Effects of Rotational Shifting Cultivation on Bird Populations in Pang Hin Fon Sub-District, Mae Chaem District, Chiang Mai Province

ผลของการทำไร่เลื่อนลอยแบบหมุนเวียนต่อประชากรนก ในตำบลปางหินฝน อำเภอแม่แจ่ม จังหวัดเชียงใหม่

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ABSTRACT

The purpose of this study was to survey the diversity of birds in rotational shifting cultivation area. Censuses of birds were conducted in fallow aged 1-2, 3-4, 5-6 year, and undisturbed primary forest by point count method during November 2015 to October 2016. There were 127 species from 42 families in 10 orders for that there were 97 species of resident birds and 30 species of migratory birds. Bird diversity, evenness, and abundance increased during successional change. Many forest bird species declined in abundance or disappeared in successional fallows, but the diversity or abundance of open country bird specialists increased. Therefore, the rotational shifting cultivation has a negative impact on forest bird specialists but positive impact on the diversity of open country bird specialists.

บทคัดย่อ

การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อศึกษาความหลากหลายทางชนิดพันธุ์ของนก ในไร่เลื่อนลอยแบบหมุนเวียนอายุต่างๆ ประกอบไปด้วย พื้นที่รกร้างที่ปล่อยทิ้งหลังการเก็บเกี่ยวข้าวไร่ (fallow) อายุ 1-2 ปี, อายุ 3-4 ปี, อายุ 5-6 ปี และป่าธรรมชาติ ด้วยวิธีกำหนดจุดสำรวจ โดยเก็บข้อมูลระหว่างเดือนพฤศจิกายน พ.ศ. 2558 ถึงเดือนตุลาคม พ.ศ. 2559 การศึกษานี้พบนก 127 ชนิด จาก 42 วงศ์ ใน 10 อันดับ เป็นนกประจำถิ่น 97 ชนิด และนกอพยพ 30 ชนิด ค่าความหลากชนิดของนก ความสม่ำเสมอของชนิดพันธุ์ และความชุกชุม มีค่ามากขึ้นตามอายุของ fallow ซึ่งนกป่า (forest bird specialists) มีความหลากหลายและความชุกชุมน้อยลงตามลำดับขั้นของการเปลี่ยนแปลงแทนที่ ในทางกลับกันนกที่ชอบพื้นที่เปิดโล่ง (open country bird specialists) จะมีความหลากหลายและความชุกชุมเพิ่มมากขึ้น ดังนั้นจึงสรุปได้ว่าการทำไร่เลื่อนลอยแบบหมุนเวียนให้ผลลบต่อความหลากหลายของนกป่า แต่ให้ผลบวกต่อความหลากหลายของนกที่ชอบพื้นที่เปิดโล่ง

Keywords: Fallow, Bird Diversity, Slash-and-Burn Agriculture

คำสำคัญ: พื้นที่ทิ้งร้างหลังการเก็บเกี่ยว ความหลากหลายของนก การเกษตรแบบถางแล้วเผา

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Introduction

Rotational shifting cultivation, swidden agriculture, or slash-and-burn agriculture, is one of the major land use systems in tropical forest ecosystems, except Australia (Bowman et al., 1990). In Northern Thailand, rotational shifting cultivation has long been an important component of the mountain ecosystem. Shifting cultivation is practiced by both lowland Thais and people of the mountains, hill tribes, and ethnic groups. Nowadays, shifting cultivators who were lowland Thais have completely disappeared (Rerkasem K, Rerkasem B, 1994). In this study, the research sites were located in Hoh Kaow Village (Lua or Lawa ethnic group), Pang Hin Fon Sub-District, Mae Chaem District, Chiang Mai Province (Figure 1). They use short cultivation-long fallow pattern (Kunstadter et al., 1987 cited in Chotikitphiwat, 1999). In this pattern, forests are cut down or slashed between January to February, burnt between March to April, during the dry season, cropping period is during the wet season, and harvesting is in November. After harvesting, the area is left, and the cultivators move to another area for cropping in the following year. They leave the harvested area (fallow) for 6 years, and are back to use again (Ramen, 2001; Chanthorn, 2002; Wangpakapattanawong et al., 2010). The duration of the fallow period is an important element for this cyclic form of agriculture, where cultivation is shifted from one location to another. In principle, the longer the duration of the fallow period, the crop yield will be better, and the level of biodiversity is also generally higher in fallows of long duration. Most studies on conservation biology reported a negative impact of shifting cultivation on animals include birds, they were dynamic and susceptible to changes in the forest landscape structure (Wang et al., 2000). However, there were only a few studies focusing on bird diversity in forest transformed by shifting cultivation in Asia (Raman, 2001; Wang, Young, 2003; Mukul, Herbohn, 2016).

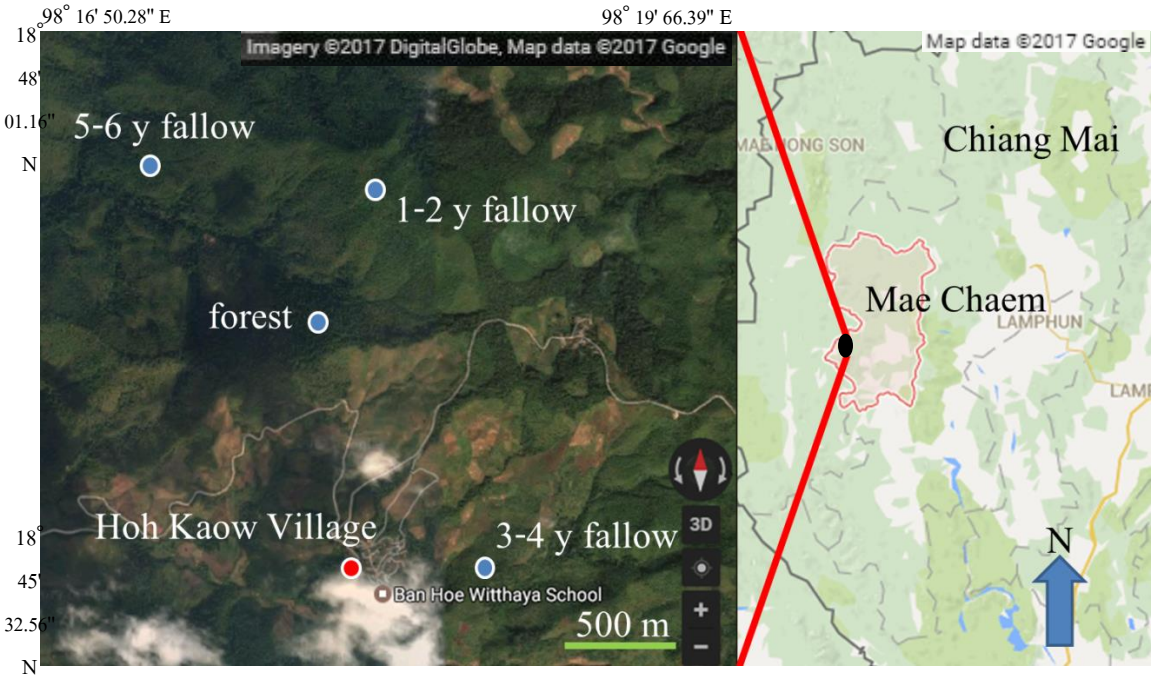

Figure 1 Approximate location of study sites in Hoh Kaow Village, Pang Hin Fon Sub-District, Mae Chaem District, Chiang Mai Province (Google, 2017a; Google, 2017b).

Objectives of the study

The aims of this study are to survey bird diversity, abundance, density, and calculate ecological indices in three different rotational shifting cultivation areas (short cultivation-long fallow pattern) and natural forest in Pang Hin Fon Sub-District, Mae Chaem District, Chiang Mai Province.

Methodology

Site description

Bird sampling sites were established in four categories: young-aged fallow (1-2 year), middle-aged fallow (3-4 year), old-aged fallow (5-6 year), and a relatively undisturbed primary forest as a control plot. Vegetation structure in each of the sites was accessed by a 10 x 50 m^2 plot, and a forest profile diagram was drawn. All trees with diameter at breast height, DBH (1.3 m) more than 4.5 cm, were identified based on Smitinand (2001). Tree height, canopy width and height, and tree position were recorded.

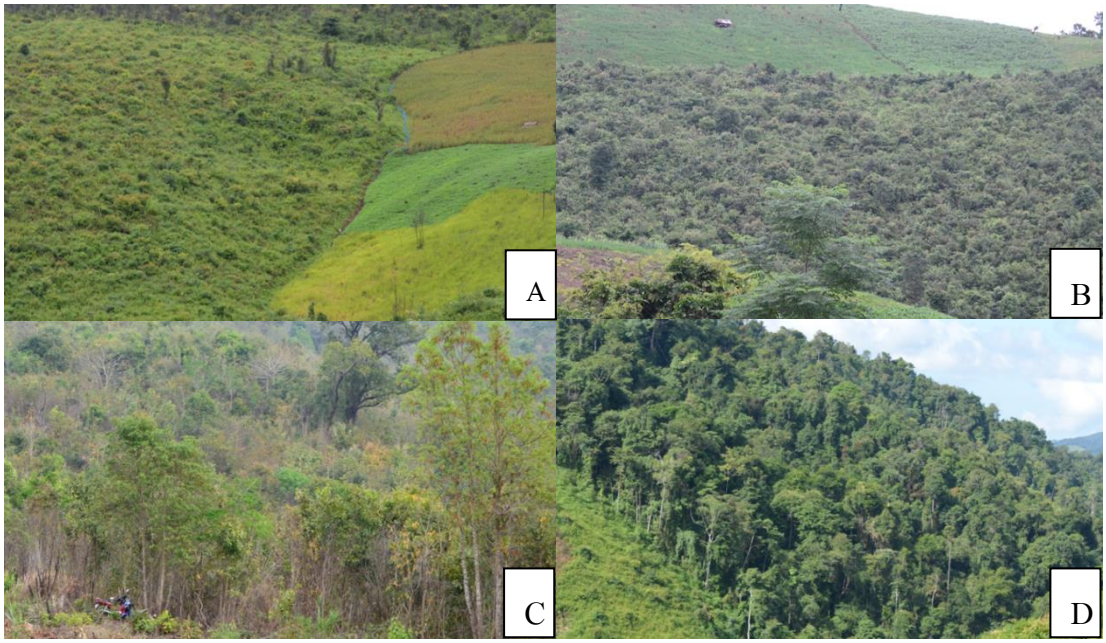

Figure 2 Three successional stages of fallow after shifting cultivation: (A) young-aged fallow (1-2 year), (B) middle-aged fallow (3-4 year), and (C) old-aged fallow (5-6 year), and primary forest (D) in Pang Hin Fon Sub-District, Mae Chaem District, Chiang Mai Province.

Bird census

The point count method was used. At least eight survey points (with 25 m radius) were established in each of the habitats, distances between the survey points were at least 50 m, and were far from the edge of habitats for at least 50 m. Censuses were done for ten minutes per survey point, with five to ten minutes between the survey points. Each of the habitats was surveyed once a month during November 2015 to October 2016. The censuses were conducted between 06h00 to 09h40 in the morning and 15h00 to 18h30 in the afternoon. Birds were identified according to Lekagul, Round (1991), Robson (2002), Nabhitabhata et al. (2012), and the birds seen or heard were counted within the 25 m radius. The observation at the

survey points included distance estimation, and the number of individuals including sex or age where possible recorded. Birds flying over weren't included.

Data analysis

Table 1 Six ecological indices

Ecological Index	**Formula**	**Detail**	**Reference**
Frequency of bird species occurrence or Relative Abundance	Relative Abundance (%) = number of surveys that a species appears / total number of surveys x 100	90 - 100% = Abundant 65 - 89% = Common 31- 64% = Moderately Common 10 - 30% = Uncommon 1 - 9% = Rare	Pettingill (1969)
Density Index	Density (individuals/hectare) = N/A	N = the number of individuals in a survey area A = the total area	Blankespoor (1991)
Diversity Index or Shannon-Wiener's Index, H'	$H' = -\sum_{i=1}^{s} (P_i \ln P_i)$	s = the number of species presented in the sample area P_i = the proportion of individuals belonging to the i species in the sample area	Shannon, Weaver (1949)
Evenness Index, E	$E = H' / \ln s$	H' = Shannon-Wiener's Index s = the number of species presented in the sample area	Whittaker (1975) cited in Wang et al. (2000)
Similarity Index or Sorensen Index, CS	$CS\ (\%) = 2c / (a + b)$	c = the number of species occurring in both communities a = the total number of species found in first community b = the total number of species found in second community	Sorensen (1948)

Results and Discussion

Site description

The elevation range of the 1-2 year fallow was 1,115 to 1,190 m above sea level, and its aspect was southwest. This 33.28-hectare area was last cultivated in 2014, so it had been left for vegetation regrowth for two years after rice cultivation. The understory of this site was very dense, and had the highest percentage of grass cover. The species of pioneer plants common in this successional stage were, for example, *Buddleja asiatica* and *Imperata cylindrical*. The woody species appeared, but all them had DBH less than 4.5 cm, such as *Aporosa villosa*, *Anneslea fragrans*, and several species of fagaceae.

The elevation range of the 3-4 year fallow was from 1,056 to 1,092 m above sea level, and its aspect was northwest. This 5.76-hectare area had undergone four years of regrowth at the time of this study. From the profile diagram, there appeared only one layer of canopy at 3-5 m height. The forest had a taller canopy and more open understory than the 1-2 year fallow. The canopy was very open, which was similar to the 1-2 year fallow. The Dominant tree species were *Lithocarpus polystachyus*, *Castanopsis acuminatissima*, and *Ilex umbellulata.*

The 5-6 year fallow had the range of elevations from 1,009 to 1,103 m above sea level, and its aspect was southwest from the north. At the study time, the 34.4-hectare area had undergone six years of regrowth, and the trees would be cut down and burnt in early 2017. The profile diagram presented only one layer of canopy at 4-7 m height. The forest had a taller, and had a more closed canopy and higher plant diversity than the 1-2 and 3-4 year fallow areas. *Wendlandia tinctoria* and *Stereospermum neuranthum* were the dominant tree species.

The control primary forest plot was the most diverse in terms of diversity and vegetation structure. The mean of the canopy height was greater and had more shade than all the fallows. From the profile diagram, can the forest could be divided into three layers of canopy. The first was the understory layer at 7 to 15 m in height, and the dominant species was *Desmos dumosus*. The second was the canopy layer at 16 to 28 m in height, and the dominant species was *Polyalthia viridis*. The last emergent layer was at 29 to 36 m in height. *Elaeocarpus stipularis* was the largest and highest tree in the primary forest plot. The range of elevations was 1,089 to 1,189 m above sea level, and its aspect is northwest, and the size of primary forest was 33.28 hectare. All studied sites were located near to a currently cropped rice field and adjacent to a natural forest.

Bird census

There were 127 species, 42 families, and 10 orders of birds found in this study, of which 97 were resident species, 27 species were winter visitors, 1 species was passage migrant, and 2 species were breeding visitors. Bird species richness in the primary forest was more diverse than secondary forest (fallow) that found 9 orders, 32 families, and 84 species. In the secondary forest, the old-aged fallow (5-6 year) was more diverse than other secondary forest stages (Table 2), the number of the bird species increased according to stage of succession (Raman et al., 1998; Borges, 2007). However, the middle-aged fallow (3-4 year) appeared to have the lesser numbers of orders, families, and species, than the young-aged fallow (1-2 year) because there were more specialists (13 species) that appeared only in the young-aged fallow, such as Brown Shrike, Green Bee-eater, Pied Bushchat, and some species of Bulbuls. Whereas, there were only 5 bird specialists found in the middle-age fallow. Moreover, the size of the middle-aged secondary forest was smaller than the other habitats, and was fragments of forests, so the number of bird species was restricted by area size (Blankespoor, 1991).

Table 2 Number of bird species in each habitat

Line Survey	Orders	Families	Species
1-2 year fallow age	6	28	62
3-4 y fallow age	2	24	51
5-6 y fallow age	7	28	64
primary forest	9	32	84

Comparing to the prior studies, Chanthorn (2002) studied effect of fallow-shifting cultivation in an upland area on bird community at Mae Chaem District, which was nearby this study site. He found 139 bird species, while there were 127 species in this study. However, the similarity of birds between Chanthorn (2002) and this study appeared to be 70.89% base on Sorensen's similarity index. There were 30 species not found in this study such as Yellow-breasted Bunting, which was an endangered species (International Union for Conservation of Nature and Natural Resources [IUCN], 2016). It is possible that the bird species richness decreased from before because of landscape transformation. However, the bird species richness and diversity of undisturbed forest was higher than disturbed forest or secondary forest according to Kunsorn (2005), he studied diversity of birds at Doi Pha Hom Pok, Chiang Mai Province, and found 177 species in 35 familes in undisturbed forest, and in the study of Cherpaiboon et al. (2015), they studied bird assemblages in Mae Yom National Park, Phrae Province, they found 16 orders, 53 families, and 172 species, also in undisturbed forests.

The abundance of the bird species in each of the rotational shifting cultivation field and the forest were analyzed (Table 3), the primary forest had the highest bird abundance, where there were 5 abundant species, 12 common species, 23 moderately common species, 24 uncommon species, and 20 rare species. The abundance of a number of forest bird species were negatively related to degree of habitat alteration due to shifting cultivation because the forest bird specialists had restricted ranges of habitats more than the species colonizing in fallows (Raman, 2001). Additionally, most migratory species were classified to rare species and uncommon species. The migratory birds immigrated to Thailand in September each year, and returned in May of next year (Nabhitabhata, 2012). The immigration time periods and destinations were different depending on bird species. Therefore, the migrant species were detected less than the resident birds (Nakwa, 2008).

Table 3 Abundance of bird species in each habitat

Line Survey	Level of Abundance					
	Rare	**Uncommon**	**Moderately Common**	**Common**	**Abundance**	**Total**
1-2 year fallow age	8 (4)	16 (15)	11	5	3	62
3-4 y fallow age	14 (9)	8 (2)	12 (1)	3	2	51
5-6 y fallow age	16 (6)	18 (3)	13 (3)	3	3	65
primary forest	14 (6)	17 (7)	21 (2)	12	5	84

*data in parentheses means number of migrant species, and outside parentheses means number of resident species

For analysis of the rare species (seen only 1 time) in each of the habitats, Ashy Drongo, Hill Blue Flycatcher, and Scarlet Minivet were rare species in the 3-4 year fallow, but they were common species in the 5-6 year fallow, and the primary forest. There were 9 rare species in the fallow areas, but they were common species in the primary forest such as

Himalayan Black Bulbul, Blue-throated Barbet, and Emerald Dove. The abundance species in the 1-2 and the 3-4 year fallows were Grey-breasted Prinia and Red-whiskered Bulbul. Grey-eyed Bulbul and Black-crested Bulbul were abundant species in the 1-2, and the 5-6 year fallows, and the primary forest, while Himalayan Black Bulbul was abundant species in the primary forest. White-rumped Munia, Puff-throated Babbler, and Red-whiskered Bulbul appeared in every habitat and every survey, so they were considered as generalists. Birds in Pycnonotidae had broad range of distribution, and they were found in every study site (Blankespoor, 1991; Chanthorn, 2002; Meesena et al., 2014).

The number of specialists in the 1-2, 3-4, 5-6 year fallows, and the primary forest were 13, 5, 7, and 30 species, respectively. Specialist birds in the primary forest were 15 rare species such as Ferruginous Flycatcher, Mrs. Gould's Sunbird, Northern White-crowned Forktail, and Wedge-tailed Green Pigeon, 6 uncommon species such as Eyebrowed Wren Babbler, Green Cochoa, and Long-tailed Broadbill, and 10 moderately common species such as Orange-bellied Leafbird, White-bellied Erpornis, and White-throated Bulbul. Many forest bird species declined in abundance or disappeared in successional fallows. The primary forest was the main habitat for specialized forest birds and rare species (Bowman et al., 1998; Anderson, 2001; Raman, 2001). In addition, Nakwa (2008) found White-bellied Erpornis, Grey-eyed Bulbul, and White-throated Bulbul, and they were announced as specialist birds for dry evergreen forests, while Sooty-headed Bulbul, Bright-capped Cisticola, and Grey-breasted Prinia were classified as specialist birds in grasslands, which was similar to this study.

Density of the bird species in each habitat of the rotational shifting cultivation showed that the primary forest had the greatest density of all the birds (37.47 individuals/hectare), and the least in the 5-6 year fallow. Comparing to the 1-2 year fallow, the number of species (Table 2) in the 5-6 year fallow age was only little greater, but the total density in the 5-6 year less than in the 1-2 year slightly (Table 4). Moreover, the young-aged fallow and middle-aged fallow had high density (Table 4) but low diversity (Table 5) because bird flock pattern was found in the young-aged fallow and the middle-aged fallow more than in the old-aged fallow such as White-rumped Munia, Red-whiskered Bulbul, and Common Rosefinch. Therefore, more numbers of bird individuals were encountered.

Table 4 Density of bird species in each habitat

Line Survey	Density (individuals/hectare)		
	Resident birds	Migratory birds	All birds
1-2 year fallow age	24.32	2.40	26.73
3-4 y fallow age	28.21	1.70	29.91
5-6 y fallow age	22.10	2.42	24.52
primary forest	32.16	5.32	37.47
Total	26.96	3.20	30.16

Comparing to the other studies, Utarak (2002) studied bird assemblages between forest edge and forest in Khao Wang Kamain Area, Sai Yok District, Kanchanaburi Province, and found that bird density in forest edge (62.94 ± 2.18 individuas/hectare) more than in the forest area (58.25 ± 1.38 individuas/hectare). In addition, in the study of Cherpaiboon et al. (2015), they studied bird assemblages in Mae Yom National Park, Phrae Province. The density of all the birds was 36.37

individuals/hectare. These studies showed that the bird density in the undisturbed forest area was more than in the disturbed area or the secondary forest. However, in the study of Nakwa (2008), he studied biodiversity of birds at Thung Salaeng Luang National Park, Phetchabun Province, and it was found that the bird density values were 31.43 to 32.97 individuals/hectare in seasonal evergreen forests, that represented the bird density in seasonal evergreen forest was slightly different to the primary forest in this study.

Table 5 Ecological indices of bird species in each habitat

Line Survey	Ecological Index		
	Shannon-Wiener, H'	Evenness, E	Species Richness
1-2 year fallow age	3.00	0.73	62
3-4 y fallow age	2.99	0.76	51
5-6 y fallow age	3.42	0.82	65
primary forest	3.66	0.83	84

The primary forest was more varied of the species and well-distributed of the individuals in each species than the old-aged fallows. The young-aged fallow (3.00) had the diversity index near to the middle-aged fallow (2.99). Moreover, the evenness of the birds in each of the study site had similar trends with the diversity index (Table 5).

Comparing to the study of Blankespoor (1991) who studied bird diversity in slash and burn shifting cultivation in Liberia, and found that diversity of resident birds was 2.14, 2.70, and 2.97 in current, recent, and old farms, respectively. According to this study, the species diversity increased following stage of succession. The primary forest was the most diverse because of resources, various food, microhabitats, and shelters. In the primary forest, there were several foraging groups such as carnivores, trunk/ branch insectivores, hawking insectivores, frugivores, granivores, ground-foraging omnivores, nectarivores, small foliage-gleaning insectivores, and ground-foraging insectivores. In addition, many food plants found in the primary forest attracted more frugivores, insectivores, and nectarivores than fallow area such as *Erythrina subumbrans*, *Walsura trijuga*, and *Rhus chinensis*. However, the fallow succession found common tree species, which were eaten by frugivorous birds such as *Eugenia fruticose* and *Macaranga denticulatae* (Wangpakapattanawong et al., 2010).

Table 6 Similarity index of bird community in habitat pairs

Line Survey	Sorensen Index, CS (percentage)		
	3-4 y fallow age	5-6 y fallow age	primary forest
1-2 year fallow age	61.95	57.14	43.83
3-4 y fallow age		62.61	44.44
5-6 y fallow age			60.81

Pairwise community similarity indices were calculated (Table 6), it was shown that bird communities in many habitat pairs were more similar than 50%, but in the former study of Chanthorn (2002) in the same sub-watershed, he found similarity values of the birds less than 50% in many habitat pairs. It might be because he separated study sites differently from this study that they were active rice field, 5-10 years fallow age, and mature primary forest. Each habitat of his had different floristic compositions and vegetation structure clearly. The age differences of the habitats affected species occurrence. Thus,

his study might appear to have the bird species more dissimilar than 50% in all of the habitat pairs. Nowadays, the farmers rotated area of shifting cultivation every six years, so for this study, the division of the fallow ages was slightly different. The similarities of the birds in the primary forest with the young and the middle-aged fallow were less than 50%, while the study of Meesena et al. (2014) found that the bird community in the primary forest was almost 70% similar to the secondary forest. They explained that the secondary forest located adjacent to the primary forest, so the birds might fly across.

The primary forest was least similar with the young-aged fallow (43.83%), but it was the most similar with the old-aged fallow (60.81%). Due to the structure and composition of vegetation that created various microhabitats, the plant species in the old-aged fallow were the most similar with the primary forest, such as *Polyalthia viridis* and *Knema erratica*. It showed that the old-aged fallow or the 5-6 year fallow age had a capability that attracted and supported forest bird species as the primary forest. From observation, some forest birds turned over to use the old-aged fallow for foraging or nesting such as Black-naped Monarch.

Conclusions

1. There were 127 species, 42 families, and 10 orders of birds found. The bird species richness in the primary forest was more diverse than in the secondary forest. In the secondary forest, the old-aged fallow was more diverse than the other fallow ages.

2. The primary forest had the highest bird abundance, where there appeared 5 abundance species, 12 common species, 23 moderately common species, 24 uncommon species, and 20 rare species.

3. The bird density in the study area, including resident and migratory birds, were 30.16 individuals/hectare. If the density was only calculated for the resident birds, there were 26.96 individuals/hectare, and the density of the migratory birds was 3.2 individuals/hectare.

4. For the diversity of the birds, the primary forest, 3.66, was more diverse than the old-aged fallow, 3.42. The young-aged fallow had the same level of the diversity with the middle-aged fallow with 3.00 and 2.99, respectively. Moreover, the evenness of the birds in all the study sites had similar trends with the diversity index.

5. For the similarity of the bird communities in many habitat pairs, the primary forest was least similar to the young-aged fallow, and more similar with the old-aged secondary forest.

6. The old-aged fallow had some capabilities that attracted and supported forest species as the primary forest, because it was rather similar to the primary forest in the species diversity and species evenness including some forest bird specialist and some tree species occurrence.

7. Bird species richness, abundance, and diversity increased during the successional stage. Many forest bird species declined in abundance or disappeared in early stages successional fallows, as a result, rotational shifting cultivation had a negative impact on forest bird specialists, but had a positive impact on diversity of open country bird specialists.

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