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Impacts of Inundation on Bird Assemblages in Forests in and around a Hydrodam in Terengganu, Malaysia

(Kesan Banjir terhadap Himpunan Burung di Dalam Hutan dan Kawasan Sekitar Empangan Hidro di Terengganu, Malaysia)

FARAH SHAFAWATI MOHD-TAIB*, SITI NABILAH ISHAK, MOHAMMAD SAIFUL MANSOR & SHUKOR MD-NOR

ABSTRACT

Despite the increasing numbers of hydrodam worldwide, only a handful of studies evaluated their impacts on biodiversity. Compared to terrestrial animals, birds were thought to be less affected by inundation process, following impoundment. At the Hulu Terengganu Hydroelectric Dam in Peninsular Malaysia, our study compared species assemblages and diversity of birds within the dam area (i.e. the dam reservoir and catchment area) after recent logging and inundation in relation to a nearby forest logged 30 years ago. Using point count and mist-netting techniques, we recorded a total of 64 species (Shannon Index (H') = 3.827) in the dam area and 91 species (H'=3.99) in historically-logged forests. Insectivore species richness was significantly higher in the historically-logged forests (Mann-Whitney: Z=4.339, N=205, p*<0.005). These results indicated that richness and diversity of bird species assemblages appear to decline following recent inundation phase. Nevertheless, the forests in the dam area still harbour charismatic species such as eagles (Family: Accipitridae) and hornbills (Family: Bucerotidae) which suggests that this habitat is relatively important for birds.*

Keywords: Avian; hydroelectric dam; Kenyir; logging; Malaysia

ABSTRAK

Walaupun jumlah empangan hidro di seluruh dunia semakin meningkat, hanya segelintir kajian menilai kesannya terhadap kepelbagaian biologi. Berbanding dengan haiwan terestrial, burung dianggap kurang dipengaruhi oleh proses pembanjiran berikutan pengempangan. Di Empangan Hidroelektrik Hulu Terengganu di Semenanjung Malaysia, kami mengkaji dan membandingkan himpunan spesies dan kepelbagaian burung di dalam kawasan empangan (empangan dan kawasan tadahan) selepas pembalakan dan pembanjiran baru-baru ini berbanding dengan hutan berdekatan yang telah dibalak 30 tahun lalu. Dengan menggunakan teknik kiraan titik dan penjaringan, kami mencatatkan sejumlah 64 spesies (Indeks Shannon, H ' = 3.827) di kawasan empangan dan 91 spesies (H' = 3.99) di hutan yang telah lama dibalak. Kekayaan spesies burung insektivor jauh lebih tinggi di hutan yang telah lama dibalak (Mann-Whitney: Z = 4.339, N = 205, p*<0.005). Keputusan ini menunjukkan bahawa kekayaan dan kepelbagaian spesies burung menurun selepas fasa pembanjiran. Walau bagaimanapun, hutan di kawasan empangan masih dapat dijumpai spesies karismatik seperti helang (Famili: Accipitridae) dan enggang (Famili: Bucerotidae) yang turut menunjukkan bahawa habitat ini adalah penting untuk burung secara relatif.*

Kata kunci: Burung; empangan hidroelektrik; Kenyir; Malaysia; pembalakan

INTRODUCTION

More hydroelectric dams are being built to meet the energy demands of Malaysia's rapidly growing human population. Although they can also contribute to flood prevention (Luis et al. 2013), dams substantially alter the environment by reducing forest cover (Zhao et al. 2010). For example, the inundation phase then fragments once continuous forests to form land bridge islands (i.e. former hilltops). However, the impacts of the inundation following dam impoundment on biodiversity are not well-documented (Chikodzi et al. 2013; Winemiller 2016).

In tropical forest, the impacts of forest fragmentation have largely focused on taxa such as small mammals (Gibson et al. 2013) and birds (Watson et al. 2004). These studies generally highlighted the importance of larger forest fragments for the persistence of biodiversity, as smaller fragments potentially lose many of the resident species more rapidly. Native forest species were also found to be confined to larger patches compared to smaller patches (Mohd-Taib et al. 2016), as these species are particularly very sensitive to habitat disturbance and deforestation (Maas et al. 2009; Sodhi et al. 2005). Insectivorous birds, for example, are known to be most affected by habitat degradation, due to their specialized niches (Mansor & Sah 2012a) and thus are most affected by resource depletion.

In Peninsular Malaysia, studies quantifying the impacts of dams have been mainly conducted in the state of Terengganu. For example, studies have investigated the impact of land-bridge islands on birds (Yong et al.

2011), dung beetles (Qie et al. 2011) and butterflies (Yong et al. 2012). These studies mainly assessed species assemblages on the land-bridges islands after inundation phase. They found that larger islands had higher species richness than smaller islands, and the degree to which islands are isolated was also important. Smaller islands, nonetheless, harbored some species that were not present in the larger islands, suggesting the importance of small islands for bird species (Fischer & Lindenmayer 2002). As birds are very sensitive to habitat disturbance (Peh et al. 2005; Yong 2009), the construction of dams and the resulting habitat loss may be detrimental to bird species assemblages. In fact, the occurrence of certain bird species can reflect the quality and the condition of an ecosystem (Leito & Kuresoo 2004). Yong et al. (2011) demonstrated that insectivorous birds were highly affected by the area of land-bridge islands. To the best of our knowledge, however, no study has assessed the impact of the dam inundation phase on bird assemblages.

Here, we investigated the impacts of dam inundation on bird assemblages in the state of Terengganu, Peninsular Malaysia. We compared bird species richness and diversity in the dam (recently logged forests within the reservoirs and surrounding catchment) to that of a historically-logged forest. Our findings will not only determine the feeding guild that is particularly vulnerable to inundation process, but also contribute towards the management of bird assemblages in the newly built hydrodam.

Materials and Methods

Study Area

We conducted our study in Puah Dam (60 km^2) (N 05° 09' 61", E 102° 35' 98"), which is north of the existing Kenyir Dam in Hulu Terengganu District, Terengganu, Malaysia (Figure 1). It is around 50 km from the Bandar Gua Musang (T156) - Hulu Terengganu roadway and about 65 km west of Kuala Terengganu (Figure 1). The impounded river, Sungai Tembat is a tributary of the Sungai (River) Terengganu, where its tributaries rise in the mountainous interior of the State of Terengganu, where it borders with the States of Pahang and Kelantan. The lower few kilometres of each river above their confluence are inundated by the Kenyir reservoir.

Our study was conducted between August 2014 and January 2015 after inundation took place in October 2014. We divided the study area into two sites: the dam and the historically-logged forest, Sg. Deka (N 05° 01' 81", E 102° 53' 40"). The dam consists of the reservoir and surrounding forest catchment, while the historically-logged forest (logged 30 years ago) is located 20 km away from the Puah reservoir.

Sampling

Two sampling methods were used in our study: Point count and mist netting. Point-counts were conducted in January 2015 within dam using a boat and in the historically-logged forest on foot, for one week each. The observations were carried out between 0700 and 1900 h every day. A total of 30 observation points were made at each site for duration of 10 min each. Two observers were involved in the bird count (FSMT and MSM). Species were identified with the aid of a pair of binocular (10 × 42) and the estimated number of individuals was recorded.

Mist netting was conducted in August 2014 and January 2015 for one week each, at the historically-logged forests and dam site (after inundation took place), respectively. Two locations were selected for mist netting (site A and B). A total of 20 mist nets were deployed along an established trail with a distance approximately 50 m apart in the forest surrounding the dam and similarly in the historically-logged forest. Each mist net was 2.5 × 9 × 4 m in dimension, with a 36 mm Diamond mesh size and a 3-pouch construction. The nets were opened at 0700 h and closed at 1900 h and monitored every hour. The duration of mist netting at the same locations was regulated to prevent birds from becoming familiar with the mist nets (Robbins et al. 1992). The birds caught were measured and ringed before released. Bird identification was aided by Robson (2008), while feeding guild information was obtained from Mansor and Sah (2012b), Wells (1999, 2007), Wong (1986) and Yong et al. (2011).

Data Analysis

In order to characterize bird species distribution patterns at the two sites, we used non-parametric analysis, the Rank-abundance Curve (RAC) (Magurran 2004; Tokeshi 1993). Species were arranged in sequence from the most to the least abundant along the *x*-axis, while log abundance was plotted on the vertical or *y*-axis. Model verification will use PAST software version 2.17c, which will give the Chi-square and p-value. Model with the lowest p-value will indicate the best model type. Using Ecosim software version 7.71, individual-based rarefaction curves (Gotelli & Colwell 2001) were generated separately for each sampling technique (Magurran 2004). Several indices were calculated with PAST software. Shannon Index is a measure of diversity at a site and is influenced by the number of species present and species uniformity. Chao-1 index gives an estimated species richness if sampling is prolonged. To compare species compositions between both sites, we use Jaccard Similarity Indexes (JSI) using MVSP (Multivariate Statistical Package) version 3.13b to determine the degree of similarity in species composition in both sites. Each species was assigned to specific feeding guild and significant differences between the group abundance for both sites were determined using the Mann-Whitney U test.

Results

A total of 120 species from 37 families were recorded in both sites (Appendix A). The most dominant family

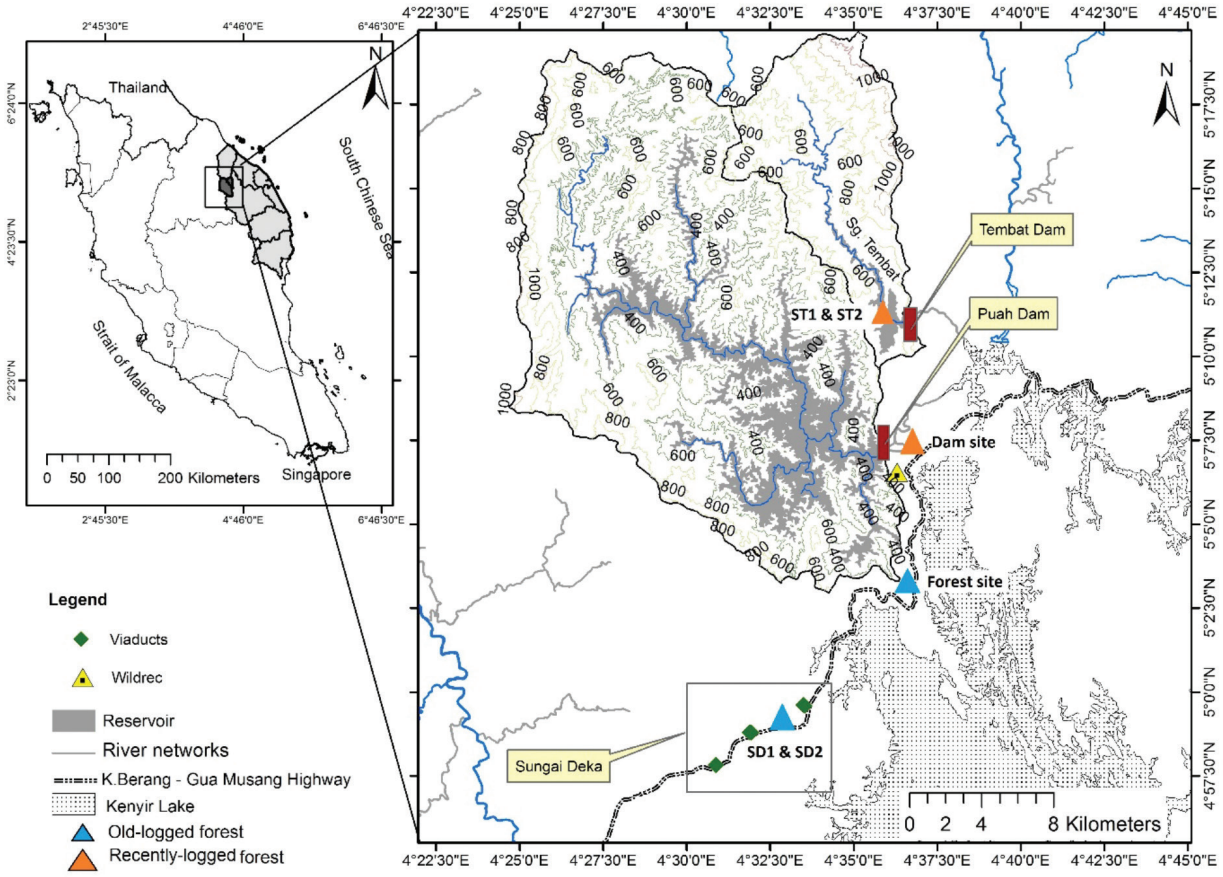

FIGURE 1. Location of our study in Hulu Terengganu district of the state of Terengganu, in Peninsular Malaysia

recorded at both sites was Timaliidae (16 species), followed by Pycnonotidae (14 species), Nectariniidae (10 species) and Muscicapidae (8 species). The Black-headed Bulbul (*Pycnonotus atriceps*), Red-eye Bulbul (*Pycnonotus brunneus*) and Spectacled Bulbul (*Pycnonotus erythrophthalmos*) were relatively common in all study areas. The most abundant species recorded from mist-netting were the Little Spiderhunter (*Arachnothera longirostra*) (n=42, 14.2% of total individuals recorded) and Grey-chested Spiderhunter (*Arachnothera modesta*) (n=26, 8.8%). Observation recorded Rhinocerous Hornbill (*Buceros rhinoceros*) (n=15, 10.3%) and Great Hornbill (*Buceros bicornis*) (n=9, 6.2%) in both areas. Species richness of birds was higher in the historically-logged forest (91 species) compared to the dam, which only recorded 63 species.

SPECIES RICHNESS AND DIVERSITY PATTERN

Rank abundance curves (RAC) for both mist netting and point counts (Figure 2(a) and 2(b)) shows two distinct relative abundance patterns at each sites. Based on mist netting, bird relative abundance at the two sites in the historically-logged forest exhibited a log-normal model, HLF_A (χ^2=1.562, p=0.458) and HLF_B (χ^2=2.905, p=0.088), respectively. Bird relative abundance patterns at two locations in the dam, on the other hand, exhibited a log-series model, Dam_A (χ^2=0.088, p=0.767) and Dam_B (χ^2=0.169, p=0.6813), respectively. Based on point counts, a log-normal model was similarly observed for bird relative abundance patterns in the historically-logged forest, (χ^2=0.9338, p=0.3339), but a log-normal model (χ^2=0.8456, p=0.358) was unexpectedly observed in the dam.

Individual rarefaction curves for both mist netting and point counts were shown in Figure 3(a) and 3(b). Species richness was higher in the historically-logged forest than in the dam (91 vs. 63 or 64 (Table 1), but there appeared to be no significant differences (p>0.05). Based on mist netting data, the rarefaction curve of the historically-logged forest was reaching an asymptote, indicating high sampling efficiency compared to the dam. Interpolation point at 29th individual (which is the least number of individually captured in dam sites), showed a slightly higher average species in dam (21.02±2.98), compared to the historically-logged forest (18.51±4.49) species. Based on point count data, rarefaction curves show somewhat similar pattern in both sites. Once again, the historically-logged forest had higher species richness compared to the dam. Interpolation at 83rd individual showed a slightly higher average species richness at the historically-logged forest with (38.29±2.71) compared to the dam (33.85±2.15).

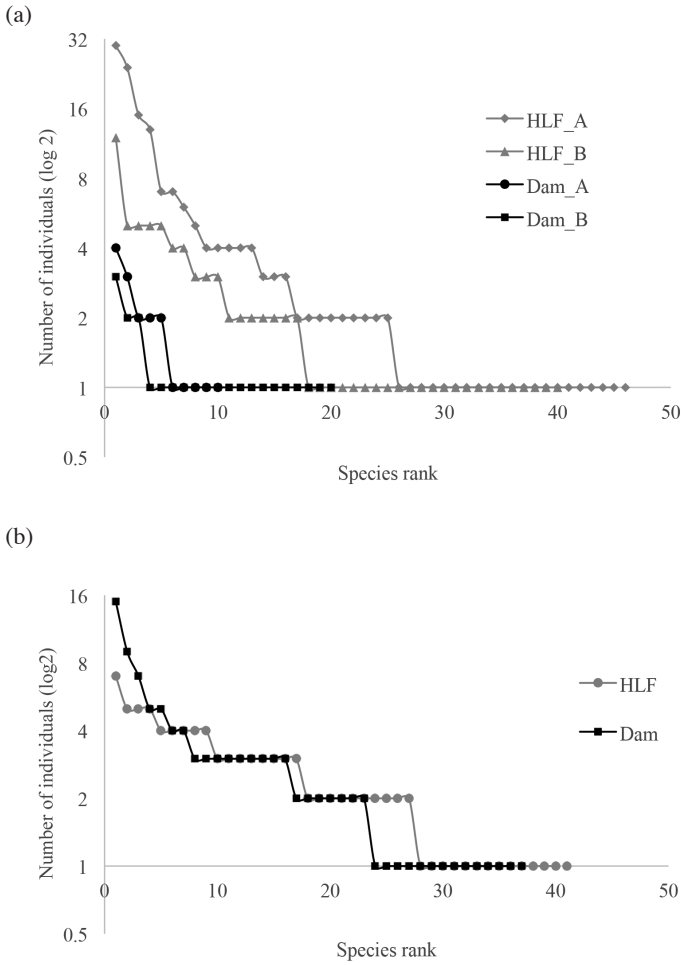

FIGURE 2. Rank abundance curve for (a) mist netting and (b) point count sampling in historically-logged forests (HLF) and the dam

Shannon diversity index was slightly higher in the historically-logged forest (3.99) compared to the dam (3.849), but the dominance index was similar in the historically-logged forest (0.032) compared to dam area (0.030). In contrast, the evenness index was lower (0.5942) in the historically-logged forest than dam area (0.7335). Chao-1 index estimated that species richness in dam area could reach up to 105 (Table 1) and 109 species in the historically-logged forest.

SPECIES COMPOSITION

Of the total 120 species recorded in our study, 84 species are resident (R) with five species having both resident and migrant status (R/M) and six migrant species (Appendix A). Species that have both resident and migrant status were the Asian Dollarbird (*Eurystomus orientalis*), Drongo cuckoo (*Surniculus lugubris*), Peregrine Falcon (*Falco peregrinus*), Asian Paradise Flycatcher (*Terpsiphone paradise*), Hill-blue Flycatcher (*Cyornis banyumas*) and Red-legged Crake (*Rallina fasciata*). Migrant species recorded were the Japanese Sparrowhawk (*Accipiter gularis*), Common kingfisher (*Alcedo atthis*), Oriental-dwarf Kingfisher (*Ceyx erithacus*), Asian Brown Flycatcher (*Muscicapa dauurica*), Blue-throated Flycatcher (*Cyornis rubeculoides*) and Common Sandpiper (*Actitis hypoleucos*).

The Jaccard coeeficient showed a 28% similarity in species composition between the historically-logged forest and the dam. A total of 35 species were shared between these two areas such as Great Hornbill, Black-bellied Malkoha, Hill Myna and Large-billed Crow. Thirty species were exclusively recorded in the dam area, for instance, Grey-headed Canary-Flycatcher, Crested Goshawk and Japanese Sparrowhawk. In the historically-logged forest, 56 species were exclusively recorded.

Insectivorous birds were the most abundant feeding guild (53%), followed by omnivores (25%), carnivores (13%), frugivores (6%) and granivore (3%). Insectivorous bird species were recorded more frequently in the historically-logged forest (49 species) than the dam area (28 species). Based on both sampling methods, insectivore species abundance was significantly higher in the historically-logged forest (Mann-Whitney: $Z=4.339$, $n=205$, $p<0.005$), but no significant differences were found for other types of feeding guild.

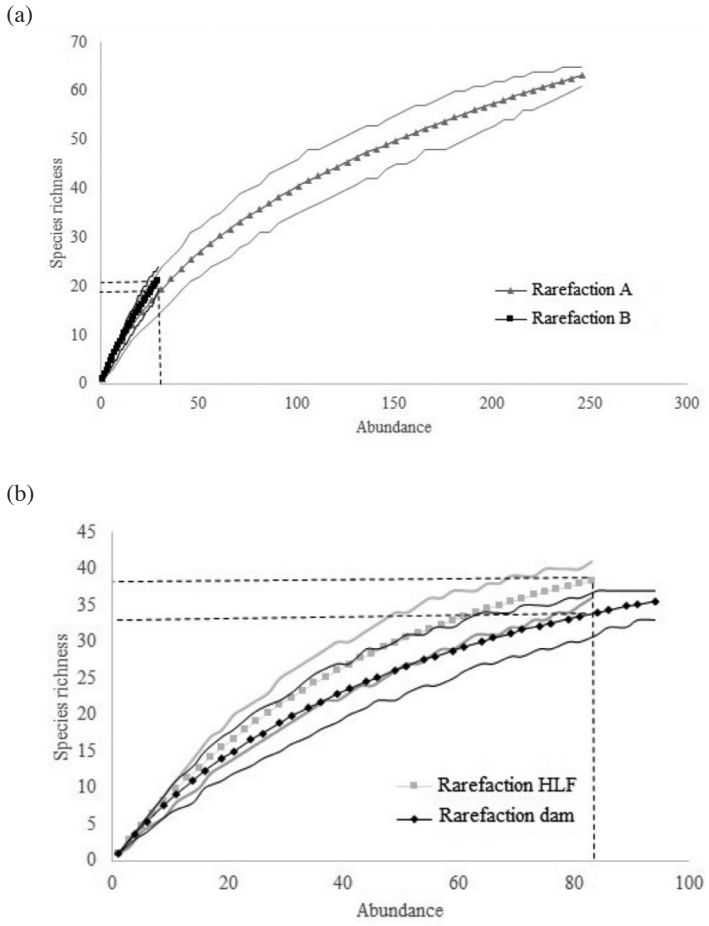

FIGURE 3. Rarefaction curves for a) mist netting and b) point count sampling in historically-logged forest (HLF) and the dam

DISCUSSION

To the best of our knowledge, our study is the first in Malaysia to quantify the richness and diversity of bird assemblages in forests around hydrodam just after its inundation phase. We found that bird species richness and diversity in the relatively more disturbed dam area was generally lower compared to a nearby historically-logged forest area that has not been logged in 30 years. Based on our RAC analysis, the historically-logged forest fitted well with the log-normal model, indicated a mature community with an ideal species distribution model (Magurran 2004; Sugihara 1980). On the other hand, dam sites illustrated a log-series model which indicated an early stage of succession with high species dominance (Fisher et al. 1943; Motomura 1932). This finding is concordant with previous studies on avifaunal assemblages in forests of different degrees of disturbance (Hashim & Ramli 2013; Johns 1989; Peh et al. 2005; Thiollay 1997). A high estimated species number at the dam area also suggests that ecological succession occurs following inundation.

This study also show that these sites harbour many highly protected species, for instance, the Blue-banded Kingfisher (*Alcedo euryzona*) is listed as critically endangered species according to the IUCN Red List of Threatened Species (2017). Another 20 other species recorded from both site categories are listed as near threatened and the remaining species are listed as least concern (Appendix A).

Certain bird species are more easily detected in disturbed habitats, including recently logged forests (Woltmann 2003). Our study showed that the dam appears to harbour more species from Accipitridae and Bucerotidae families following the inundation phase, but less Passerines. Species from Accipitridae and Bucerotidae family were easily detected in the open environment of the dam. It is interesting to note the dominant of hornbills species through point count observation in the dam. This group of birds feed primarily on fruiting trees especially *Ficus* spp. (Wells 1999). The abundance of hornbills recorded during the inundation phase could be due to the fact that logging operations have avoided felling of fig trees, which are not highly valued in the timber industry due to their properties (Johns 1989). However, hornbill populations in the dam may decline over time because they can no longer find tall trees with cavities for nesting. Nevertheless, *Ficus* sp. in dam area appears to be attracting frugivorous species from the Family Pycnonotidae and sensitive species such as the Green Broadbill (*Calyptomena viridis*), which is a forest-specialist bird.

TABLE 1. Bird diversity indices from our sampling in historically-logged forests and the dam in our study area

	Historically-logged forest	Dam
Taxa_S	91	63
Individuals	361	149
Dominance_D	0.03225	0.03022
Simpson_1-D	0.9677	0.9698
Shannon_H	3.99	3.849
Evenness_e^H/S	0.5942	0.7335
Fisher_alpha	39.15	42.53
Berger-Parker	0.1163	0.1007
Chao-1	109.5	105.3

Several species from family Accipitridae were recorded perching and nesting at the tip of emergent trees now submerged by the dam, such the Crested Goshawk (*Accipiter trivirgatus*), Blyth's Hawk-eagle (*Spizaetus alboniger*) and Japanese Sparrowhawk (*Accipiter gularis*). Some of these species are montane forest inhabitants, but can now be found in hill-lowland forests. Our findings suggest that for now, certain species can still persist, but it remains to be seen whether the forests in the dam can support native forest species in the long run.

Bulbuls (Family: Pycnonotidae) made up the largest proportion of the total species captured in both areas and several species from this family is commonly found in the dam area. Most bulbul species are resilient to disturbance and are also considered as open country birds, which utilize open areas, such as parks, gardens and plantations. They are well-known as colonizing species and prefer to inhabit the logged forest. They are frugivores but also feed on insects, which has proven to be advantageous because they can tolerate seasonal variation in fruit abundance in logged forests (Wong 1986). The presence of fruit-eating birds may also speed up the recovery and successional process in regenerating forests through seed dispersal (Carlo & Morales 2016).

Sensitive forest-dependent birds such as Timaliidae (Babblers) and Muscicapidae (Flycatchers) were poorly represented in the dam. Babbler species are forest-dependent insectivores and have a low tolerance to habitat loss and degradation (Yong 2009). Flycatcher species such as *Cyornis* spp. are also more sensitive to disturbance than other genera (Lambert 1992). The presence of the Blue-throated Flycatcher (*Cyornis rubeculoides*) in the historically-logged forest albeit in low relative abundance, suggests that the forest is maturing and if left undisturbed could attract more forest-specialist species. The absence of such species in the dam reflects the loss of understorey vegetation and foraging substrata as well as associated preferred insect prey (Robinson 1969).

The after-effects of logging on birds have been documented in the literature. Johns (1989) stated that logging will have an impact on bird population for 12 years post-logging, particularly on native forest bird species. Species such as Rufous-winged Philentoma (*Philentoma pyrhropterum*), Asian Paradise Flycatcher (*Terpsiphone paradise*), Crested Jay (*Platylophus galericulatus*) and White-crowned Forktail (*Enicurus leschenaultia*) were only recorded in the historically-logged forests. In some areas, the bird assemblages in maturing-logged over forest may approach those of primary forests, even though it would be unlikely to reach the original species composition. Peh et al. (2005) reported that around 75% of a bird species community was shared between logged and primary forest.

Edge-forest species such as Rufescent prinia (*Prinia rufescens*) and open country species such as munias were commonly recorded in the historically-logged forests. However, the Little Spiderhunter and Grey-breasted Spiderhunter were two most dominant species in this habitat. Spiderhunters feed on wild bananas (Musaceae), gingers (Zingiberaceae) and herbaceous plants that easily grow shortly after logging (Johns 1989). The absence of these species in the dam indicates that the forests are at a very early stage of regeneration.

EFFECTS OF DAM INUNDATION OF DAM ON BIRD FEEDING GUILDS

Secondary forests offer a wider variety of niches and higher levels of plant and insect diversity due to structurally complex habitat (Miller et al. 2004). The abundance of food resources (flowers, fruits, arthropods) most likely influence bird species richness and individual abundance in forests (Wong 1986). Our study demonstrated that insectivores were the more dominant feeding guild in the historically-logged forests compared to the dam. Zakaria et al. (2005) found that insectivorous bird species are usually adversely affected by logging activities and are therefore suitable indicators of forest health. The low detection rates of insectivorous birds in disturbed habitats were also reported by many studies (Bregman et al. 2014; Canaday 1997; Powell et al. 2015; Şekercioğlu et al. 2002; Sodhi et al. 2004). However, some bird guilds are more mobile and less susceptible to logging, as they might be using different patches of (logged) forests for different resource needs. Certain frugivores and nectarivores species, for example, may successfully forage in disturbed habitats at intermediate intensities, where food is more abundant,

while still nesting in primary forests (van Heezik & Seddon 2012). Thus, the abundance and richness of food resources, (e.g. fruits, seeds, insects and nectar) is a key in influencing the diversity and richness of bird guilds.

Conclusion

Due to our relatively small sample size (i.e. comparisons were made across two locations at most) and short sampling period (i.e. we only conducted two months of sampling), further research is needed to determine the extent to which bird assemblages are affected by post-inundation phases of hydrodams over longer periods and larger spatial scales. It appears that insectivorous birds were the most vulnerable guild in our study site. Changes in species distribution in the dam areas, particularly at the newly formed islands are critical to determining the species turnover in the dam. Information regarding altitudinal ranges and other parameters of bird distributions are also required, such as habitat needs, foraging behaviour and habitat changes on ground-dwelling species, such as pheasants. Assessing the defining factors that govern the species composition and dynamics of tropical avifauna is certainly complex and difficult because detailed knowledge of ecology for bird species are often unavailable. When possible, future bird monitoring activities should take into account spatial and temporal distributions of populations, breeding activities, turnover rates and recruitment in the dam. Ultimately, we believe our findings can contribute to better management of bird and wildlife habitats in the hydrodam in our project site.

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School of Environmental Science & Natural Resources
Faculty of Science and Technology
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor Darul Ehsan
Malaysia

*Corresponding author; email: farah_sh@ukm.edu.my

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APPENDIX A. Summary statistics of birds recorded in historically-logged forests and the dam our study areas

Family	Scientific Name	Common Name	Old-logged site			Dam site			Forest dependency types	Status	Feeding guilds	IUCN Status
			MN1	MN2	OBS	MN1	MN2	OBS				
ACCIPITRIDAE	*Spizaetus alboniger*	Blyth's Hawk-Eagle	0	0	0	0	0	1	F	R	C	LC
	Spilornis cheela	Crested Serpent-Eagle	0	0	2	0	0	1	F	R	C	LC
	Accipiter gularis	Japanese Sparrowhawk	0	0	0	0	0	2	F	M	C	LC
	Accipiter trivirgatus	Crested Goshawk	0	0	0	0	0	1	F	R	C	LC
	Spizaetus cirrhatus	Changeable Hawk-eagle	0	0	1	0	1	1	F	R	C	LC
ALCEDINIDAE	*Alcedo atthis*	Common kingfisher	0	0	0	0	0	1	F	M	C	LC
	Alcedo euryzona	Blue-banded Kingfisher	4	0	0	0	0	0	F	R	C	CR
	Alcedo meninting	Blue-eared Kingfisher	1	0	0	0	0	0	F	R	C	LC
	Ceyx erithacus	Oriental-dwarf Kingfisher	2	2	0	0	0	0	NF	M	C	LC
	Ceyx rufidorsa	Rufous-backed Kingfisher	0	0	0	0	1	0	F	R	C	LC
BUCEROTIDAE	*Buceros rhinoceros*	Rhinoceros Hornbill	0	0	4	0	0	15	F	R	O	NT
	Buceros bicornis	Great hornbill	0	0	1	0	0	9	F	R	O	NT
CAMPEPHAGIDAE	*Pericrocotus flammeus*	Scarlet Minivet	0	0	4	0	1	0	F	R	I	LC
	Tephrodornis gularis	Large Wood Shrike	0	0	0	0	1	0	F	R	I	LC
CHLOROPSEIDAE	*Chloropsis cochinchinensis*	Blue-winged Leafbird	0	0	3	0	2	1	F	R	I	LC
	Aegithinia viridissima	Green Iora	0	2	3	0	0	0	F	R	I	NT
	Chloropsis cyanopogon	Lesser Green Leafbird	0	0	5	0	0	7	F	R	I	NT
CISTICOLIDAE	*Prinia rufescens*	Rufescent Prinia	0	1	1	0	0	1	F	R	I	LC
COLUMBIDAE	*Chalcophaps indica*	Emerald Dove	2	3	0	0	0	0	F	R	G	LC
CORACIIDAE	*Eurystomus orientalis*	Asian Dollarbird	0	0	3	0	0	5	NF	R/M	I	LC
CORVIDAE	*Corvus macrorhynchos*	Large-billed Crow	0	0	7	0	0	3	NF	R	O	LC
DICRURIDAE	*Dicrurus paradiseus*	Greater Racquet-tailed Drongo	4	0	0	0	0	0	F	R	I	LC
	Platylophus galericulatus	Crested Jay	1	0	0	0	0	0	F	R	I	NT
CUCULIDAE	*Phaenicophaeus diardi*	Black-bellied Malkoha	0	0	1	0	0	1	F	R	O	NT
	Surniculus lugubris	Drongo cuckoo	1	1	0	0	1	0	F	R/M	I	LC
	Cacomantis variolosus	Plaintive Cuckoo	0	1	1	0	0	0	F	R	I	LC
	Cacomantis sepulcralis	Rusty-breasted Cuckoo	0	0	0	0	1	0	F	R	I	LC
DICAEDIAE	*Prionochilus percussus*	Crimson-breasted Flowerpecker	2	1	0	0	0	0	F	R	F	LC
	Dicaeum trigonostigma	Orange-bellied Flowerpecker	0	1	0	0	0	0	F	R	F	LC
	Prionochilus maculatus	Yellow-breasted Flowerpecker	0	2	0	0	0	0	F	R	F	LC
	Dicaeum chrysorrheum	Yellow-vented Flowerpecker	0	1	0	0	0	0	F	R	F	LC
ESTRILDIDAE	*Lonchura leucogastra*	White-bellied Munia	2	4	0	0	0	0	NF	R	G	LC
	Lonchura maja	White-rumped Munia	0	1	0	0	0	0	NF	R	G	LC

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Family	Scientific Name	Common Name	Old-logged site			Dam site			Forest dependency types	Status	Feeding guilds	IUCN Status
			MN1	MN2	OBS	MN1	MN2	OBS				
EURYLAIMIDAE	*Eurylaimus ochromalus*	Black-and-Yellow Broadbill	0	0	3	0	0	3	F	R	I	NT
	Calyptomena viridis	Green Broadbill	0	0	0	0	0	1	F	R	I	NT
	Cymbirhynchus macrorhynchos	Black and Red Broadbill	1	0	1	0	0	1	F	R	I	LC
FALCONIDAE	*Falco peregrinus*	Peregrine Falcon	0	0	0	0	0	2	F	R/M	C	LC
HEMIPROCNIDAE	*Hemiprocne longipennis*	Grey-rumped Treewift	0	0	0	0	0	1	F	R	I	LC
	Hemiprocne comata	Whiskered Treeswift	0	0	4	0	0	3	F	R	I	LC
LANIIDAE	*Lanius tigrinus*	Tiger Shrike	0	0	0	0	1	0	F	M	C	LC
MEGALAIMIDAE	*Megalaima mystacophanos*	Red-throated Barbet	0	0	4	0	0	1	F	R	F	NT
MONARCHIDAE	*Terpsiphone paradisi*	Asian Paradise Flycatcher	1	1	0	0	0	0	F	R/M	I	LC
MUSCICAPIDAE	*Muscicapa dauurica*	Asian Brown Flycatcher	0	0	2	0	0	3	F	M	I	LC
	Cyornis rubeculoides	Blue-throated Flycatcher	1	0	0	0	0	0	F	M	I	LC
	Rhinomyias brunneatus	Brown-chested Jungle Flycatcher	0	0	0	1	0	0	F	M	I	VU
	Rhinomyias olivacea	Fulvous-chested Jungle Flycatcher	0	0	0	0	3	0	F	R/M	I	LC
	Rhinomyias umbratilis	Grey-chested Flycatcher	0	1	0	0	0	0	F	R	I	NT
	Cyornis banyumas	Hill-blue Flycatcher	1	0	0	0	0	0	F	R/M	I	LC
	Cyornis unicolor	Pale-blue Flycatcher	1	0	0	0	0	0	F	R	I	LC
	Eumyias thalassinus	Verditer Flycatcher	0	1	0	0	0	0	F	R	I	LC
NECTARINIIDAE	*Anthreptes simplex*	Plain Sunbird	0	0	2	0	0	2	F	R	O	LC
	Anthreptes malacensis	Brown-Throated Sunbird	0	0	3	0	1	0	F	R	O	LC
	Aethopyga temminckii	Temminck's Sunbird	0	0	2	0	1	0	F	R	O	LC
	Aethopyga siparaja	Crimson Sunbird	0	2	0	0	0	0	F	R	O	LC
	Arachnothera modesta	Grey-breasted Spiderhunter	24	2	0	0	1	0	F	R	O	LC
	Arachnothera longirostra	Little Spiderhunter	30	12	0	0	0	0	NF	R	O	LC
	Arachnothera robusta	Long-billed Spiderhunter	1	0	0	0	0	0	F	R	O	LC
	Hypogramma hypogrammicum	Purple-naped Sunbird	4	1	0	0	0	0	F	R	O	LC
	Anthreptes singalensis	Ruby-cheeked Sunbird	0	0	2	0	0	3	F	R	O	LC
	Arachnothera affinis	Streaky-breasted Spiderhunter	0	0	0	0	1	0	F	R	O	LC
ORIOLIDAE	*Oriolus xanthonotus*	Dark-throated Oriole	1	0	1	0	0	0	F	R	O	NT
PICIDAE	*Meiglyptes tristis*	Buff-rumped Woodpecker	0	0	1	0	0	0	F	R	I	LC
	Blythipicus rubiginosus	Maroon Woodpecker	0	0	1	0	0	0	F	R	I	LC
	Reinwardtipicus validus	Orange-backed Woodpecker	0	0	1	0	0	0	F	R	I	LC
	Meiglyptes tukki	Buff-necked Woodpecker	0	5	0	0	0	0	F	R	I	NT
	Sasia abnormis	Rufous Piculet	1	0	0	0	0	0	F	R	I	LC
PRIONOPIDAE	*Philentoma pyrhropterum*	Rufous-winged Philentoma	7	2	0	0	0	0	F	R	I	LC

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Family	Scientific Name	Common Name	Old-logged site			Dam site			Forest dependency types	Status	Feeding guilds	IUCN Status
			MN1	MN2	OBS	MN1	MN2	OBS				
PYCNONOTIDAE	*Pycnonotus atriceps*	Black-headed Bulbul	5	5	1	0	0	2	F	R	O	LC
	Iole olivacae	Buff-vented Bulbul	0	1	2	0	0	4	F	R	O	NT
	Pycnonotus simplex	Cream-vented Bulbul	2	0	3	0	0	2	NF	R	O	LC
	Pycnonotus cyaniventris	Grey-bellied Bulbul	0	1	1	0	0	3	F	R	F	NT
	Iole propinqua	Grey-eyed Bulbul	0	0	0	0	1	0	F	R	O	LC
	Ixos malaccensis	Streak Bulbul	0	0	0	0	0	3	F	R	O	NT
	Pycnonotus brunneus	Red-eyed Bulbul	3	5	3	0	0	5	NF	R	O	LC
	Pycnonotus eutilotus	Puff-backed Bulbul	0	0	0	0	1	0	F	R	F	NT
	Pycnonotus plumosus	Olive-winged Bulbul	0	0	0	3	2	0	NF	R	O	LC
	Tricholestes criniger	Hairy-backed Bulbul	1	3	0	4	1	0	F	R	O	LC
	Pycnonotus erythrophthalmos	Spectacled Bulbul	7	1	2	0	0	3	NF	R	O	LC
	Pycnonotus finlaysoni	Stripe-throated Bulbul	1	0	2	0	0	3	NF	R	O	LC
	Alophoixus phaeocephalus	Yellow-bellied Bulbul	6	1	0	0	0	4	F	R	O	LC
	Pycnonotus goiavier	Yellow-vented Bulbul	0	4	5	0	0	0	NF	R	O	LC
RALILIDAE	*Rallina fasciata*	Red-legged Crake	1	0	0	0	0	0	F	R/M	C	LC
RHIPIDURIDAE	*Rhipidura javanica*	Pied Fantail	0	0	5	0	0	0	F	R	I	LC
SCOLOPACIDAE	*Actitis hypoleucos*	Common Sandpiper	0	0	0	0	0	2	F	M	C	LC
STENOSTIRIDAE	*Culicicapa ceylonensis*	Grey-headed Canary Flycatcher	0	0	0	0	1	0	F	R	I	LC
STRIGIDAE	*Otus bakkamoena*	Collared Scops-Owl	0	1	0	0	0	0	F	R	C	LC
STURNIDAE	*Gracula religiosa*	Hill Myna	0	0	4	0	0	3	F	R	O	LC
SYLVIDAE	*Orthotomus sutorius*	Common Tailorbird	0	0	3	0	0	2	NF	R	I	LC
	Phylloscopus borealis	Arctic Warbler	0	0	0	2	0	0	F	M	I	LC
	Phylloscopus trochiloides	Two-barred Warbler	0	0	0	1	0	0	F	M	I	LC
	Orthotomus ruficeps	Ashy Tailorbird	1	1	0	0	0	0	NF	R	I	LC
	Orthotomus atrogularis	Dark-necked tailorbird	0	0	2	0	0	1	F	R	I	LC
	Orthomotus sericeus	Rufous-tailed Tailorbird	1	0	1	0	0	0	F	R	I	LC

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Family	Scientific Name	Common Name	Old-logged site			Dam site			Forest dependency types	Status	Feeding guilds	IUCN Status
			MN1	MN2	OBS	MN1	MN2	OBS				
TIMALIIDAE	*Trichastoma abbotti*	Abbott's Babbler	3	0	2	0	0	1	F	R	I	LC
	Pellorneum capistratum	Black-capped Babbler	1	0	0	0	0	0	F	R	I	LC
	Trichastoma tickelli	Buff-breasted Babbler	4	0	0	0	0	0	F	R	I	LC
	Stachyris erythroptera	Chestnut-winged Babbler	4	3	0	0	0	0	F	R	I	LC
	Trichastoma bicolor	Ferruginous Babbler	2	0	0	0	0	0	F	R	I	LC
	Macronous ptilosus	Fluffy-backed Tit-Babbler	1	0	0	0	0	0	F	R	I	NT
	Stachyris poliocephala	Grey-headed Babbler	15	2	0	0	0	0	F	R	I	LC
	Stachyris nigriceps	Grey-throated Babbler	1	0	0	0	0	0	F	R	I	LC
	Malacopteron magnirostre	Moustached Babbler	0	0	0	0	1	0	F	R	I	LC
	Malacopteron magnum	Rufous-crowned Babbler	13	0	0	0	0	0	F	R	I	NT
	Malacocincla malaccensis	Short-tailed Babbler	2	0	0	0	0	0	F	R	I	NT
	Malacopteron cinereum	Scaly-Crowned Babbler	0	0	0	1	0	0	F	R	I	LC
	Malacopteron affine	Sooty-capped Babbler	2	0	0	0	0	0	F	R	I	NT
	Macronous gularis	Pin-striped Tit-babbler	0	1	0	0	0	0	F	R	I	LC
	Erpornis zantholeuca	White-bellied Yuhina	1	0	0	0	0	0	F	R	I	LC
	Trichastoma rostratum	White-chested Babbler	0	1	0	0	0	0	F	R	I	NT
TROGONIDAE	*Harpactes oreskios*	Orange-breasted Trogon	0	0	1	0	0	0	F	R	I	LC
	Harpactes diardii	Diard's Trogon	0	0	0	2	0	0	F	R	I	NT
	Harpactes duvaucelii	Scarlet-Rumped Trogon	0	0	0	0	1	0	F	R	I	NT
TURDIDAE	*Enicurus ruficapillus*	Chestnut-naped Forktail	2	1	0	0	0	0	F	R	I	NT
	Zoothera citrina	Orange-Headed Thrush	0	0	0	2	0	0	F	M	I	LC
	Luscinia cyane	Siberian Blue Robin	0	0	0	1	0	0	F	M	I	LC
	Enicurus leschenaulti	White-crowned Forktail	1	1	0	0	0	0	F	R	I	LC
	Copsychus malabaricus	White-rumped Shama	3	5	0	0	0	0	F	R	I	LC
TYTONIDAE	*Phodilus badius*	Oriental Bay-owl	0	1	0	0	0	0	F	R	C	LC
ZOSTEROPIDAE	*Zosterops palpebrosus*	Oriental White-eye	0	1	0	0	0	0	F	R	O	LC
	Zosterops everetti	Everett's White-Eye	0	0	0	1	0	0	F	R	O	LC

Method: MN=mist-netting, OBS=point count observation; Forest dependency type: F=forest birds, NF= non-forest birds; Status: R=resident, R/M=resident/migrant, M= migrant; Feeding Guild: I=insectivores, F=frugivores, O=omnivores, C=carnivores, G=granivores; IUCN status: CR=critically endangered, NT=near-threatened, LC= least concern