J. Korean Soc. For. Sci. Vol. 109, No. 1, pp. 109~114 (2020)
https://doi.org/10.14578/jkfs.2020.109.1.109

한국산림과학회지
JOURNAL OF KOREAN SOCIETY OF FOREST SCIENCE
ISSN 2586-6613(Print), ISSN 2586-6621(Online)
http://e-journal.kfs21.or.kr

Elevational Distribution of Breeding Bird Communities in Seoraksan National Park, Korea

Hyun-Su Hwang[1], Jae-Kang Lee[1], Tae-Kyung Eom[1], Ho-Kyoung Bae[1], Dong-Ho Lee[1], Jong-Hwan Lim[2], Sung-Cheol Jung[2], Chan-Ryul Park[3] and Shin-Jae Rhim[1]*

[1]*School of Bioresource and Bioscience, Chung-Ang University, Ansung 17546, Korea*
[2]*Forest Ecology and Climate Change Division, National Institute of Forest Science, Seoul 02455, Korea*
[3]*Urban Forests Research Center, National Institute of Forest Science, Seoul 02455, Korea*

Abstract: In this study, the elevational distribution of breeding birds in Seoraksan National Park, Korea was investigated. Forty-six species of birds were documented from line transect surveys taken from Seorakdong at 230 m above sea level (a.s.l.) to the Daechungbong summit at 1708 m asl. Birdspecies richness and diversity were highest in Seorakdong and lowest at the Daechungbong summit. As elevation increased, bird species richness and diversity decreased, with a humped-shape trend being observed between 700 m and 1200 m a.s.l. Stepwise analyses revealed that breeding bird species diversity indices were significantly negatively correlated with elevation (r^2 = 0.327, P < 0.001) and positively correlated with vegetational coverage (r^2 = 0.324, P = 0.046). Higher elevations supported fewer birds than low and intermediate elevations. Projections at the local scale, including data on behavior and habitat use by birds, will be necessary for optimal conservation and management of the bird communities in Seoraksan National Park.

Key words: *breeding bird; conservation; diversity; elevation; richness*

Introduction

Species distribution and richness can vary widely over a given area, and many studies have explored gradients of species richness and diversity (Rosenzweig, 1995). Energy, habitat heterogeneity, and human activity are important factors influencing the spatial variation of organisms; such patterns also correlate with climate (Koh et al., 2006). Biodiversity is influenced by multiple interrelated environmental factors (Lee et al., 2004) and often associated with gradients of environmental variables and ecological interactions (Mohandass et al., 2017).

Biodiversity tends to be broad in mountain forest ecosystems. Many studies have reported that elevation is a predominant determinant of biodiversity and species distribution (Lee et al., 2014a). Birds are no exception, with both diversity and distribution depending upon several biotic and abiotic factors (Gill, 2007). Studies have reported the correlations of abundance and distribution to population, community, elevational variation, forest management, and habitat size (Rhim et al., 2002; Laurance et al., 2014; Lee et al., 2017).

Knowledge of elevational species patterns is essential for conservation planning and prediction of biodiversity responses to climate-driven changes (Kissling et al., 2010). The biogeographic region of South Korea is characterized by a complex topography that varies dramatically over spatial scales. Moreover, over 60% of the land of South Korea is mountainous (Chun et al., 2006). Few studies have addressed whether bird species diversity and richness are transient or persistent in these areas nor how they are influenced by elevational gradients. In this work, we assessed bird species diversity and richness as a function of elevation in a montane forest area.

In this study, we described the elevational patterns of breeding bird species along a line transect of Seoraksan National Park. This study evaluates the effect of elevation and forest type on this community. Within this study, we explored the following hypotheses: first, breeding bird species richness and species diversity will decrease as elevation increases, and second, bird species will respond differently to habitat variables to depending upon elevation.

* Corresponding author
E-mail: sjrhim@cau.ac.kr
ORCID
Shin-Jae Rhim https://orcid.org/0000-0003-3098-1148

Methods

This study was conducted during bird species breeding season, in May 2018, in Seoraksan National Park (37°27′–37°28′ N, 127°33′–127°34′ E). Seoraksan National Park is located on the east-central Korean peninsula and covers an area of 373 km^2.The elevation of Daecheongbong summit is 1708 m above sea level (a.s.l.) (Rhim et al., 2002). The annual mean temperature is 3.8°C (range 29.9 to –21.5°C) at the summit and 11.5°C (range 37.9 to –18.1°C) at the lowest elevation in Seorakdong. Annual precipitation was 1890 mm and 2248 mm for Daechungbong summit and Seorakdong, respectively (National Institute of Forest Science, 2018).

The Korean government designated the Mt. Seoraksan area as natural monument No. 171 in 1965 and made it a national park in 1970. The area was then designated as a Biosphere Reserve in 1982 by the Man and the Biosphere Programme (MBP) of UNESCO (United Nations Educational, Scientific and Cultural Organization) (Korea National Park, 2003). The vegetation of Seoraksan National Park is best described as temperate deciduous forests dominated by oaks (*Quercus* spp.) mixed with coniferous trees (Chun et al., 2006).

To assess the elevational characteristics of the breeding bird community, we assessed species richness and diversity using line transect surveys (Bibby et al., 2000; Lee et al., 2011). A line transect was established along the trail from Seorakdong (Shinheungsa temple, 230 m a.s.l.) to Daechungbong summit (1708 m a.s.l.). The length of line transect was 11 km. Surveys were conducted three times over three consecutive days between 0400 and 1100 h from June 1 to 3, 2018. All birds heard or observed landing or hovering were recorded (Lee et al., 2014b) within a 50 m belt of the line transect were documented. On the first and third days, the bird survey was conducted from Seorakdong to Daechungbong summit. On the second day, the survey was conducted from Daechungbong summit to Seorakdong to add temporal detail to the survey (National Institute of Forest Science, 2018).

Bird survey data was divided vertically into 100 m elevation sections. Species richness and diversity (*H'*, Shannon and Weaver, 1949) were analyzed for each section. Along the 50 m belt of the line transect, elevation and forest type were classified and analyzed with a digital map. Forest types were mixed, deciduous, and coniferous forests, or unstocked area. We analyzed the effects of habitat variables on breeding birds using a stepwise approach (Hwang et al., 2014). As stepwise regression model was applied to determine which variables resulted in the greatest amount of variation in species diversity (*H'*).

Results

We recorded a total of five orders, 20 families, 34 genera, and 46 species of birds across the line transect from Seorakdong to Daecheongbong summit. According to the migration data, 22 species were residents, 22 species were summer visitors, and two species were passage migrants (Table 1). The Asian stubtail *Urosphena squameiceps*, Eastern crowned warbler *Phylloscopus coronatus*, Arctic warbler *Phylloscopus borealis*, large-billed crow *Corvus macrorhynchos* and marsh tit *Poecile palustris* were the dominant bird species in the study area. The Eurasian hobby *Falco subbuteo*, which is a class Ⅱ of endangered wild animals according to the Ministry of Environment, was also documented.

Patch types differed in proportion along the line transect at each 100 m section of elevation. Deciduous forest was the most dominant overall in Seoraksan National Park. We also observed mixed forest at all elevations. Coniferous forest was only observed below 400 m a.s.l. Unstocked area was dominant in the 600 to 700 m a.s.l. range but less common in other elevation sections (Figure 1).

Both species richness and diversity (*H'*) of breeding birds were the greatest in the 200 to 300 m section of elevation in Seoraksan National Park (Figures 2 and 3). Bird species richness and diversity declined as elevation increased up to 700 m a.s.l. An increase, however, was noted in the range from 700 to 1200 m a.s.l. At elevations above 1200 m, species again decreased as elevation increased. Bird species richness and diversity were at their lowest at Daechungbong summit.

The results of stepwise analyses revealed that the breeding bird species diversity index was significantly co rrelated with certain habitat variables (Table 2). Species diversity was negatively correlated with elevation (r^2= 0.327, $p < 0.001$) and positively correlated with vegetational coverage (r^2=0.324, $p = 0.046$).

Table 1. List of observed birds in May 2018 between Seorakdong and Daechungbong summit, Seoraksan National Park, Korea.

Order	Family	Genus	Species	Migration
Falconiformes	Falconidae	*Falco*	*subbuteo*	SV
Columbiformes	Columbidae	*Streptopelia*	*orientalis*	Res
Cuculiformes	Cuculidae	*Hierococcyx*	*hyperythrus*	SV
		Cuculus	*canorus*	SV
			optatus	SV
			micropterus	SV
			poliocephalus	SV
Piciformes	Picidae	*Dendrocopos*	*kizuki*	Res
			major	Res
			leucotos	Res
		Picus	*canus*	Res
Passeriformes	Motacillidae	*Motacilla*	*cinerea*	SV
			grandis	SV
	Pycnonotidae	*Hypsipetes*	*amaurotis*	Res
	Cinclidae	*Cinclus*	*pallasii*	Res
	Troglodytidae	*Troglodytes*	*troglodytes*	Res
	Muscicapidae	*Calliope*	*calliope*	PM
		Lavivora	*cyane*	SV
		Phoenicurus	*auroreus*	Res
		Saxicola	*stejnegeri*	SV
		Ficedula	*zanthopygia*	SV
		Cyanoptila	*cyanomelana*	SV
	Turdidae	*Turdus*	*pallidus*	SV
			hortulorum	SV
		Zoothera	*aurea*	SV
	Cettidae	*Urosphena*	*squameiceps*	SV
		Horornis	*canturians*	SV
	Sylviidae	*Sinosuthora*	*webbiana*	Res
	phylloscopidae	*Phylloscopus*	*inornatus*	SV
			borealis	SV
			tenellipes	SV
			coronatus	SV
	Aegithalidae	*Aegithalos*	*caudatus*	Res
	Paridae	*Sittiparus*	*varius*	Res
		Poecile	*palustris*	Res
		Periparus	*ater*	Res
		Parus	*major*	Res
	Sittidae	*Sitta*	*europaea*	Res
	Emberizidae	*Emberiza*	*chrysophrys*	PM
			elegans	Res
	Ploceidae	*Passer*	*montanus*	Res
	Oriolidae	*Oriolus*	*chinensis*	SV
	Corvidae	*Pica*	*pica*	Res
		Nucifraga	*caryocatactes*	Res
		Corvus	*corone*	Res
			macrorhynchos	Res

SV: summer visitor, Res: resident, PM: passage migrant

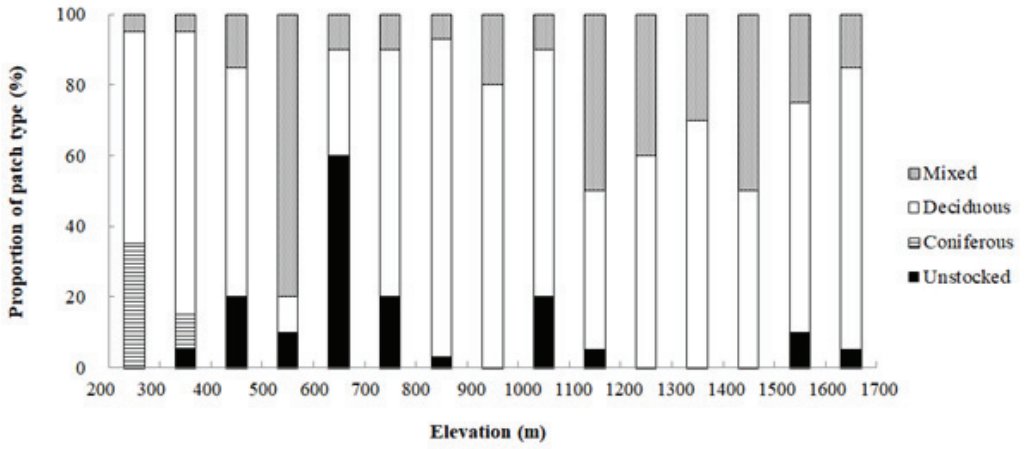

Figure 1. Proportion (%) of patch types along the 50 m line transect at each 100 m section of elevation in Seoraksan National Park, Korea.

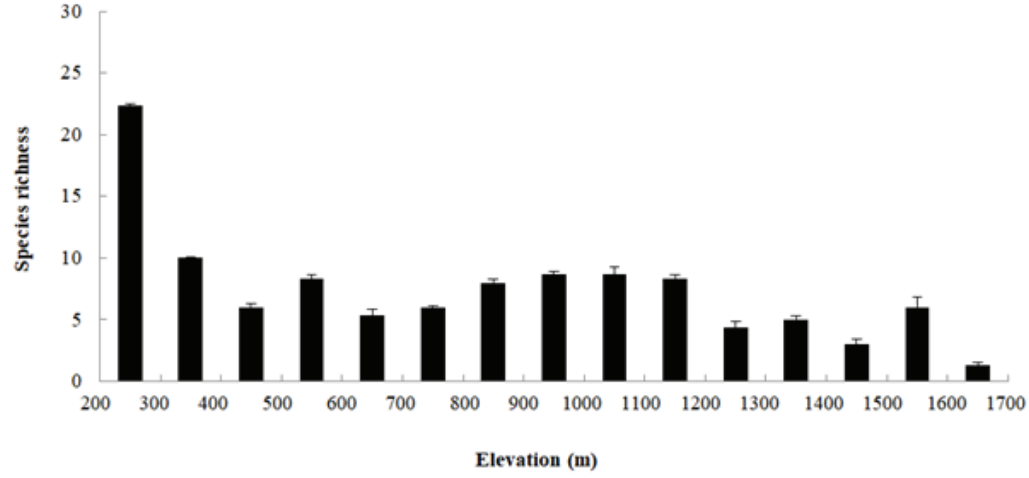

Figure 2. Breeding bird species richness (mean ± SD) at each 100 m section of elevation in Seoraksan National Park, Korea.

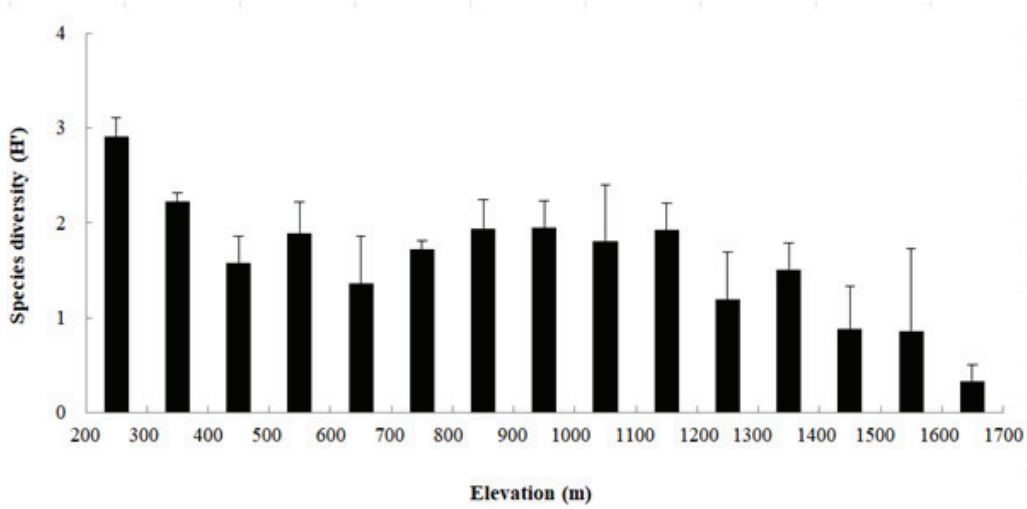

Figure 3. Breeding bird species diversity (H', mean ± SD) at each 100 m section of elevation in Seoraksan National Park, Korea.

Table 2. Results of stepwise regression model tests for relationships between habitat variables and breeding bird species diversity (H') in Seoraksan National Park, Korea.

Variable	Order entered	Standard coefficient	Partial r^2	Model r^2	t	p
Elevation (m)	1	-0.655	0.399	0.327	-5.284	<0.001
Coverage (%)	2	0.255	0.092	0.374	-2.061	0.046

Discussion

The importance of Seoraksan National Park for conservation is evident from its bird species richness and high diversity. At lower elevations, bird species were abundant in all habitats, including old-growth forest, secondary forest, streams, and open areas. The Siberian rubythroat *Calliope calliope* and spotted nutcracker *Nucifraga caryocatactes* were observed at Daechungbong summit, where lower bushes dominated; overall, however, there were fewer individual birds and fewer species at this elevation. Dramatic changes in bird species composition according to elevation reflect changes in habitat characteristics and resources types at these different heights (Blake and Loiselle, 2000).

Bird species richness and diversity were most strongly affected by elevation, as the species richness and diversity index of the breeding bird community in the Seoraksan National Park decreased as elevation increased, the only exception being a hump-shaped pattern of species richness and diversity indices observed between 700 and 1200 m a.s.l. Species richness is expected to be inversely correlated with elevation in higher mountainous regions (Lee et al. 2004). However, a hump-shaped pattern of species richness in correlating to elevation has also been revealed in other recent studies (Lomolino, 2001).

Although the mechanisms underlying elevational patterns of species are still subject to debate, typical explanations include productivity, vegetation, and geometric constraints (McCain, 2009; Lee et al., 2014a). Mountainous landscapes are considered biodiversity hotspots due to their high endemism and regional diversity (Myers et al., 2000). Elevational shifts in temperature, humidity, habitat conditions, and topography typify these zones (McCain, 2009), with expected impacts on the bird communities therein. In this study, stepwise regression models revealed that elevation and vegetational coverage were the most important predictors of bird species diversity.

Vegetational composition and structure also change with elevation, and previous studies have reported that avian species distribution can be limited by these factors (Jankowski et al., 2009). In particular, tree growth rate and fruit crop production are significantly reduced in high elevational areas such as Daechungbong summit. Reduced vegetational productivity results in trophic consequences for local avian species (Jankowski et al., 2013).

The documentation of the broad bird species richness and diversity at low elevation is of overriding importance, as deforestation and urbanization in lowlands are major causes of habitat loss and fragmentation in South Korea. Habitat conservation must be incorporated into land use planning, particularly in our study area, Seorakdong, currently undergoing development pressure from the tourism industry.

This study was conducted during the breeding season; however, elevation may also have a significant impact on bird species diversity outside the breeding season, particularly during wintering and migratory periods. Seasonal fluctuations to habitat variables and bird communities should be monitored to enhance our understanding of local avifauna. Moreover, analyses of vegetation productivity, habitat structure, and food availability will also provide a more thorough understanding of elevational characteristics affecting bird communities.

Conclusions

Our analysis of the breeding bird community along an elevational gradient in Seoraksan National Park revealed correlations between birds and habitat variables such as elevation and vegetational coverage. Overall, higher elevations support fewer birds than low and intermediate elevations. However, additional data will be necessary to inform conservation and management efforts for the bird community in Seoraksan National Park. Projections on a local scale, including data on behavior and habitat use by birds, will be necessary for optimal conservation and management of the local bird community.

Acknowledgements

This study was supported by the National Institute of Forest Science, Republic of Korea.

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Manuscript Received : September 17, 2019
First Revision : September 24, 2019
Accepted : September 24, 2019