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The Relationship between Birds Diversity and Habitats in Phou Khao Khouay (PKK) National Park of Lao PDR

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Abstract

In recent years, global warming, drought and little rain, forest fires, forest destruction and other human disturbances have had an important impact on the habitat environment of birds, affecting the number and quality of bird habitats, directly threatening the survival and reproduction of birds, leading to a sharp decline in the diversity of bird species. In this study, the PKK National Park (18°14' - 18°32'N; 102°38' - 102°59'E), Laos was used as a research site. The birds and their habitats in the park were used as research objects. The species, quantity and distribution of birds were investigated. In addition, the distribution of vegetation and the relationship between bird's community and habitat types in PKK National Park were studied. Species diversity and Abundance of birds at PKK National Park, was monthly assessed by point count method between January and December 2018. A total of 117 species of birds belonging to 43 families and 18 orders were found in the inspection areas. Among them, Passerine birds (60 species) and Non-Finches (57 species) were almost equal to each other, accounting for 51.3% and 48.7% of total birds species respectively. Again, Anseriformes birds account for the largest number amongst Non-Passeriformes, reaching 15 species, followed by Falconiformes, accounting for 20.5% of total. On the other hand, based on migratory habits, resident birds were found to be highest in our research site which account for 35.04% of total birds and followed by Summer Migratory birds (32.28%), Passage Migrant (23.93%) and Winter Migratory birds (6.83%). Through the quantitative measurement and analysis of various parameters, the focus is on the diversity of birds and species in the park. Further, the factors that can affect species diversity, especially the bird's survival factors such

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as vegetation change pattern, transformation rate of green areas, recruitment and restoration pattern of wild animals, especially birds, and other beneficial animal populations were also emphasized in our study. Over and above, exploring the scientific basis for the construction of the green space system of the PKK National Park in Laos with reasonable structure, complete functions and ornamental values was in the heart of this research.

1. Introduction

Biodiversity is the sum of all ecological processes related to the ecological complex formed by organisms and their environment, including millions of animals, plants, microorganisms, their genes and the complex ecological system formed by them and their living environment. It is the basic feature of living systems. Biodiversity is the basis for human survival and development. In urban development, it is of great significance to maintain ecological security and ecological balance and improve people's living environment. The value of biodiversity can be understood from two aspects: First, the direct value; Second, indirect value. It is mainly related to the functions of the ecosystem, mainly manifested in seven aspects: fixing solar energy, regulating hydrology, preventing soil and water loss, regulating climate, absorbing and decomposing pollutants, storing nutrient elements, promoting nutrient circulation and maintaining the evolutionary process. Over time, the greatest value of biodiversity may lie in providing humans with the opportunity to adapt to local and global changes.

Birds have a large number of species in nature and are highly sensitive to environmental changes. They are easy to observe in wild animals and occupy an important position in the ecosystem. They play an important role in maintaining the balance of the ecosystem and biodiversity. It is also related to habitat structure, vegetation diversity, plant complexity and other factors. At present, bird species structure and its dynamic trend are important reference indexes for regional environmental changes.

Bird diversity is the core of the research on bird ecology and the hotspot of conservation biology. The diversity of birds not only reflects the state of birds themselves, but also reflects the fine habitat of birds, which can play a better indicator of ecological balance and environmental quality. A large number of studies at home and abroad have confirmed that the diversity index of birds is closely related to their habitats. The difference of habitat environment and the degree of external interference have an important impact on the bird population and quantity. The research on the relationship between bird species diversity and habitat environment is helpful to provide theoretical basis for the bird habitat protection and suitability evaluation.

Forest park is not only an important green land in urban areas, but also a major leisure and entertainment place for residents. It is also an important habitat for urban birds, providing four most important basic elements for urban birds: food, space, water and shelter. Urban Park, as the main part of urban landscaping, provides favorable conditions and opportunities for the protection and development of biodiversity. It is also an important biological habitat, a clearinghouse of biological flow and energy, and a carrier of urban biodiversity. In recent years, the research focus of conservation biology has shifted from the protection of single species to the protection of species habitats and ecosystems. Nature reserves are places for biodiversity conservation, and their establishment and effective management are strategic measures for biodiversity conservation.

2. Research Background

Rainforests are the most productive and biodiversity terrestrial ecosystems on earth (Leigh, 1999). Tropical rainforest accounts for 60% of the total forest area in Southeast Asia. Tropical moist deciduous forest and tropical dry forest each account for 15% and 10% of the total forest area in Southeast Asia (FAO, 2001). They cover less than 10 percent of the earth's land surface but contain nearly half of all species. A basic concern of ecologists is the mechanism of species coexistence, especially on the small spatial scale of different forests (Wright, 2002).

Forest composition and the relationship between the bird species abundance is close, can often be found, they can form a self-sufficient community or biological association, plants and birds can live independently, geographical distribution, combination of plants and birds usually letters and species composition of association in its range, there's nothing like a broader portfolio of different plants.

There is a close relationship between forest composition and bird species richness. They can form a self-sufficient population or biological community, and neither plants nor birds can live alone. Within a certain range, the species composition of the community, different combinations of plants than a single species change more (Vestal, 1914). Therefore, understanding forest composition, i.e. the relationship between plant diversity, density and bird type, can more accurately predict the richness and distribution of bird species (Mohd, 2016). The composition of plant community is influenced by the structure and function of ecosystem. For example, species composition and species diversity strongly influence ecosystem processes, such as nutrient cycling, productivity, decomposition rate, and nutrient dynamics, especially when one or more species have strong ecosystem effects (Hooper & Vitousek, 1997). Plant diversity is important because species depend on each other. Therefore, the disappearance of one species leads to the loss of others. There has been discussion about the concept of diversity and its measurement. The concept of diversity is well represented in linguistics, sociology and physics (Patil & Taillie, 1982).

Forest birds mainly require a large number of forest habitats, different from

other requirements on forest structure and composition. Many studies have reported that forest areas are closely related to bird distribution and abundance (Mcgarigal & Mccomb, 1995; Radford et al., 2005; Trzcinski, Fahrig, & Merriam, 1999; Villard, Trzcinski, & Merriam, 2010; Westphal, Field, Tyre, Paton, & Possingham, 2003). Mitchell, Lancia and Gerwin (2001) found that in the two related coniferous forests in southern south Carolina of the United States, the study found that in the two managed coniferous forests in south Carolina (the United States), the generalist had a low sensitivity to forest characteristics, while the expert had a strong response to them. We found that on a landscape scale, high canopy density (over 70%) was not conducive to species richness of forest birds, which was consistent with other authors' views on the impact of forest density and canopy density on species richness in the Iberian Peninsula (Carrascal, 1987; James & Wamer, 1982; Teller & Santos, 1994; Swift, Larson, & Degraaf, 1984). This is because in the understory of high-density forests, the development of shrubs and herbaceous species is restricted, possibly due to the reduction of sunlight penetration. Shrubs provide food as well as foraging and nesting sites, and the related heterogeneity of forest structure can also reduce the predation risk of many bird species through greater visual hindrance (Martin, 1993).

However, this study takes the PKK National Park in Laos as the research area, and mainly studies the relationship between bird diversity and plant community and its species composition, density and relationship, as well as between birds and habitat, so as to provide decision-making basis for the protection of birds in relevant areas.

3. Objective

The aim of this study is to examine the relationship between plant species composition, elevation gradient and forest habitat with bird diversity.

4. Research Questions

Q1: How does plant species composition affect the bird diversity?
Q2: Does bird diversity vary along forest habitat?

5. Hypothesis

Plant species composition, forest habitat and elevation gradient affect the bird diversity in the seasonal tropical forest at PKK National Park.

6. Research Methods

6.1. Study Area

Laos is a land-locked country located at the heart of the Indo-Chinese peninsula. Figure 1 shows that the PKK National Park is one of the most important places in Lao People's Democratic Republic. In 2017, it was designated as the state animal and plant protection, the location of the PKK National Park is 18°14' - 18°32'
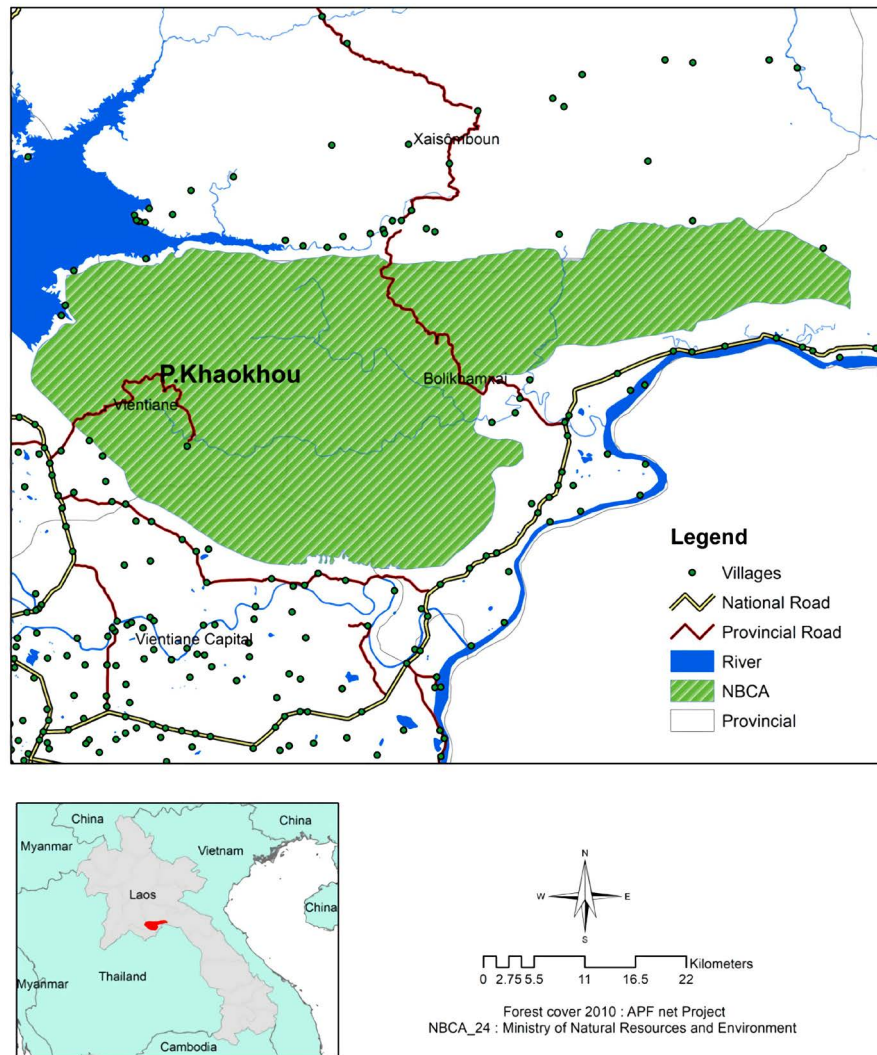
Figure 1. PKK National Park in Lao PDR (Source: ArcGIS, version 10.5).

east longitude, 102˚38'- 102˚59' north latitude, about 40 kilometers northeast to Vientiane, the whole reserve area is about 2000 square kilometers, covering the area including province like Borlikhamxay, altitude range from 100 meters to nearly 1700 meters or less. The average rainfall during the rainy season (May to October) was 3369 mm. From November to April, the average rainfall was only 265 mm. The temperature is highest before and during the rainy season. April is the hottest month with an average temperature of 39˚C whereas December is the coldest month with an average temperature of 10˚C (Laos measurement units, 2011). Animal and plant resources of the park are very rich. Management now aims at restoring and strengthening biodiversity and preserving the park's habitat and ecosystem value. It is a dense forest with a wide variety of plants and rich diversity.

6.2. Bird Survey and Analysis

Some basic methods adopted in this study are described by (Bibby, Burgess, &

Hill, 1992). Point count method: it is suitable for estimating the diversity and richness of birds. This method moves along a fixed route and records the species of birds found. The birds survey did sit and see all of the bird in the 3 area between Januarys and December 2018; on the morning from 6.00am to 9.00am and in the evening from 3.00pm to 6.00pm (1 area 1 day and 2 times for 1 area of birds survey). A binocular (Olympus) and birds survey manual was used to confirm the identification of the birds; nests were located by sight. For every bird species the following parameters were recorded: 1) activity of the bird when first sighted; 2) the number of bird species at every sighting; 3) location of nests and species involved; all the numbers done noted.

6.3. Plant Investigation and Analysis

The study was carried out in four forest plots of the PKK National Park for sampling plots established in forest areas, the physical characteristics of the forest and the availability of plant species are covered. The sampling plot is a stratified sub-plot used for different measurements, which is used to identify the efficiency of the location and number of the scaled plots used to describe the vegetation (El-Ghani, Mobarak, & Bakr, 2012; Soukhavong, Yong, Nanthavong, & Millet, 2013), was analyzed through data collection and field investigations. The tree species were investigated in 10 m × 10 m quadrangle, the shrub species in 2 m × 2 m quadrangle, and the herbaceous plants in 1mx1m quadrangle. The main indicators are:

1) Trees: plant name, number of plants, height, crown width, DBH, growth status, hierarchy, whether updated, etc.

2) Shrubs: name of shrubs, number of plants, height, width, density of hedges, growth status, whether there is any update, etc.

3) Herbaceous: name of herbaceous, number of plants/clusters, coverage, height, growth status, whether it is wild, etc.

In the survey, the greenbelt patches with small functional area types or small greenbelt patches that cannot be divided into communities piecewise was integrated into adjacent areas for the survey, and the unknown species that survived was not be counted when species statistics are carried out.

The plant species data adopt the important value as the comprehensive index, which is the sum of the relative density, relative frequency and relative coverage of the ecological important value. In this paper, the important value is calculated by the relative height, relative advantage and relative spelling.

$$\text{Important value of trees} = \frac{(\text{relative height} + \text{relative frequency} + \text{relative advantage})}{3}$$

$$\text{Shrub and herbaceous significance} = \frac{(\text{relative coverage} + \text{relative height} + \text{relative frequency})}{3}$$

6.4. Correlation Analysis

Pearson correlation coefficient was used to analyze and measure the correlation

between bird's diversity and habitat, and SPSS was used to process data. *P* value less than 0.05 was significantly positive and *P* value less than 0.01 was extremely significantly positive. $P < 0.05$ was considered relevant.

7. Results and Discussion

7.1. Characteristics of Birds

In urban compound ecological system, city park has irreplaceable functions; plays a regulating climate to reduce the noise, absorbs carbon dioxide and releases oxygen, conserves soil and water and improves the thermal environment. At the same time, it builds favorable conditions and opportunities for conservation and development of biodiversity; thus providing the wild animals in the city within the scope of an important habitat, feeding and refuge place (Zhu, 2001; Yang & Wu, 2000; Li et al., 2001). Zhu (2001) describes city park as a biological flow and energy exchange place which is an important carrier for urban biodiversity. Moreover, City Park has become an important index to measure the comprehensive quality of the city.

Urban wildlife and its habitats are important components of urban ecology and biodiversity. The structural diversity of wildlife, especially urban birds, is an important component of urban biodiversity as well as an important evaluation index of environmental quality, which directly reflects the level of urban biodiversity (Costa & Furness, 1982). Birds are a good indicator of ecosystem health. Through the study of bird community in an ecosystem, the rationality of system structure and the stability of function can be understood. This study conducted sampling surveys in different types of parks to understand the characteristics urban park's bird community and its changing rules.

7.2. Composition and Characteristics of Bird Diversity

A total of 117 species of birds, belonging to 18 orders and 43 families, were recorded during 12 days long field survey; twice a month from January to December 2018. They were divided into Passerine birds and Non-passerine birds. Among them, 60 species of Passerine birds under 23 families, accounting for 51.3% of the total population while Non-Finches accounted for 48.7%. Among Non-Passeriformes birds, Anseriformes birds account for the largest number, reaching 15 species, followed by Falconiformes birds, accounting for 20.5% in total. It can be seen that the diversity of birds in the PKK National Park is a contributing feature. In terms of species, birds of the order Passeriformes are the main ones, while birds of the Non-Passeriformes are mainly geese and falcons.

Passerine birds play a very important role in maintaining the relationship among species, food chain structure and controlling the population and quantity of pests. Besides, they help plants to spread seeds and pollens, and are indicative of the health of the ecosystem. In terms of appearance, the plumage color of finches is bright and beautiful, and the crowing sound is melodious and melodious. Whether it is auditory or visual, it gives people a pleasant feeling, and is

an indispensable bird in the PKK National Park.

As can be seen from Figure 2, among three investigated areas, Tad Xai has the largest number of bird species, accounting for 76.92% of all species, followed by Had Khai, accounting for 66.67% of all species, and Tad Leuk, accounting for only 17.09% of all species. From the perspective of conservation biology, the larger the area, the higher the number of available species. This is one of the reasons for highest number of bird species appearance in Tad Xai. Moreover, the ecological diversity caused by shrubs is of great attraction to birds.

7.3. Settlement Analysis of Bird Communities

On the basis of differences in migration and migratory habits, birds can be divided into four types: Resident birds, Summer migratory birds, Winter migratory birds and Passage migrant birds. Summer migratory birds breed in a certain area in summer and leave to spend the winter in a warm place in the south in autumn, and return to the previous area in the following spring. On the other hand, Winter migratory birds spend the winter in a certain area, fly north to breed in the spring of the next year, and fly back to the former place in the autumn to spend the winter. Passage Migrant birds are birds that pass through a place during their migration and do not spend the winter or breed. According to our observation and statistics, the quantity of resident birds, summer migratory birds, passage migrant and winter migratory birds in inspected area are 35.04%, 32.28%, 23.93% and 6.83%, respectively (Figure 3).

As observed from the figure below, there are relatively more resident birds and summer migratory birds in Tad Xai and Had Khai area. These two types of birds generally prefer to nest and forage in forest canopy, standing tree and ground cover. Such ecological environment can provide necessary places for birds to breed and sleep at night. In a word, the number of resident birds reflects whether the ecological region is stable for the habitat environment of birds. As shown in the figure below, Tad Xai is the most suitable habitat for birds among three investigated sites.
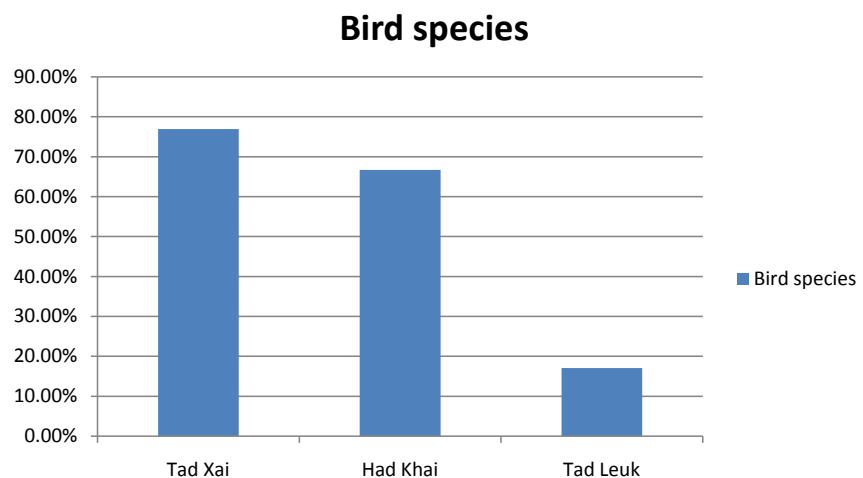

Figure 2. Comparison of the number of bird species in the surveyed area.
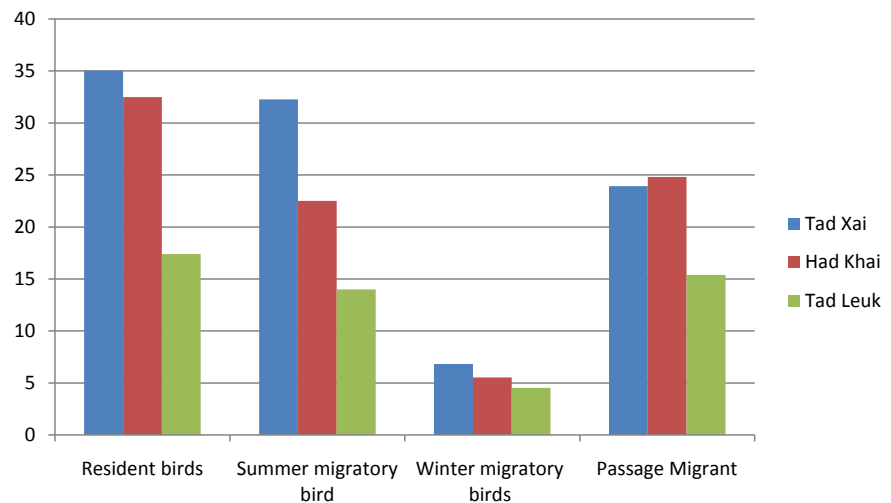
Figure 3. Bird residence patterns in three inspection areas of PKK National Park.

7.4. Study on the Relationship between Bird Community and Habitat

Wild animals are closely related to the habitat environment. Through the inspection of three selected area of the PKK National Park, the ecological environment of the PKK National Park can be directly or indirectly understood, so as to provide a scientific basis for further improvement of the ecological environment of the PKK National Park orchards and surrounding areas. Based on the investigation results of the three inspection areas, this research analyzes and discusses the relationship between bird diversity and environment in the PKK National Park for the first time.

7.5. Analysis of Environmental Factor

At the same time, the environmental factors which have great influence on birds, were selected. The environmental factors that affect birds mainly are of two types: one is natural factors, and the other is human factors. Based on natural factors, this study selected six indicators for analysis that are closely related to the survival of birds namely green coverage rate, plant diversity, tree species diversity, shrub species diversity, herbaceous diversity and total area. Specific evaluation criteria are as follows:

Plant area (PA): The actual values there are 5 grades from low to high, respectively 1 - 5 points. 1 points: PA < 80; 2 points: 80 ≤ PA < 160; 3 points: 160 ≤ PA < 240; 4 points: 240 ≤ PA < 320; 5 points: PA ≥ 320; Unit/ha.

Evergreen biodiversity (VB): Measured values for evergreen biodiversity were grouped into 5 grades from less to more as follows- 1 points: VB < 0.6; 2 points: 0.6 ≤ VB < 0.7; 3 points: 0.7 ≤ VB < 0.8; 4 points: 0.8 ≤ VB < 0.9; 5 points: VB ≥ 0.9.

Evergreen coverage rate (VR): Measured values for evergreen coverage rate were grouped into 5 grades from less to more as follows-1 points: VR< 0.6; 2 points: 0.6 ≤ VR < 0.7; 3 points: 0.7 ≤ VR< 0.8; 4 points: 0.8 ≤ VR < 0.9; 5 points:

VR ≥ 0.9.

Arbor biodiversity (AB): measured value according to the diversity of trees from less to more were divided into 5 grades, were given 1 - 5 points. AB < 0.75; 2 points: 0.75 AB < 0.8; 3 points: 0.8 AB < 0.85; 4 points: 0.85 Ab < 0.9; 5 points: AB 0.9.

Forest biodiversity (FB): Measured values of forest biodiversity were categorized into 5 grades from less to more as follows-1 point: VR < 0.75; 2 points: 0.75 ≤ VR < 0.8; 3 points: 0.8 ≤ VR < 0.85; 4 points: 0.85 ≤ VR < 0.9; 5 points: VR ≥ 0.9.

Herbaceous biodiversity (HB): Measured values of herbaceous biodiversity were categorized into 5 grades from little to much as follows-1 point: VR < 0.75; 2 points: 0.75 ≤ VR < 0.8; 3 points: 0.8 ≤ VR< 0.85; 4 points: 0.85 ≤ VR < 0.9; 5 points: VR ≥ 0.9.

Regional bird habitats were evaluated according to the sample land assessment criteria of the surveyed areas (Table 1). As noticed from the table, regarding natural quality of habitats Tad Xai is the best followed by Had Khai and Tad-Leuk.

7.6. Correlation Analysis between Bird Diversity and Habitat

Bird community is a comprehensive reflection of the relationship between birds and the environment and the species of birds. Within a certain space and time, there are many factors affecting species diversity, including the complexity of regional landscape, the nature of landscape elements, survey intensity and survey area. Therefore, bird communities have different characteristics in different habitats. To study the relationship between birds diversity and habitat, in all sample plots, three indicators of birds community characteristics namely species (S), density (D) and habitat (H) were taken into consideration. Furthermore, different important habitat factors such as Evergreen Biodiversity rate (VR), plant biodiversity (PB), plant species (PS), arbor biodiversity (AB), arbor species (AS), forest biodiversity (FB), forest species (FS), herbaceous biodiversity (HB), herbaceous species (HS), plant area (PA), water area (WA) were also studied as shown in Table 2 and Table 3.

The study on the correlation between bird species and habitat in the three investigation areas found that bird species (S) were related to plant area (PA), evergreen rate (VR), herbaceous species (HS), plant biodiversity (PB) and plant

Table 1. Evaluation table of regional green space ecological environment quality.

Area	PA	VB	VR	AB	FB	HB	Combine
Tad Leuk	2.00	3.00	4.00	3.00	1.00	1.00	15.00
Tad Xai	5.00	5.00	5.00	4.00	4.00	5.00	28.00
Had Khai	5.00	4.00	5.00	3.00	4.00	5.00	26.00

Note: PA: Plant Area; VB: Evergreen Biodiversity; VR: Evergreen Coverage Rate; AB: Arbor Biodiversity; FB: Forest Biodiversity; HB: Herbaceous Biodiversity.

Table 2. Correlation analysis of birds and habitats in the investigated areas.

	PA	VR	AB	FB	HB	PB	PS
H	0.916*	0.908*	0.663	0.622	0.587	0.851*	0.714*
D	0.568	0.184	0.202	0.477	0.697	0.343	0.492
S	0.825*	0.922**	0.587	0.780	0.645	0.857*	0.690

Note: *: $p < 0.05$; **: $p < 0.01$.

Table 3. Correlation analysis of species and habitat of forest birds.

	PB	PS	PA	AB	FB	HB	VR
Forest bird	0.843*	0.874*	0.691	0.604	0.702	0.755	0.985**

Note: *: $p < 0.05$; **: $p < 0.01$. PB: Plant Biodiversity; PS: Plant Species.

species (PS), but not significantly related to other factors. Bird species (Y) were positively correlated with the area (X) studied. The regression equation was $Y = 0.223X - 5.375$, R = 0.818, $P < 0.05$.

According to the principle of conservation biology, species with large area are relatively numerous. Tad Xai and Had Khai attract more birds. The larger the area, the more trees and shrubs in the forest land, and the more diverse the habitat, which attracts a large number of birds. There was a significant positive linear correlation between bird species (Y) and greening rate (X). The regression equation was $Y = 287.565X - 173.677$, $R = 0.922$, $P < 0.01$. High vegetation coverage, rich plant species and good natural vegetation growth can provide more suitable living space for more birds, and the species composition of bird community is more abundant.

7.7. Correlation Analysis between Different Roosting Birds and Roosting Sites

According to living environment, the habitat types of birds can be divided into three types-water birds, forest birds and intermediate birds. Water birds are mainly dependent on wetland environment for survival, whereas forest birds depend on woodland environment for their survival, and those between water birds and forest birds are called intermediate birds.

According to the results of this survey, based on the analysis of the habitat types of birds, we found that, the species of water birds and forest birds among the existing birds are equivalent. However, the numbers of forest birds were highest (61.5%) among the existing birds and almost double to that of water birds (31.6%), while the middle type birds accounting for only 6.9% (**Figure 4**). These results are in accordance with the natural environment and vegetation of surveyed area; as we know, to a certain extent, the number of bird species reflects the local vegetation. The presence of more species and numbers of forest birds as well as water birds is because of more water areas from natural waterfalls and large flow area.

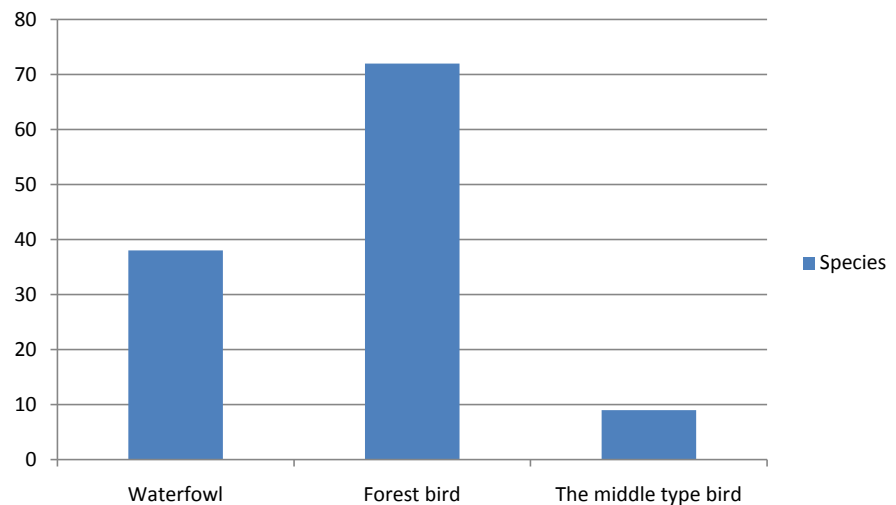Comparing the data from three inspection areas of PKK national park, regarding

Figure 4. Statistics of birds of different habitat types in the inspection areas of PKK National Parks.

intermediate type birds no obvious difference was found. However, according to the observation records, Tad Xai area was found to harbour most species of the forest birds, a total of 69 kinds, accounted for 76.67% of total birds species, suggesting it a better ecological place compared to other two areas. Again, the highest number of waterbirds (28 species) was found in Tad Xai, accounting for 35.9% of the total species followed by Had Khai and Tad Leuk (**Figure 5**). The main reason behind this is the presence of great natural falls Xai falls in Tad Xai, with good water resources as the water area has greater influence on the water bird species.

7.8. Correlation Analysis between Different Feeding Birds and their Habitats

The structure and function of bird's community can be further understood by analyzing and studying the feeding habits of birds. From the survey of bird's feeding habits, the majority of the birds, a total of 83 species, accounting for 70.94% of the total bird species, were found to be carnivorous, which mainly feed on meat, aquatic animals and insects including a large numbers of waterfowl feeding on aquatic animals and insect-eating birds. The distribution range of this largest birds group is very wide, throughout all the surveying area including Tad Xai, the largest regional area. Because of having high habitat diversity with rich vegetation, Tad Xai provides favourable conditions for the growth of many insects like bees, butterflies, beetles, moths, flies, thus providing foods for insect-eating birds and consequently harbouring them. Moreover, large water bodies present in this area make it inhabitable for waterfowls as they supply adequate aquatic foods to them. The carnivorous groups were followed by a total of 32 species of graft mainly passeriformes fringillidae birds. However, compared to the first two groups, there were only 17 species of omnivorous birds. Feeding statistics of birds in the inspection area of PKK National Park is depicted in **Figure 6**.
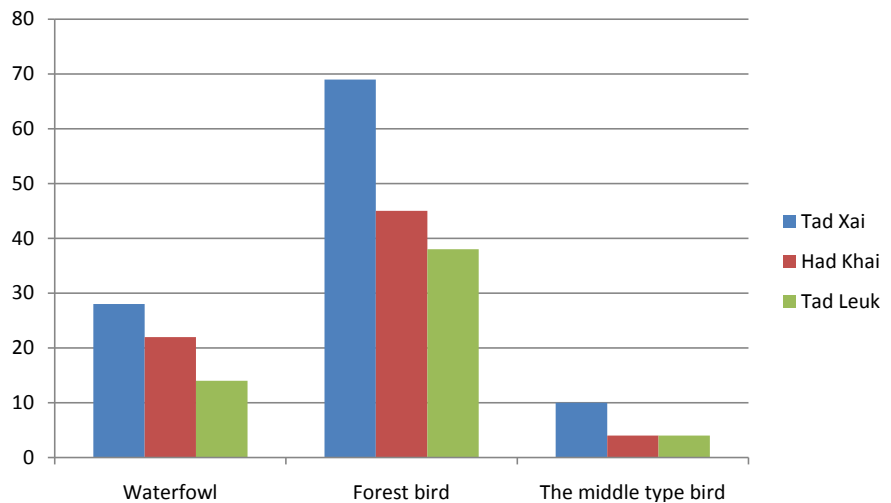
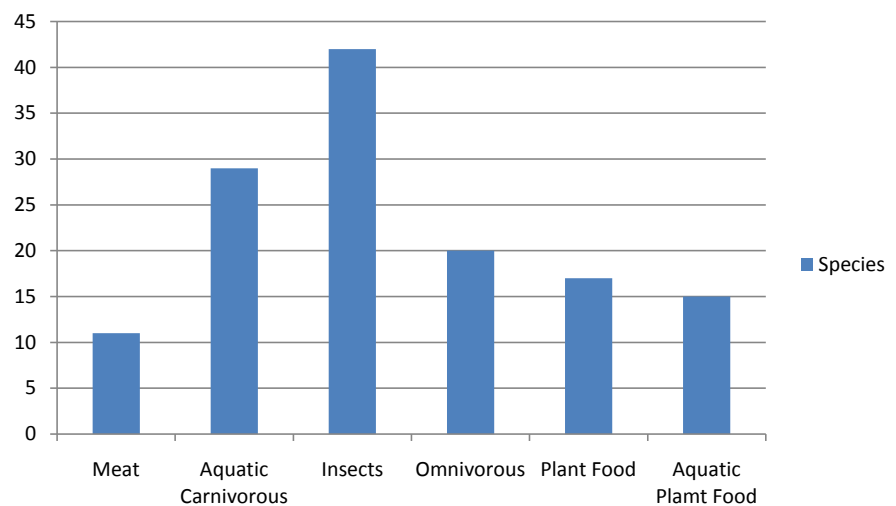**Figure 5.** Comparison of bird habitat types in the inspection areas of the PKK National Park.

Figure 6. Feeding statistics of birds in the inspection area of PKK National Park.

On the basis of feeding types birds can be divided into six groups: water or wetland feeding, ground feeding, grass feeding, tree feeding, air feeding. According to the survey results, there are 62 species of birds feeding on the ground, 23 species of birds feeding on the air, and 53 species of birds feeding on trees, accounting for 45.30% of the total birds species. It is clearly evident that the vegetation quality of bird habitats directly affects the feeding sources of birds. Types of bird predation observed in PKK National Parks are shown in Table 4.

The correlation analysis between different feeding birds (such as meat-eating birds, aquatic animals eating birds, insect eating birds, predatory birds, aquatic plant feeding birds, omnivorous birds) and habitats found in the investigation areas, shows that three kinds of birds namely insect eating birds, omnivorous birds and those feed on plant has significant correlation with evergreen coverage rate (VR). This indicates that vegetation affects the habitat and reproduction of birds, especially that of insectivorous, omnivorous and herbivorous birds. The

Table 4. Types of bird predation observed in PKK National Parks.

Feeding type	Ground feeding	Air feeding	Shrub feeding	Tree feeding	Water feeding
Number of species	25	23	29	53	36
Accounting	21.37%	11.11%	24.79%	45.30%	30.77%

Note: some birds prey in a variety of ways and can prey in different circumstances.

excellent species and quantity of green plants directly affect the food sources of birds.

8. Conclusion

The aim of this study has been to examine the relationship between plant species composition, elevation gradient and forest habitat with bird diversity in PKK National Park, Lao PDR. The findings show that the species, quantity and distribution of birds were diverse. We have investigated the species and quantity of birds in the park, the status of distribution of vegetation and the relationship between bird community and habitat type in PKK National Park based on the data analysis. Species diversity and abundance of birds at PKK National Park, was monthly assessed by point count method between January and December 2018. There were 117 species of birds from 43 families and 18 orders. The study also has found that there were some water bodies and rural settlements in the park and the people surrounding the park, are also dependent, to some extent, on its resources for their livelihoods. In fine, it can be said, there is an intimate relationship between environmental factors, ecological issues and human habitats. Therefore, the government should take appropriate policy measures to protect the forest resources as well as the biodiversity and eco-systems of this forest.

Acknowledgements

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Bibby, C. J., Burgess, N. D., & Hill, D. A. (1992). *Bird Census Techniques*. Cambridge: Cambridge Univ. Press.

Carrascal, L. M. (1987). *Relacio'n entre avifauna y estructura de la vegetacio'n en las repoblaciones de con'íferas de Tenerife (Islas Canarias)*. Ardeola 34.

Costa, M., & Furness, J. B. (1982). Nervous Control of Intestinal Motility. *Handbook of*

Experimental Pharmacology, 59, 279-382.
https://doi.org/10.1007/978-3-642-68437-1_10

El-Ghani, M. A., Mobarak, A., & Bakr, R. J. (2012). Factors Affecting the Diversity and Distribution of Synanthropic Vegetation in Urban Habitats of the Nile Delta, Egypt. *Rendiconti Lincei. Scienze Fisiche e Naturali, 23,* 327-337.
https://doi.org/10.1007/s12210-012-0179-z

FAO (2001). *International Action in the Management of Forest Genetic Resources: Status and Challenges.* Forest Genetic Resources Working Papers, Working Paper FGR/1, Rome: Forest Resources Development Service, Forest Resources Division, FAO of the United Nations.

Hooper, D. U., & Vitousek, P. M. (1997). The Effects of Plant Composition and Diversity on Ecosystem Processes. *Science, 277,* 1302-1305.

James, F. C., & Wamer, N. O. (1982). Relationships between Temperate Forest Bird Communities and Vegetation Structure. *Ecology, 63,* 159-171.
https://doi.org/10.2307/1937041

Leigh, E. G. (1999). *Tropical Forest Ecology: A View from Barro Colorado Island by E. G. Leigh.* Oxford and New York: Oxford Univ. Press.

Li., Y. M., He, G. J., Wang, W., Ding, S. L., Jia, X., & Yan, Z. G. (2001). Remote Sensing Research on Relationship between Urban Heat Island and Vegetation Covering. In *National Symposium on Remote Sensing Technology.* Fuzhou.

Martin, T. E. (1993). Nest Predation among Vegetation Layers and Habitat Types: Revising the Dogmas. *The American Naturalist, 141,* 897-913.
https://doi.org/10.1086/285515

Mcgarigal, K., & Mccomb, W. C. (1995). Relationships between Landscape Structure and Breeding Birds in the Oregon Coast Range. *Ecological Monographs, 65,* 235-260.
https://doi.org/10.2307/2937059

Mitchell, M. S., Lancia, R. A., & Gerwin, J. A. (2001). Using Landscape-Level Data to Predict the Distribution of Birds on a Managed Forest: Effects of Scale. *Ecological Applications, 11,* 1692-1708.
https://doi.org/10.1890/1051-0761(2001)011[1692:ULLDTP]2.0.CO;2

Mohd, S. K. (2016). Effect of Forest Composition on Bird Species Abundance in Tropical Dry Deciduous Forest: A Case of Bhimbandh Wildlife Sanctuary, India. *Biodiversitas, 18,* 78-85.

Patil, G. P., & Taillie, C. (1982). Diversity as a Concept and Its Measurement. *Journal of the American Statistical Association, 77,* 548-561.

Radford, J. Q., Bennett, A. F., & Cheers, G. J. (2005). Landscape-Level Thresholds of Habitat Cover for Woodland-Dependent Birds: An Introduction to Ecological Thresholds. *Biological Conservation, 124,* 317-337.

Soukhavong, M., Yong, L., Nanthavong, K., & Millet, J. (2013). Investigation on Species Composition of Plant Community at Tad Xai at Phou Khao Khouay National Park, Lao PDR. *Our Nature, 11,* 654-660. https://doi.org/10.3126/on.v11i1.8237

Swift, B. L., Larson, J. S., & Degraaf, R. M. (1984). Relationship of Breeding Bird Density and Diversity to Habitat Variables in Forested Wetlands. *Wilson Bulletin, 96,* 48-59.

Teller, L. Ã. J., & Santos, T. J. (1994). Factors Involved in the Distribution of Forest Birds in the Iberian Peninsula. *Bird Study, 41,* 161-169.

Trzcinski, M. K., Fahrig, L., & Merriam, G. (1999). Independent Effects of Forest Cover and Fragmentation on the Distribution of Forest Breeding Birds. *Ecological Applications, 9,* 586-593. https://doi.org/10.1890/1051-0761(1999)009[0586:IEOFCA]2.0.CO;2

Vestal, A. G. (1914). Prairie Vegetation of a Mountain-Front Area in Colorado. *Botanical Gazette, 58,* 377-400. https://doi.org/10.1086/331429

Villard, M.-A., Trzcinski, M. K., & Merriam, G. (2010). Fragmentation Effects on Forest Birds: Relative Influence of Woodland Cover and Configuration on Landscape Occupancy. *Conservation Biology, 13,* 774-783.

Westphal, M. I., Field, S. A., Tyre, A. J., Paton, D., & Possingham, H. P. (2003). Effects of Landscape Pattern on Bird Species Distribution in the Mt. Lofty Ranges, South Australia. *Landscape Ecology, 18,* 413-426.

Wright, S. J. (2002). Plant Diversity in Tropical Forests: A Review of Mechanisms of Species Coexistence. *Oecologia, 130,* 1-14. https://doi.org/10.1007/s004420100809

Yang, X., & Wu, Q. S. (2000). Characteristics of Secondary Vegetation Restoration in Abandoned Farmland in Tropical Area of Hainan Island. *Journal of Plant Ecology, 24,* 477-482.

Zhu, W. Q. (2001). Advances in Urban Forest Research. *Ecology, 20,* 55-59.