

Article

Non-Breeding Season Habitat Selection of Three Commonly Occurring Bird Species in a Patchy Habitat in SE China

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Abstract: Research into bird habitat selection can unveil the impact of specific habitat characteristics on bird survival. However, empirical information on the environmental factor preferences and differences within the yew ecological garden for birds is still lacking. This study was conducted in a yew ecological garden located in the southern experimental area of the Meihua Mountain National Nature Reserve, Fujian Province, China. We selected three commonly occurring bird species for analysis to discern the factors influencing habitat selection and interspecific differences and the impact of habitat environmental factors. Canopy density and coverage were identified as dominant factors influencing habitat selection for the Red-billed Blue Magpie (*Urocissa erythrorhyncha*), Black Bulbul (*Hypsipetes leucocephalus*), and Orange-bellied Leafbird (*Chloropsis hardwickii*). The height of perching trees, average tree height, and average diameter at breast height were all important determinants for the habitat selection of Red-billed Blue Magpie and Black Bulbul. These dominant factors were consistent with logistic regression analysis results. Both one-way ANOVA and stepwise discriminant analysis revealed significant differences in habitat selection among three commonly occurring bird species. Our results provide important insights into avian habitat selection in patchy habitats, which can be used as a guideline for future conservation and habitat management.

Keywords: *Urocissa erythrorhyncha*; *Hypsipetes leucocephalus*; *Chloropsis hardwickii*; bird habitat; habitat characteristics; bird conservation



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1. Introduction

Habitat fragmentation represents one of the most significant threats to global biodiversity, leading to environments that are increasingly patchy and disconnected [1,2]. The survival of species within these fragmented habitats is contingent upon their ability to select and utilize available habitats effectively [3]. The quality of bird habitats directly influences their survival and reproduction [4]. The process of fragmentation often leads to a reduction in habitat size and an increase in the number of habitat edges, which can negatively affect bird populations [5,6]. Smaller, isolated patches are less capable of supporting diverse bird communities, and increased edge effects can threaten the survival of bird species [7]. In recent years, human activities and ecological changes have threatened bird habitats, leading to fragmentation, degradation, and loss. Moreover, fragmented habitats may alter the behavior and distribution of bird species, which can result in genetic isolation and reduced genetic diversity [8]. Consequently, bird diversity and abundance have declined, exacerbating the survival crisis for birds [9,10]. Therefore, further studies on bird habitat selection are crucial for understanding ecological processes and conserving bird resources [11,12].

Land use changes, such as urban expansion and agricultural development, can lead to habitat fragmentation, subsequently impacting birds' habitat selection and population dynamics [2,13]. Habitat strategies among birds primarily manifest in spatial feature

preferences, food resource utilization, and reproductive tactics [14,15]. For example, in a study of tropical forest alterations, two bird species living in the same area showed significant differences in habitat preferences, with one species favoring moist environments and the other preferring dry forests, demonstrating how species can coexist by selecting different ecological niches within the same habitat [16]. These differences help to reduce interspecific competition and promote biodiversity maintenance [17]. By delving into the habitat selection strategies of different bird species, we can uncover how they adapt to their ecological niches and how these strategies influence their survival and reproductive success rates [3,18]. Although many studies have highlighted interspecific variations in the selection of perch tree characteristics among bird species [19,20], empirical information on the environmental factor preferences and differences within patchy habitats for birds is still lacking.

Here, we selected three commonly occurring frugivorous bird species as our study subjects, namely, Red-billed Blue Magpie (*Urocissa erythrorhyncha*), Black Bulbul (*Hypsipetes leucocephalus*), and Orange-bellied Leafbird (*Chloropsis hardwickii*). These three species have a relatively high population size and higher abundance. Red-billed Blue Magpie belonging to the Corvidae family, which is widely distributed in China and Southeast Asia [21]. Currently, it is listed as Least Concern by the International Union for Conservation of Nature (IUCN). Black Bulbul belongs to the Pycnonotidae family, with its range extending from India eastward to Southeast Asia. It is the type species of the genus *Hypsipetes* and is currently listed as Least Concern by the IUCN. Orange-bellied Leafbird, part of the Chloropseidae family, is native from the central and eastern Himalayas to the northern parts of Southeast Asia. Due to ongoing habitat destruction, the population is suspected to be declining, but it is still listed as Least Concern by the IUCN. We evaluated habitat selection and utilization within patchy environments by these three species. Specifically, we examined the following: (1) What are the dominant factors in the habitat selection process of birds? (2) What are the differences in habitat selection among commonly occurring bird species and how do environmental factors impact them? Our results provide insights into avian habitat selection preferences and can be used as a guideline for the conservation and management of birds in patchy habitats.

2. Materials and Methods

2.1. Study Area

This study was conducted in a yew ecological garden, located in the southern experimental area of the Meihua Mountain National Nature Reserve (25°15′–25°35′ N, 116°45′–116°57′ E) in the western part of Fujian Province, China. This area boasts a temperate climate characterized by an average annual temperature of 13 °C to 18 °C, an annual rainfall ranging from 1700 mm to 2200 mm, and a relative humidity consistently above 70%. This area serves as a quintessential transitional zone bridging the southern periphery of the central subtropics and the southern subtropical regions. Within the reserve, the yew ecological garden lies in Chongtou Village in the southern part of the Meihua Mountain National Nature Reserve (25° 16′ 28″–25° 16′ 29″ N, 116° 52′ 40″–116° 52′ 59″ E). The garden spans an elevation range of 900 m to 1200 m and covers a total area of 15 hectares. The yew ecological garden is dominated by evergreen broad-leaved forests and hosts numerous Chinese Yew (*Taxus chinensis*) along with other towering dominant tree species [22], including Fujian Cypress (*Fokienia hodginsii*), Smiling Monkey Forest Tree (*Michelia maudiae*), Ring-cupped Oak (*Quercus glauca*), and *Sloanea sinensis*. Surrounding the yew ecological garden, bamboo forests and farmland contribute to the patchy distribution characteristics of the area [23]. In this study, we specifically noted the human disturbance activity of clearing low shrubbery within certain patch habitats of the yew ecological garden during the autumn and winter of 2021. However, it is important to clarify that the quadrats of this experiment were not located within the areas affected by this disturbance. Therefore, the clearing of shrubbery did not constitute an additional influencing factor on the sampling sites of this study.

2.2. Data Collection

To evaluate the habitat characteristics of birds, our study observed the Red-billed Blue Magpie, Black Bulbul, and Orange-bellied Leafbird in the yew ecological garden across the autumn and winter seasons of 2020 (October–December) and 2021 (October–November). The use of the habitat was evaluated during the non-breeding season because the fruits of many plants ripen in the autumn and winter. These ripe fruits are an important food source for birds. Therefore, plant fruits at this time can also have an impact on bird habitat selection. We used the sample point method as the sampling type. During 2020 and 2021, two observers conducted daily surveys using binoculars from 06:00 to 10:00 and 15:00 to 18:00. When the foraging or roosting of target species was observed, we set up 10 m × 10 m quadrats, with the perching tree as the center of the quadrat. In total, 120 available quadrats were set up to collect information on habitat factors during the years 2020 and 2021. To avoid the issue of resampling, the distance between quadrats in this study was set to be no less than 50 m. Our investigation encompassed the characteristics of perching trees, vegetation within the sample plots, and human disturbance factors. The characteristics of perching trees mainly included diameter at breast height, height, canopy density, coverage above the perch, coverage under the perch, and distance to a water source. These characteristics are related to the safety conditions of habitat selection by birds [24]. Next, we measured the number of fruit trees, altitude, slope, average tree height, average diameter at breast height, shrub coverage, herb coverage, litter layer coverage, canopy density, tree density, shrub density, and the amount of dead wood in the habitat samples. In addition, we recorded human disturbance data, such as distance to a residential area (settlements were mainly villagers' houses, tourist consumption sites, and tourist cable car transfer stations). The method of investigating the characteristics of perching trees mainly followed that of Fang et al. [25]. The diameter at breast height and average diameter at breast height were measured using diameter tape; the height and average tree height were measured using a hypsometer; coverage above the perch, coverage under the perch, shrub coverage, herb coverage, litter layer coverage, tree density, and shrub density were estimated using the quadrat method; canopy density and the canopy density of perching trees were measured using a fisheye lens; altitude, distance to a water source, and distance to a residential area were measured using GPS; slope was measured using a clinometer; and the number of fruit trees and amount of dead wood were counted using the direct counting method.

2.3. Data Analysis

Based on the preliminary data processing by SPSS version 25.0, since there were no significant interannual differences in bird habitat selection within the yew ecological garden, we merged the data for each bird species from 2020 and 2021 into a single dataset for an integrated analysis. To analyze habitat selection by birds, we first compared the differential habitat factor utilization among various bird species across 19 habitat characteristics by one-way ANOVA. Principal component analysis (PCA) was used to determine the main ecological factors affecting habitat selection for the three bird species by analyzing the dataset from the yew ecological garden during autumn and winter. PCA is a multivariate technique that simplifies and reduces complex raw data relationships [26] and has been widely used in wildlife habitat research. The multinomial logistic regression model is a discriminative model that predicts the categorical probabilities of a dependent variable based on the values of the independent variables [27]. To explore the role of habitat factors in bird habitat selection, we established a multinomial logistic regression model with bird species as the dependent variable and environmental factors as the independent variables. We selected a main effects model, using Orange-bellied Leafbird as the reference category, to test the model's goodness of fit, parameter estimation, and predictive probabilities. To determine whether there was a clear differentiation in the ecological niches of the three bird species, we also used stepwise discriminant analysis to identify the key discriminant factors for habitat selection among three bird species in the yew ecological garden and analyze

the model's discriminative power in comparing the differences in habitat factor utilization among these bird species. All descriptive statistical values in the text are represented as the mean $\pm$ standard error. Prior to further statistical testing, all data were subjected to normality testing using the Kolmogorov–Smirnov method, with the significance level set at $\alpha = 0.05$.

3. Results

3.1. Bird Habitat Characteristics and Inter-Species Differences

One-way ANOVA showed significant differences in habitat selection among the species Red-billed Blue Magpie, Black Bulbul, and Orange-bellied Leafbird in the yew ecological garden during autumn and winter (Table 1). Significant differences in the selection of habitat characteristics among the three species were found in height of perching tree, canopy density of perching tree, diameter at breast height of perching tree, coverage above the perch, coverage under the perch, average tree height, average diameter at breast height, shrub coverage, litter layer coverage, altitude, and slope ($p < 0.05$), whereas no significant differences were found in the selection of the other eight habitat characteristics ($p > 0.05$). The Orange-bellied Leafbird often perched on low, small-breasted trees with high concealment requirements, and their perching trees had the highest canopy density, while the Red-billed Blue Magpie and Black Bulbul perched in taller, larger-breasted trees with lower canopy density. There was a differentiation between the three species in terms of their position in the canopy.

Table 1. ANOVA results for the selective use of habitat characteristics of three bird species during autumn and winter in the yew ecological garden, Meihua Mountain National Nature Reserve, Fujian province, southeastern China.

Habitat Characteristics	<i>U. erythrorhyncha</i>	<i>H. leucocephalus</i>	<i>C. hardwickii</i>	F	p
HPT	22.85 $\pm$ 1.15 a	24.07 $\pm$ 0.99 a	17.25 $\pm$ 0.73 b	13.945	0.000 **
CDRT	58.25 $\pm$ 2.65 b	62.13 $\pm$ 2.76 b	69.95 $\pm$ 2.30 a	5.341	0.006 **
DBHPT	59.47 $\pm$ 5.66 b	73.97 $\pm$ 6.26 a	32.32 $\pm$ 2.53 c	17.273	0.000 **
CAP	51.33 $\pm$ 2.91 b	32.93 $\pm$ 3.68 c	60.75 $\pm$ 3.33 a	18.138	0.000 **
CUP	48.80 $\pm$ 3.66 b	62.33 $\pm$ 2.93 a	49.50 $\pm$ 4.73 b	3.926	0.022 *
ATH	17.48 $\pm$ 0.73 a	16.54 $\pm$ 0.57 a	13.48 $\pm$ 0.45 b	12.312	0.000 **
ADBH	35.50 $\pm$ 3.01 a	32.82 $\pm$ 2.32 a	21.56 $\pm$ 1.09 b	10.517	0.000 **
SC	26.10 $\pm$ 2.28 b	34.55 $\pm$ 2.74 a	26.68 $\pm$ 2.32 b	3.689	0.028 *
LLC	80.05 $\pm$ 2.56 a	66.28 $\pm$ 4.37 b	75.08 $\pm$ 3.94 ab	3.551	0.032 *
AL	974.93 $\pm$ 5.45 c	993.28 $\pm$ 4.29 b	1007.10 $\pm$ 4.91 a	10.811	0.000 **
SL	25.80 $\pm$ 1.38 b	27.35 $\pm$ 1.29 b	36.00 $\pm$ 1.69 a	14.125	0.000 **

The data of various birds are expressed as mean $\pm$ standard error. ** $p < 0.01$; * $p < 0.05$. ADBH: average diameter at breast height; AL: altitude; ATH: average tree height; CAP: coverage above the perch; CDRT: canopy density of perching tree; CUP: coverage under the perch; DBHPT: diameter at breast height of perching tree; HPT: height of perching tree; LLC: litter layer coverage; SC: shrub coverage; SL: slope. Means with different lowercase letters differ significantly (Tukey's test, $\alpha = 0.05$, $a > b > c$).

3.2. The Factors Influencing Avian Habitat Selection

The PCA results highlighted that the main factors affecting *Urocissa erythrorhyncha* habitat selection were height of perching tree, canopy density of perching tree, average tree height, average diameter at breast height, shrub density, shrub coverage, amount of dead wood, tree density, and canopy density. In the case of *Hypsipetes leucocephalus*, the main factors were height of perching tree, canopy density of perching tree, coverage under the perch, average tree height, average diameter at breast height, shrub density, shrub coverage, altitude, and distance to a residential area. For *Chloropsis hardwickii*, canopy density of perching tree, tree density, average diameter at breast height, canopy density, altitude, and distance to a residential area were the main factors affecting habitat selection (Table 2). PCA revealed that the common factor variances of the original variables selected by the three

bird species were generally greater than 0.5. This indicated that the principal components effectively summarized and described the characteristic habitat selection variables for these birds (Figure 1).

Table 2. Principal component analysis for habitat characteristics used by three bird species in the yew ecological garden, Meihua Mountain National Nature Reserve, Fujian province, southeastern China.

Habitat Characteristics	Components											
	<i>U. erythrorhyncha</i>				<i>H. leucocephalus</i>				<i>C. hardwickii</i>			
	PC1	PC2	PC3	PC4	PC1	PC2	PC3	PC4	PC1	PC2	PC3	PC4
HPT	0.626	0.216	0.211	0.438	0.264	−0.149	0.802	0.056	0.554	−0.522	0.219	−0.214
CDRT	−0.716	0.295	0.258	−0.003	0.781	0.206	−0.142	−0.087	0.34	0.603	−0.170	0.411
DBHPT	0.594	0.11	0.058	0.059	0.377	−0.554	0.405	−0.191	0.386	−0.507	0.3	−0.403
CAP	−0.598	0.09	0.054	−0.062	0.6	−0.229	−0.120	0.166	0.373	0.368	−0.410	0.321
CUP	−0.549	0.26	0.502	0.123	0.801	0.154	−0.168	−0.099	−0.034	0.382	0.05	−0.085
ATH	0.676	0.472	−0.049	0.34	−0.397	−0.196	0.683	0.019	0.566	−0.472	−0.234	0.243
TD	0.113	−0.353	0.713	−0.163	0.517	−0.034	0.326	0.186	0.622	−0.034	0.431	−0.232
ADBH	0.686	0.29	−0.192	−0.122	−0.132	−0.762	0.311	−0.340	0.238	−0.712	−0.173	0.112
NFT	0.558	0.288	0.432	−0.451	0.387	−0.253	0.24	0.246	−0.361	−0.294	0.367	0.392
CD	0.078	0.244	0.851	−0.123	0.552	0.166	0.424	−0.179	0.617	0.389	0.067	−0.222
SD	0.11	−0.824	0.055	0.321	0.203	0.794	0.232	−0.316	0.518	0.373	0.477	−0.222
SC	0.052	−0.808	0.203	0.303	0.068	0.799	0.229	−0.208	0.332	0.398	0.506	−0.105
HC	0.407	−0.175	0.377	−0.311	−0.284	0.175	−0.050	0.669	−0.440	−0.261	0.168	−0.030
LLC	0.42	−0.272	0.353	0.069	−0.278	0.461	0.316	0.119	0.519	0.031	−0.154	0.158
NDW	−0.084	−0.699	0.108	0.182	0.114	0.019	−0.191	−0.728	0.079	0.348	−0.146	−0.058
AL	−0.048	0.472	0.351	0.466	0.658	0.067	−0.062	0.26	−0.460	0.097	0.662	0.243
SL	−0.565	0.19	0.248	−0.194	0.032	−0.245	−0.501	−0.034	−0.377	0.146	0.35	−0.585
DWS	−0.227	0.193	0.245	0.72	−0.291	0.344	0.357	0.187	0.494	−0.217	0.469	0.567
DRA	−0.036	0.492	−0.158	0.263	0.688	−0.042	−0.052	0.355	−0.108	0.103	0.683	0.552
Contribution rate %	20.59	17.14	12.73	9.27	20.68	15.03	12.67	8.9	18.13	14.31	13.42	10.18
Cumulative contribution rate %	20.59	37.73	50.47	59.74	20.68	35.71	48.37	57.27	18.13	32.43	45.86	56.03

ADBH: average diameter at breast height; AL: altitude; ATH: average tree height; CAP: coverage above the perch; CD: canopy density; CDRT: canopy density of perching tree; CUP: coverage under the perch; DBHPT: diameter at breast height of perching tree; DRA: distance to a residential area; DWS: distance to a water source; HC: herb coverage; HPT: height of perching tree; LLC: litter layer coverage; NFT: number of fruit trees; NDW: number of dead wood; SC: shrub coverage; SD: shrub density; SL: slope; TD: tree density.

3.3. The Contribution Rate of Bird Habitat Characteristics

The multinomial logistic regression model revealed the contributions of various habitat characteristics. The final model exhibited a lower Akaike information criterion (AIC) and a -2 log-likelihood ratio compared to the intercept-only model, indicating a higher model fit that more closely approximated the actual data (Table 3). The significance of the final model was less than 0.01, thereby confirming that environmental factors have a significant impact on bird habitat selection. The likelihood ratio test table demonstrates the contribution of each independent variable to the model (Table 4), with canopy density of perching tree, coverage above the perch, coverage under the perch, canopy density, litter layer coverage, altitude, slope, and distance to a residential area all showing significant contributions ($p < 0.05$). Among these, coverage above the perch, litter layer coverage, and altitude contributed the most, indicating that environmental concealment and geographical location requirements are crucial for distinguishing species such as Red-billed Blue Magpie, Black Bulbul, and Orange-bellied Leafbird, whereas the contributions of the other 11 habitat characteristics were not significant ($p > 0.05$). The overall correct classification probability of the logistic regression model was 84.20%, suggesting that the model had a good overall classification effect, with a high accuracy rate in bird species classification based on their selection of habitat characteristics (Table 5).

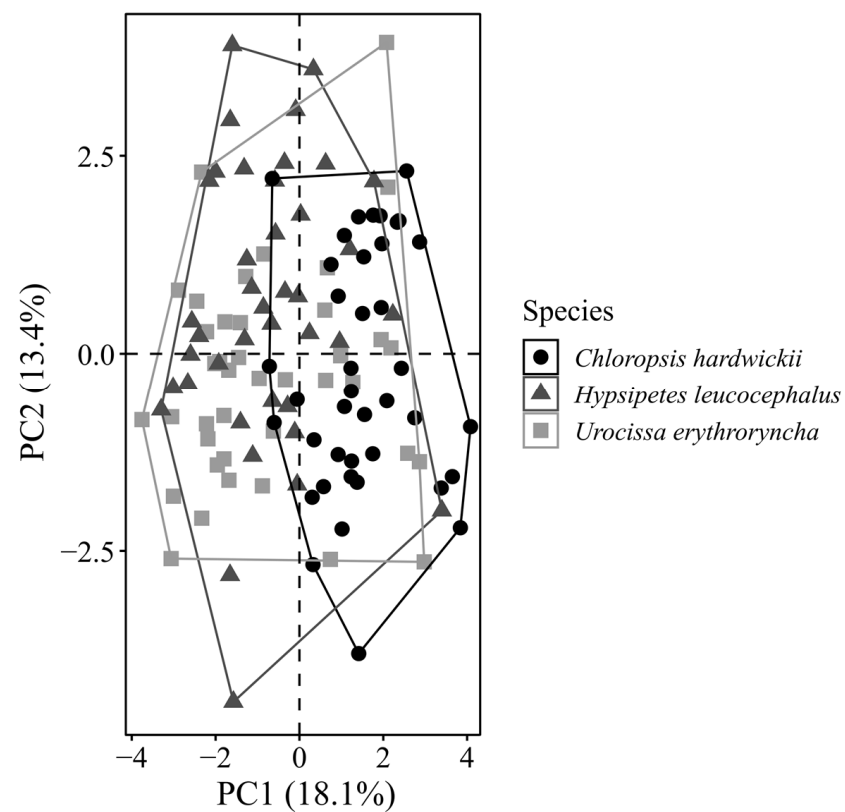


Figure 1. Principal component analysis plot of linearly transformed values of habitat characteristics using orthogonal transformation.

Table 3. Model fit information for multinomial logistic regression of habitat characteristic selection of three bird species.

Model Fit Statistics				Likelihood Ratio Test		
Model	AIC	BIC	−2 Log-likelihood	χ^2	df	<i>p</i>
Intercept only	267.667	273.242	263.667	-	-	-
Final model	190.325	301.825	110.325	153.342	38	0.000 **

** $p < 0.01$.

Table 4. Likelihood ratio test for multinomial logistic regression model of habitat characteristic selection of three bird species.

Effect	Model Fit Statistics			Likelihood Ratio Test		
	AIC for a Reduced Model	BIC for a Reduced Model	−2 Log-Likelihood for a Reduced Model	χ^2	df	<i>p</i>
Intercept	206.924	312.848	130.924	20.598	2	0.000 **
CDRT	196.712	302.637	120.712	10.387	2	0.006 **
CAP	204.266	310.19	128.266	17.94	2	0.000 **
CUP	193.68	299.604	117.68	7.354	2	0.025 *
CD	194.138	300.062	118.138	7.812	2	0.020 *
LLC	208.898	314.822	132.898	22.572	2	0.000 **
AL	205.312	311.237	129.312	18.987	2	0.000 **
SL	199.161	305.086	123.161	12.835	2	0.002 **
DRA	196.171	302.096	120.171	9.846	2	0.007 **

** $p < 0.01$, * $p < 0.05$. AL: altitude; CAP: coverage above the perch; CD: canopy density; CDRT: canopy density of perching tree; CUP: coverage under the perch; DRA: distance to a residential area; LLC: litter layer coverage; SL: slope.

Table 5. Classification prediction probability table for multinomial logistic regression model.

Actual	Predicted			Percentage Correct
	<i>U. erythroryncha</i>	<i>H. leucocephalus</i>	<i>C. hardwickii</i>	
<i>Urocissa erythroryncha</i>	30	5	5	75.00%
<i>Hypsipetes leucocephalus</i>	3	35	2	87.50%
<i>Chloropsis hardwickii</i>	3	1	36	90.00%
Overall percentage	30.00%	34.20%	35.80%	84.20%

3.4. The Key Discriminant Factors Differentiating the Three Bird Species

The results of the stepwise discriminant analysis of habitat characteristics for the three bird species demonstrated that the model had good discriminant ability (Table 6), with the correct classification rate of the discriminant model at 74.17%. The model significantly differentiated the habitat selection and utilization of the Red-billed Blue Magpie, Black Bulbul, and Orange-bellied Leafbird ($p < 0.01$). The Wilks' Lambda value decreased progressively from 0.763 to 0.322, and the F value was much greater than 1, indicating that these eight key discriminant factors contributed significantly to the discriminant analysis. Among them, the discriminant function coefficient for coverage above the perch had the largest absolute value, showing the strongest discriminant ability for differentiating the three bird species. The first two discriminant functions were used to create a discriminant classification diagram (Figure 2), which, overall, shows a clear distinction in habitat feature preferences among the three bird species, reflecting differences in habitat selection and utilization among them within the yew ecological garden.

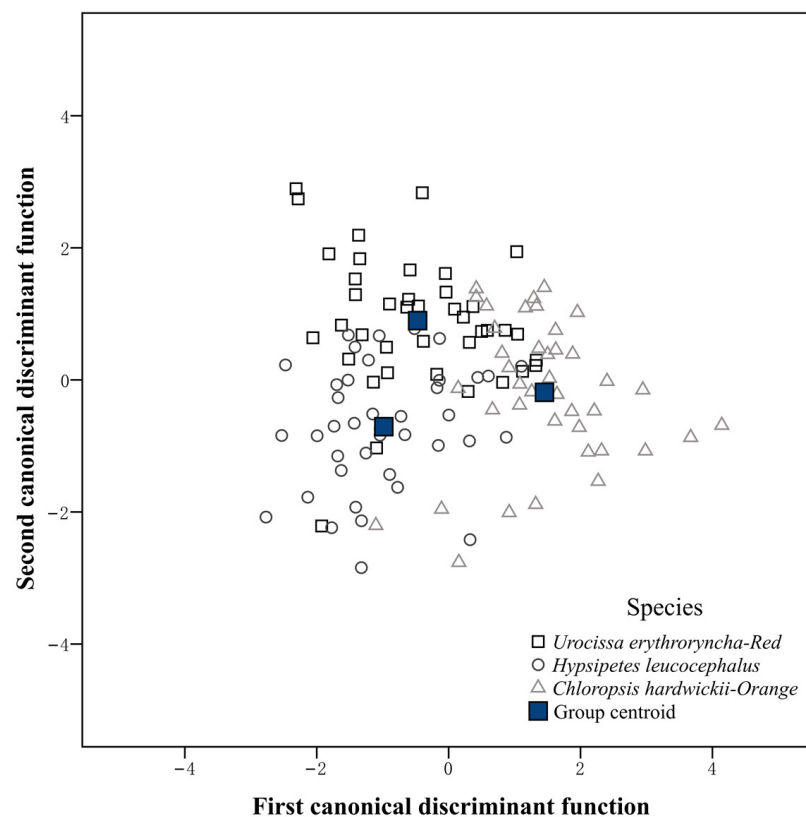
**Figure 2.** Linear discriminant classification diagram for three bird species in the yew ecological garden during autumn and winter.

Table 6. Discriminant analysis results for habitat characteristics of three bird species in the yew ecological garden during autumn and winter.

Habitat Characteristics	Discriminant Function Coefficients		Wilks' Lambda	F	p
	Function1	Function2			
CAP	0.460	0.963	0.763	18.138	0.000 **
SL	0.494	0.132	0.612	16.145	0.000 **
DBHPT	−0.463	0.030	0.524	14.641	0.000 **
CDRT	0.298	−0.987	0.457	13.681	0.000 **
LLC	0.190	0.468	0.422	12.185	0.000 **
AL	0.488	−0.663	0.393	11.101	0.000 **
DRA	−0.419	0.543	0.348	11.016	0.000 **
CUP	−0.494	0.287	0.322	10.475	0.000 **
Cumulative contribution rate %	71.1	100	-	-	-
Classification accuracy %	74.2		-	-	-

** $p < 0.01$. AL: altitude; CAP: coverage above the perch; CDRT: canopy density of perching tree; CUP: coverage under the perch; DBHPT: diameter at breast height of perching tree; DRA: distance to a residential area; LLC: litter layer coverage; SL: slope.

4. Discussion

Our research highlights the importance of environmental concealment in the habitat selection process among the Red-billed Blue Magpie, Black Bulbul, and Orange-bellied Leafbird. The three bird species exhibited clear preferences in habitat selection, demonstrating significant differences across the eleven habitat characteristics. The habitat characteristics that influenced habitat selection differed among these species, indicating a clear differentiation in their ecological niches. Birds are affected by different environmental factors due to different habitat selections.

Variations in habitat characteristics within fragmented forests significantly influence the habitat selection of birds [28]. An optimal habitat offers birds a sanctuary from predators and ensures access to consistent food sources [29]. The PCA results indicated that canopy density and coverage were dominant factors influencing habitat selection for the Red-billed Blue Magpie, Black Bulbul, and Orange-bellied Leafbird. Regions with higher canopy density provide birds with increased shelter and protection, facilitating evasion from predators and protection from adverse weather conditions [30]. Additionally, dense canopies indicate greater foraging opportunities due to the support of a richer array of food resources such as insects and fruits [31]. Recent studies in Fujian Province have corroborated these findings, demonstrating that sparse forests in urban mountain parks in Southeast China support more bird species and greater bird diversity, which could be attributed to the varied vegetation habitats that offer different foraging opportunities with high canopy density [32]. Optimal coverage is crucial for providing ample breeding sites and concealment [33]. Another study conducted in the yew ecological garden has shown that the complexity of vegetation habitats significantly affects bird communities, with some traits such as tree height and canopy density influencing bird diversity and the foraging behavior of frugivorous birds [34]. The height of perching trees, average tree height, and average diameter at breast height are all important determinants for the habitat selection of the Red-billed Blue Magpie and Black Bulbul. Generally, taller trees offer birds refuge and perching sites, with increased height correlating to enhanced safety from ground predators [35,36]. Similarly, a larger average diameter at breast height implies taller trees, yielding the same effect. However, for the species Orange-bellied Leafbird, tree height and diameter at breast height were not the main factors affecting habitat selection. This could be explained by the fact that the Orange-bellied Leafbird primarily considers habitat characteristics related to canopy closure when selecting a habitat. These dominant factors were consistent with the logistic regression analysis results, underlining their importance in habitat selection.

In commonly occurring bird species, habitat selection differences primarily manifest in their preferences for environmental factors. Each species selects habitats based on its unique ecological needs [37]. Both one-way ANOVA and stepwise discriminant analysis revealed significant differences in habitat selection among three bird species. Specifically, the Orange-bellied Leafbird exhibited a marked preference for habitats with dense canopies, which offer more stable temperature conditions due to the shade provided by the vegetation, thereby mitigating the effects of solar radiation [38,39]. The vegetation layer is crucial in mitigating the impact of rain on the ground by enhancing water infiltration and subsequently maintaining soil moisture [40]. As a result, habitats with higher canopy cover exhibit higher humidity levels compared to those with lower canopy cover. Additionally, perching trees and other plants serve as wind barriers, reducing heat loss caused by airflow [41]. The average perching height of the Black Bulbul is higher than that of the Red-billed Blue Magpie and Orange-bellied Leafbird, often feeding in the upper layers of the tall *Taxus* trees, which are concentrated within patches, with fewer numbers at the edges. A diverse array of fruiting plants provides ample food resources for various bird species. The Orange-bellied Leafbird shares some perching trees with the Black Bulbul, but its feeding locations are primarily in the mid to lower canopy layers, distinctly separate from the Black Bulbul. The Black Bulbul has the least coverage above the perch and the most below, with perches often located in the upper canopy, indicating a preference for environments with sufficient light. The Red-billed Blue Magpie selects habitats at lower altitudes and with gentler slopes. Lower altitudes typically have higher temperatures, which is beneficial for birds to maintain their body temperature [42]. Areas with gentler slopes are likely to receive increased sunlight exposure, which promotes plant growth. Consequently, these areas provide richer food resources, a point that has been emphasized by other studies as well [43,44]. Apart from vegetation characteristics, food, water resources, and topography, habitat selection differences among bird species are also closely linked to human activities [45]. Human disturbance significantly influenced habitat selection by birds in the yew ecological garden. During the study period, it was observed that in the autumn and winter of 2021, low shrubbery within certain areas of the park's patch habitats was cleared. This cleared area contained several individuals of *T. chinensis*, which are part of the habitat of the Orange-bellied Leafbird. Consequently, the shrub density and shrub coverage of its habitat were reduced during the fall and winter seasons. Moreover, this area serves as a habitat for many bird species that typically forage in low shrubs, such as Collared Finchbill (*Spizixos semitorques*), Chinese Hwamei (*Garrulax canorus*), and Vinous-throated Parrotbill (*Sinosuthora webbiana*). However, habitat sites for these birds were destroyed due to shrub clearing, resulting in the absence of a ground foraging guild within the yew ecological garden during the autumn and winter of 2021. Disturbance can significantly alter the distribution of food resources within habitats, thereby impacting bird foraging behavior and habitat selection [46,47].

Research into bird habitat selection can unveil the impact of specific habitat characteristics on bird survival [48]. By investigating the habitat characteristics of bird species within the yew ecological garden, we identified the crucial ecological factors influencing bird habitat selection. Our study demonstrated that vegetation characteristics, geographical factors, and human disturbance are the primary determinants of avian habitat selection within patchy habitats. These factors not only mirror the differences in habitat selection among bird species but also emphasize the distinct ecological niches occupied by commonly occurring birds. Our results also highlight the impact of habitat environmental factors on birds. This knowledge enables effective measures for protection and restoration to be implemented, mitigating habitat loss and fragmentation. It is important to emphasize that the habitat selection discussed in this study refers to the non-breeding season. During the non-breeding season, birds' habitat selection may differ from that in the breeding season as they are likely not constrained by reproductive behaviors but more by the availability of food resources, shelter, and climatic conditions [49]. Therefore, our findings provide an important perspective on understanding the ecological needs of these common bird species

during the non-breeding season and have practical implications for their conservation management. Comprehending the underlying mechanisms of avian habitat selection is pivotal for devising conservation strategies, catering to the variegated habitat requirements of bird species to bolster their survival prospects and ensure the perpetuity of their populations [50]. Future research may focus on the differences in avian habitat selection between patchy and continuous habitats, providing a deeper scientific basis for avian conservation and ecological management.

5. Conclusions

In general, our results reveal the crucial ecological factors influencing bird habitat selection and the differences among different bird species. Our study also highlights the impact of habitat environmental factors on birds. Overall, our study not only provides a deeper understanding of avian behavioral ecology but also holds significant implications for the formulation of conservation strategies and management measures. With increasing human activities, researching the behavioral strategy differences among typical passerine species under human disturbance is crucial for predicting the impact of future environmental changes on biodiversity and devising effective ecological conservation policies.

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