).

Fitzherbert, E.B., M.J. Struebig, A. Morel, F. Danielsen, C.A. Brühl, P.F. Donald and B. Phalan: How will oil palm expansion affect biodiversity? *Trends Ecol. Evol.,* **23,** 538–545 (2008).

Grove, S.J.: The influence of forest management history on the integrity of the saproxylic beetle fauna in an Australian lowland tropical rainforest. *Biol. Conse.*, **104**, 149–171 (2002).

Henderson, P.A. and R.M.H. Seaby: Community Analysis Package 4.0, Pisces Conservation Ltd, Lymington, UK. URL: http://www.pisces-conservation.com (2007).

Jackson, S.M., T.S. Fredericksen and J.R. Malcolm: Area disturbed and residual stand damage following logging in a Bolivian tropical forest. *For. Ecol. Manag.*, **166,** 271–283 (2002).

Jennings, S.B., N.D. Brown, D.H. Boshier, T.C. Whitmore and J. Lopes: Ecology provides a pragmatic solution to the maintenance of genetic diversity in sustainably managed tropical rainforests. *For. Ecol. Manag.*, **154**, 1–10 (2001).

Johns, A.D.: Effects of selective logging on the behavioral ecology of west Malaysian primates. *Ecology*, **67**, 684–694 (1986).

Johns, A.D.: Effects of selective timber extraction on rain forest structure and composition and some consequences for frugivores and folivores. *Biotropica,* **20,** 31–37 (1988).

Kettle, C.J.: Ecological considerations for using dipterocarps for restoration of lowland rainforest in Southeast Asia. *Biodiv. Conser.*, **19**, 1137–1151 (2010).

Koh, L.P., N.S. Sodhi and B.W. Brook: Ecological correlates of extinction proneness in tropical butterflies. *Cons. Biol.*, **18**, 1571–1578 (2004).

Laurance, W.F.: Reflections on the tropical deforestation crisis. *Biol. Conserv.*, **91**, 109–117 (1999).

Márquez, A.L., R. Real and J.M. Vargas: Dependence of broad-scale geographical variation in fleshy-fruited plant species richness on disperser bird species richness. *Global Ecol. Biogeog.*, **13**, 295–304 (2004).

Meijaard, E. and D. Sheil: The persistence and conservation of Borneo's mammals in lowland rainforests managed for timber: Observations, overviews and opportunities. *Ecolo. Rese.*, **23**, 21–34 (2008).

Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A.B. de Fonseca and J. Kent: Biodiversity hotspots for conservation priorities. *Nature*, **403**, 853–858 (2000).

Peters, M.K., G. Fischer, F. Hita Garcia, T. Lung and J.W. Wägele: Spatial variation in army ant swarm raiding and its potential effect on biodiversity. *Biotropica*, **45**, 54-62 (2013).

Potts, K.B.: The long-term Impact of timber harvesting on the resource base of chimpanzees in Kibale National Park, Uganda. *Biotropica*, **43**, 256–264 (2011).

Rautner, M., M. Hardino and R.J. Alfred: Borneo: Treasure Island at Risk: Status of Forest, Wildlife and related Threats on the Island of Borneo. WWF Germany, Frankfurt am Main, pp.80 (2005).

Robbins, C.S., B.A. Dowell, D.K. Dawson, J.A. Colon, R. Estrada, A. Sutton, R. Sutton and D. Weyer: Comparison of Neotropical migrant land bird populations wintering in tropical forest, isolated fragments, and agricultural habitats. In: Ecology and Conservation of Neotropical Migratory Landbirds (Eds.: Hagan III, J.M. and D.W. Johnston). Smithson. Inst. Press, Washington, (DC. ISBN–10: 1560981407). pp. 207-210 (1992).

Robson, C.: Real World Research: A Resource for Social Scientists and Practitioner Researchers 2nd Ed. Oxford: Blackwell (2002).

Samejima, H., R. Ong, P. Lagan and K. Kitayama: Camera-trapping rates of mammals and birds in a Bornean tropical rainforest under sustainable forest management. *For. Ecol. Manag.*, **270**, 248–256 (2012).

Sehgal, R.N.M.: Deforestation and avian infectious diseases. *J. Exp. Biol.,* **213,** 955–960 (2010).

Sheil, D. and M. Van Heist: Ecology for tropical forest management. *Int. For. Rev.*, **2**, 261–270 (2000).

Silva, R.R. and C.R.F. Brandao: Morphological patterns and community organization in leaf-litter ant assemblages. *Ecol. Monog.,* **80,** 107–124 (2010).

Tang, H.T.: Problems and strategies for regenerating dipterocarp forests in Malaysia. In: *Natural Management of Tropical Moist Forests* (Eds.: E. Mergen and J.R. Vincent). Yale University, School of Forestry and Environment Studies, New Haven, CT. pp. 23–46 (1987).

Thiollay, J.M.: Influence of selective logging on bird species diversity in a Guianan rainforest. *Conser. Biol.*, **6**, 47–63 (1992).

Wright, S.J.: Tropical forests in a changing environment. *Trends in Ecol. Evol.*, **20**, 553–560 (2005).

WWF.: The Malaysian Rainforest Web Accessed on 29th May, 2013 at URL: http://www.wwf.org.my/-about_wwf/what_we_do/forests_main/the_malaysian_rainforest/(2013)