Bird’s species response to the ex-coal mining reclamation stages

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Abstract. Birds played an essential role in the life cycle. This study aimed to determine the bird diversity in coal mining reclamation areas with different ages of reclamation plants: one, four, and eight years old, located in East Kalimantan, Indonesia. The bird diversity was determined using two methods: direct observation and capture-released using mist nets. The birds captured by mist nets were identified, and morphometric measurements were conducted. The results showed 26 species of birds found in this study. Birds species were dominated by Blue-throated bee-eater (Merops viridis), Yellow-vented bulbul (Pycnonotus goiavier), Asian-glossy starling (Aplonis panayensis), and Javan myna (Acridotheres javanicus). The bird’s diversity in the reclamation area with four years of reclamation plants was higher than the other areas. However, the number of birds in the reclamation area with eight years of reclamation plants was the highest. Differences in habitat conditions in the three research areas might cause a low similarity index of bird diversity. Javan myna and Yellow-vented bulbul were found in all research sites. In conclusion, pioneer bird species were observed during the early process of post-coal mining reclamation. The existence of cover crops was essential as a source of food for the birds and nests.

1. Introduction

East Kalimantan is one of the provinces that has the largest coal reserves in Indonesia. By the end of 2018, East Kalimantan's coal production reached ± 257 million tonnes, equivalent to 46% of total national production [1]. In general, the coal mining system in Indonesia is open-pit mining. On a large scale, this coal mining technique can affect soil structure, sedimentation, habitat loss, and a reduction in the population of biodiversity that lives above the soil surface [2-3]. One of the stages of efforts to restore environmental conditions after coal mining is through reclamation activities.

The reclamation of coal mining land was through land-use activities, revegetation, and the completion process in assessing canopy cover and plant maintenance [4]. Unfortunately, the implementation of coal mine reclamation in Indonesia does not include the criteria for restoring biodiversity, such as wildlife [5]. The presence of wild animals is an essential indicator of ecological restoration's success, especially for reclamation areas with the Borrowing and Use of Forest Area Permit (IPPKH= Izin Pinjam Pakai Kawasan Hutan) scheme.

Birds are wild animals that have an essential role in helping the succession process in coal mine reclamation areas. Bird communities have an ecological role as seed dispersers, thus triggering new plant’s emergence in the natural succession process [6]. Birds are accelerating the ongoing revegetation process. This phenomenon causes bird community’s presence in the reclamation area of coal mines to
be an essential indicator in the process of restoring biodiversity [7]. Many studies have been conducted to record bird species in the coal mine reclamation area [6-8]. Environmental variations between coal mine reclamation sites affect the bird community’s existence [7-8]. So, the presence of bird species is not always the same between reclamation locations, so conducting a more specific study for each location is necessary.

This study aims to determine the response to bird species’ presence at various ages of coal mine reclamation. Understanding the coal mine reclamation area’s succession process is expected to help accelerate the ongoing environmental restoration efforts.

2. Materials and Methods

2.1. Study site
The research was conducted in September 2012 at coal mining company areas of PT Kideco Jaya Agung (KJA), located at Batu Kajang Subdistrict, Paser District, East Kalimantan Province of Indonesia (S0°51’- 1°58’ E115°50’-115°53’). The company’s coal mining concession area was about 23,000 hectares, which was previously a forest area. However, according to the regulations in Indonesia, the company could not occupy all the concession areas to extract coal. They were also obliged to reclaim and rehabilitate after the coal was extracted. The plants used for reclamation were usually fast-growing and harvested at the ages of 6-8 years.

Three reclamation areas with different ages of reclamation plants were selected as the observation areas: 1) Location A was planted with a year old Enterolobium cyclocarpa plantation area with 3 x 3 m spacing. The average height and diameter of the plants were about 3 m and 4 cm, respectively. This place was adjacent to a limestone hill with a diverse vegetation composition. 2) Location B was four years old of mixed Paraserianthes falcataria and Acacia mangium plantation area, with 3 x 3 m spacing. The plant's average height and diameter were about 12 m and 17 cm, respectively. 3) Location C, was an eight-year-old of P. falcataria plantation with the spacing of 4 x 4 m. The plant's average height and diameter were about 17 m and 30 cm, respectively.

2.2. Procedure
Bird biodiversity was estimated using direct observation using 10x50 binoculars and capture-release using mist nets for 10 days in a row (+120 hours). The observations were performed using the transect method in the morning (5-7 AM) and evening (5-6.30 PM) at each reclamation area: locations A, B, and C. There were two bird observers at each location. In the second method, a mist net-sized 6x2 m was installed at each observation area. The mist nets were placed in the area where the birds were most likely to cross. Mist nets were inspected every two hours, and the captured birds were identified and measured. Identification was done using a field guide of birds [9]; morphometric measurements were taken using calipers for beak length, head length, head width, total length, tail length, limb length, wing length, and weight by digital scale. Subsequently, the data were tabulated, and the bird’s abundance was compared among the research locations.

2.3. Data analysis
The recorded bird species were further analyzed to determine the species dominance index and species diversity index. Species dominance index (Di) was calculated by (ni/N) x 100%, where N is the total individual of birds, and ni is the individual number of birds i [10]. A bird species is not dominant if the Di is less than 2%. When the Di is between 2-5%, the species is sub-dominant, and it is a dominant species when the Di is more than 5%. Meanwhile, the diversity index was calculated using Shannon index (H') = -∑pi =1(pi)(log2 pi), where pi is the proportion of species i to total species (s) [11]. Overlapping of species presence between locations were described using Venn diagram analysis. Inter-location clustering of bird communities is analyzed using hierarchical clustering with the "ward.D" method. Meanwhile, cluster distance was determined with Jaccard similarity index (J), which was calculated by a/(a+b+c), where a is the total number of species in both location A and B, b is the number
of species found only in location A, and $c$ is the number of species found only in location B [12]. Hierarchical clustering analysis was conducted using software R version 3.4.4, the vegan package [13]. Additionally, the dietary preference of each bird species was categorized into six groups of feeding guilds, i.e., carnivorous (bird feed mainly non-insect animals, e.g., fish, lizard, small mammal, etc.), insectivorous (feeding insect, arthropods, etc.), frugivorous (fruit-eating species), nectarivorous (feeding floral nectar), granivorous (feeding seed/grains), and omnivorous (feeding both on animals and part of the plant) [14].

3. Result

3.1 Bird species

There were 26 species of birds found in all reclamation areas, which comprised 16 families. Of the total, 20 bird species were classified as the understory species, recorded through direct observation using the transect method and the mist nets. There were differences in the composition of bird species between locations. Location B (4 years old reclamation plant) has the highest number of bird species with the highest species diversity. Meanwhile, location C (8 years old reclamation plants) has the highest number of individual birds than other locations (Table 1).

Table 1. Composition and diversity of birds in reclamation stage

| Parameter          | Location A (1 year) | Location B (4 years) | Location C (8 years) | Total number |
|--------------------|---------------------|----------------------|----------------------|--------------|
| Number of species  | 7                   | 14                   | 10                   | 20           |
| Number of family   | 6                   | 11                   | 9                    | 12           |
| Number of individuals | 18                  | 18                   | 20                   | 56           |
| Diversity indices ($H'$) | 2.17                | 3.73                 | 2.70                 | 3.47         |

3.2 Bird dominance

The under-canopy bird species found in this study were dominated by the Blue-throated Bee-eater (*Merops viridis*) ($Di = 16.1\%$), Yellow-vented Bulbul (*Pycnonotus goiavier*) ($Di = 16.1\%$), Asian Glossy Starling (*Aplonis panayensis*) ($Di = 15.5\%$), and Javan Myna (*Acridotheres javanicus*) ($Di = 6.5\%$). On the other hand, several non-under-canopy bird species were also observed flying around in the reclamation areas, such as Glossy Swiftlet (*Collocalia esculenta*), Silver-rumped Spinetail (*Rhaphidura leucopygialis*). There were also observed several raptor species of birds: *Haliaastur indus*, *Pandion haliaetus*, *Maclearamphus alcinus*, which often flown around the mining area to search for some prey. The Black hornbill (*Anthracoceros malayanus*) had also observed in this study. This species often flew across mining areas, moving from and to the forest fragments, but these birds did not visit the reclamation areas.

3.3 Bird Species Community

The similarity of bird communities between locations A-B was 40\%, higher than the similarity between locations A-C, and B-C which are 21\% and 20\%, respectively. Meanwhile, the habitat clustering based on the dissimilarity value with the threshold value of 50\% indicated that locations A and B were in the same cluster (Figure 1).

Javan myna and Yellow-vented Bulbul were two species found at the three locations in this study. On the other hand, Asian Glossy Starling (*A. panayensis*), Short-toed Coucal (*Centropus rectunguis*), Eastern Spotted Dove (*Spilopelia chinensis*), White-breasted Waterhen (*Amaurornis phoenicurus*), and Blue-throated Bee-eater (*M. viridis*) were considered as the initial bird species because they were found in the coal mine reclamation area with 1-year-old reclamation plants (Figure 2).
3.4 Birds Morphometry
Morphological measurements were carried out on all birds caught in nets in this study. However, analysis can only be conducted on those birds that were found in two or three locations. These birds were *A. panayensis*, *M. viridis* and *P. goiavier*. *Aplonis panayensis* and *Merops viridis* caught at locations A and B, while *P. goiavier* was captured in all locations. The average size of all morphometric parameters of *A. panayensis* found at Location A was larger than in Location B. Meanwhile, except for the sizes of wing length, the average size of all morphometric parameters of *M. viridis* found at Location A was also larger than Location B (Figure 3). The body weights of *A. panayensis* and *Merops viridis* at Location A were also heavier than Location B by 1.75% and 1.60%, respectively. In general, *P. goiavier* found at Location C was the largest compared to the other two locations (Figure 3), accounted for 1.75-1.90% heavier. However, our data is limited, so it cannot be supported by further statistical analysis.
3.5 Guild Classification

All identified bird species can be grouped into five dietary categories. We found that insectivorous dominated each study site (Figure 4). In the location A and B, the dominance of insectivorous was followed by omnivorous. Meanwhile, carnivorous became dominant after insectivorous in Location C. There were no species in frugivorous and granivorous in location C.

Figure 4. Percentage of bird trophic guilds in each location

4. Discussion

In this study, the dominant bird species, such as *M. viridis*, *P. goaivier*, and *A. panayensis*, had wide adaptability to various habitat conditions [6], [8] and [15]. The presence of these species of birds in the coal mining reclamation area was also reported in the other studies in Kalimantan [8]. Naturally, these bird species preferred to inhabit various types of habitat: secondary forests, plantation areas, and surrounding human settlements [9]. These habitat conditions might be comparable to the conditions in the research areas. The reclamation area provided food sources, especially for bird species with
generalist feeding behavior, such as *P. goavier* and *A. panayensis*. In other words, that both species have high adaptability compared to others.

Direct observations also found the species of raptor birds, which often flew over above the mining reclamation areas during the day. This flying behavior was generally carried out when the birds hunted for prey, such as rats or other small mammals on the ground. The presence of the raptor bird species as the top predator in this study might indicate that a local food chain had been established. Based on the analysis of the feeding guild, it can be seen that the occurrence of carnivorous birds was increasing along the natural succession process. Location C was starting to become a habitat for top predatory birds, e.g., eagles. It has denser vegetation than locations A and B. Frugivorous and granivorous play a role in helping the colonization of pioneer plants. It is found in younger reclamation areas (locations A and B). Furthermore, the dominance of insectivorous birds in all study sites is natural since it is a key indicator of the coal mining reclamation until the stage of 5 years old [7].

The *Centropus rectunguis* observed in the research area were categorized as vulnerable species according to the IUCN Red List (The International Union for Conservation of Nature’s Red List of Threatened Species). Consequently, the vulnerable category required conservation efforts for this species so that the population could be maintained. Human access in coal mining areas was limited, reducing the potential threat to bird species, including protected and vulnerable species.

The different composition of bird species among locations A, B, and C in this study might be related to the different ages of reclamation plants. Among the three locations, dynamic changes affected bird preferences for selecting places to inhabit [8]. Various plants for post-mining reclamation and the pioneer plant species at various age levels have influenced the bird species composition. For example, it was generally preceded by frugivores/granivores bird species [3]. Furthermore, nectarivore birds could be a marker of the succession of reclamation areas after 5 years [7]. However, the bird similarity index among the reclamation areas in this study was low, indicating only a few species-specific birds as the habitat characteristic. Species-specific animals were those that were only found in specific habitats [16].

Species of plants usually planted at the reclamation areas were fast-growing species, such as *Paraserianthes falcataria*, *Enterolobium cyclocarpa*, and *Acacia mangium*. At the age of four, these species of plants had grown into a small tree, and its canopy began to form with shrubs dominating the floor at the reclamation sites. Shrubs usually can produce seeds and small fruit, which could be one of the factors these birds visit; some even created nests, such as *P. goavier*. Shrubs could also provide adequate shelters for small birds against predators, strong winds, and cold air [17]. At the age of eight, these fast-growing plants could reach the mature age, ready for harvest with a height of 15 m and a diameter of 20 cm; The tree canopies were already formed and created a microclimate underneath.

The number of bird species and the diversity value at the reclamation site with eight years old of reclamation plants (location C) were lower than at the reclamation site with four years old (location B). There were still many shrubs in the reclamation area with 4-year-old reclamation plants that provided a food source for pioneer birds. On the other hand, in the reclamation area with 8-year-old plants, a 17-meter-high tree canopy has been formed, reducing sunlight for undergrowth. However, the reclamation area with eight-year-old plants was often visited and crossed by birds on the canopy, such as swallows and three species of eagles.

The reclamation area with one-year-old reclamation plants was still an open area where the sunlight reached the floor. In addition, there were also found several pioneer plant species such as *Melastoma malabathricum*, *Trema cannabina*, *Trema tomentosa*, *Geunsia pentandra*, *Vitex pinnata*, and *Piper aduncum* [6]. At the beginning of the post-mining reclamation process, these plants were planted as cover crops to reduce soil erosion. These pioneer plant’s fruits and seeds were generally food sources for various birds from the *Pyconotidae* family.

Birds observed in the reclamation area with one-year-old reclamation plants could come from the limestone hills near that reclamation area. The limestone hills were a suitable habitat for these birds because they had various vegetation structures and compositions. The presence of birds in the reclamation areas might purposely for foraging for food or passing because there were no bird nests found in this reclamation area. This limestone hill was a small patch of natural forest remaining in the
mining concession area. The remaining forest fragments could have benefits because they were a suitable habitat for birds and other animals. Furthermore, the birds could spread plant seeds from the remaining forest fragments traveling to the reclaimed land, accelerating the natural succession process.

5. Conclusion
At the early stage of post-coal mining reclamation, birds with wide adaptability appeared to the reclamation areas. Meanwhile, the existing cover crops planted before the reclamation plants had become the source of food for these birds. These cover crops created shrubs in the above-ground of reclamation areas. The growth of wild shrubs in the reclamation areas aged 1 and 4 years was needed to be maintained because they were to provide a seed and fruit feed source for pioneer birds and serve as a nesting site. Furthermore, the presence of raptor species suggested that a local food chain had been established, along with small terrestrial mammals.

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