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Effects of Area on Breeding Bird Communities in Urban Forests in Daejeon Metropolitan, South Korea

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Abstract: This study was conducted to clarify the effect of area on breeding bird communities in 35 urban forest fragments ranging from 2.1-1936 ha in Daejeon Metropolitan, South Korea. Bird communities were surveyed using the line transect method. Thirty seven species were observed and the number of resident species was higher than the number of visiting species. Hole and bush nesting guild species and bush and air foraging guild species were the most common. As the forest area increased, the number of bird species and bird species diversity index (H') increased significantly. The number of long-tailed tits (*Aegithalos caudatus*), Indian cuckoos (*Cuculus micropterus*), black-naped orioles (*Oriolus chinensis*) and yellow-throated buntings (*Emberiza elegans*) were significantly related with forest area. Forest size may be a critical factor affecting bird communities in urban areas. For the conservation and management of avian species in urban areas, forest fragment size and structural diversity of habitat should be maintained.

Key words: Area, bird community, breeding season, patch, urban area

INTRODUCTION

Composition and structure of bird communities worldwide have been affected by forest fragmentation (Austen *et al*., 2001). Fragmentation is a process through which a focal habitat type is completely or partially removed (Villard *et al*., 1999). Effects of fragmentation on birds may be due to changes in habitat and population dynamics caused by edge effects. Edge effects are more pronounced in small patches because of the increased ratio of edge to interior (Burke and Nol, 1998).

Changes in land use patterns and urbanization present particular challenges to conservation and management of urban areas (Blair, 1996). Urbanization changes the vegetation structure composition and plant communities. In addition, intensive development may decrease available resources to birds through the removal of substantial areas of primary production. These changes may affect resource abundance and distribution which are linked to individual bird species and the entire bird community (Whitney and Adams, 1980; Beissinger and Osborne, 1982; Blair, 1996).

Species composition in urban areas is determined by biotic and abiotic components associated with the potential species pool (Roy *et al*., 1999; Clergeau *et al*., 2001). Characteristics of the surrounding habitat (Kubes and Fuchs, 1998; Jokimaki, 1999) and patch size may also affect the structure of avian communities in urban areas.

MATERIALS AND METHODS

Researchers selected 35 patches (N36°17-27', E127°17-28') of urban forest based on present vegetation maps of Daejeon Metropolitan, South Korea (Fig. 1). Mean annual temperature is 12.6°C and mean annual precipitation is 1943 mm. The total area of Daejeon Metropolitan is 540 km^2, of which 286 km^2 is forested (Lee, 2012). Patch size varied from 2.1-1934.1 ha (Table 1). The survey sites were located in vegetated urban and suburban areas.

The bird surveys were conducted between 500 and 900 h in May 2012 in 35 forest patches by line transect surveys (Bibby *et al*., 2000). Census routes were set up to determine the number of avian species present in each patch. All birds heard or seen were recorded and only the birds estimated to be within 25 m on either side of the census routes were used in the analysis (Stuart-Smith *et al*., 2006; Lee *et al*., 2011).

A guild is defined as a group of species that exploits environmental resources in a similar manner (Lee *et al*., 2010). This definition is commonly used in environmental assessment and management of avian

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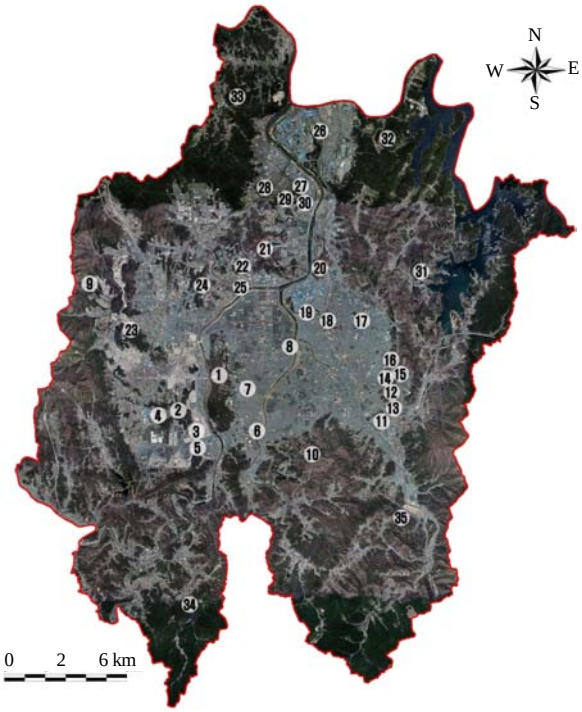

Fig. 1: Location of the study sites in Daejeon Metropolitan, South Korea

Table 1: Size and edge length of study sites in Daejeon Metropolitan, South Korea

Study sites	Size (ha)	Edge (km)
Wolpyeong Park	501.0	15.17
Doan Park	151.0	13.80
Keonyang University Hospital	11.0	2.05
Daejeong Elementary School	9.1	2.12
Gasuwon Park	308.7	13.46
Daeshin High School	11.1	1.56
Byeondong Park	2.6	0.72
Namsun Park	12.2	1.75
Daejeon National Cemetery	1934.1	27.97
Sajeong Park	1482.0	36.50
Humansia Apartment	25.6	4.09
Panamdong North	34.0	4.10
Panamdong South	4.1	1.01
Daejeon/Woosong University	9.5	2.16
Daejeon University	18.1	2.45
Woosong University	46.6	4.46
Yongjeon Park	15.3	3.40
Hannam University	8.8	2.48
Ojeong Farm Market	2.1	3.41
Hoedeok Park	31.5	2.34
National Research Institute of Cultural Heritage	413.0	21.45
Maebong Park	41.5	3.01
Bokyong Horse Racing Course	220.0	7.98
Chungnam National University	101.4	8.52
Seongdusan Park	26.2	2.65
Eulmigi Park	58.2	7.29
Cheongbyeoksan Park	19.9	1.85
Kwanpyeongdong	16.7	3.45
Saesomang Church	24.5	3.64
Yeojin Buddhism Museum	18.9	2.80
Hyemyeong Temple	223.0	9.11
Yongho Public Cemetery	203.0	6.05
Obongsan	344.0	16.86
Jangan Reservoir	137.0	4.72
Songlim Temple	218.0	7.68

Table 2: Categories of nesting and foraging guilds of bird communities in this study

Guilds	Nesting or foraging site	Abbreviation
Nesting		
Canopy	Canopy	C
Hole	Tree hole	H
Bush	Bush and ground	B
Brood parasite	Nest of other birds	P
Foraging		
Canopy	Leaf, twig, branch, trunk and bud	c
Bush	Vine, litter, bush, fallen log and ground	b
Air	Air	a
Water	Stream and river	w

C: Conopy; H: Hole; B: Bush; P: brood parasite; a: air; b: bush; c: conopy; w: water

species (Simberloff and Dayan, 1991). Researchers used breeding season (May) survey results for breeding bird communities (Rhim and Lee, 2000). Researchers divided the nesting guild into canopy, hole, bush and brood parasite and the foraging guild into canopy, bush, air and water based on nesting and foraging sites (Table 2). Migration habits of each avian species were taken from Lee *et al*. (2000) (Table 3).

Simple regression analyses were used to examine the relationship between forest area and variables of interest (number of species and bird species diversity index). Bird species diversity index (H') was used for analysis of bird communities (Shannon and Weaver, 1949). Logistic regression analyses were employed to examine the relationship between forest area and each bird species.

Table 3: Bird community in the breeding season within urban forests in Daejeon Metropolitan, South Korea

Species	No. of individuals	Migration	Guilds	
			Nesting	Foraging
Ardea cinerea	1	R/SV	-	-
Egretta alba modesta	1	SV	-	-
Anas poecilorhyncha	1	R/WV	-	-
Falco tinnunculus	2	R	B	a
Falco subbuteo	3	SV	B	a
Phasianus colchicus	48	R	B	b
Streptopelia orientalis	66	R	C	b
Cuculus micropterus	13	SV	P	c
Cuculus saturatus	7	SV	P	c
Otus scops	2	R	H	a
Eurystomus orientalis	22	SV	H	a
Dendrocopos kizuki	4	R	H	c
Dendrocopos major	9	R	H	c
Picus canus	7	R	H	c
Motacilla alba	4	SV	B	w
Hypsipetes amaurotis	141	R	C	c
Lanius bucephalus	4	R	C	b
Phoenicurus auroreus	18	R	B	b
Turdus dauma	6	SV	C	b
Turdus pallidus	12	R/SV	C	b
Paradoxornis webbianus	88	R	B	b
Urosphena squameiceps	7	SV	B	b
Ficedula zanthopygia	6	SV	H	a
Cyanoptila cyanomelana	15	SV	B	a
Aegithalos caudatus	58	R	C	c
Parus palustris	42	R	H	c
Parus ater	16	R	H	c
Parus major	134	R	H	c
Parus varius	19	R	H	c
Sitta europaea	12	R	H	c
Emberiza elegans	41	R	B	b
Passer montanus	74	R	B	b
Oriolus chinensis	47	SV	C	c
Garrulus glandarius	22	R	C	b
Pica pica	78	R	C	b
Corvus macrorhynchos	6	R	C	b
Columba livia	19	R	-	-
No. of species	37	-	-	-
No. of individuals	1,055	-	-	-

Migration (R = Resident; SV = Summer Visitor; WV = Winter Visitor). Nesting guild (B = Bush; C = Canopy; H = Hole; P = Brood Parasite). Foraging guild (a = air; b = bush; c = canopy; w = water)

RESULTS

Thirty seven bird species were observed in 35 forest patches of Daejeon Metropolitan, South Korea during the breeding season (May 2012). The total number of birds observed was 1055. Brown-eared bulbuls (*Hypsipetes amaurotis*) and great tits (*Parus major*) were the dominant bird species in the study areas. Twenty five species (68%) were residents and 12 species (32%) were Summer visitors (Table 3).

No differences were observed in the number of species among the canopy, hole and bush nesting guilds. Indian cuckoo (*Cuculus micropterus*) and Oriental cuckoo (*C. saturatus*) were belonged to the brood-parasite nesting guild. Within the foraging guild, bird species in the bush and air foraging guilds were higher than that in the canopy foraging guild. White wagtail *Motacilla alba* was the only species belonging to the water foraging guild in this study (Table 4).

Table 4: Guild structure of bird community in the breeding season within urban forests in Daejeon Metropolitan, South Korea

Guilds	No. of species	Percentage
Nesting		
Canopy	10	30.3
Hole	10	30.3
Bush	2	6.1
Brood parasite	11	33.3
Foraging		
Canopy	6	18.2
Bush	13	39.4
Air	13	39.4
Water	1	3.0

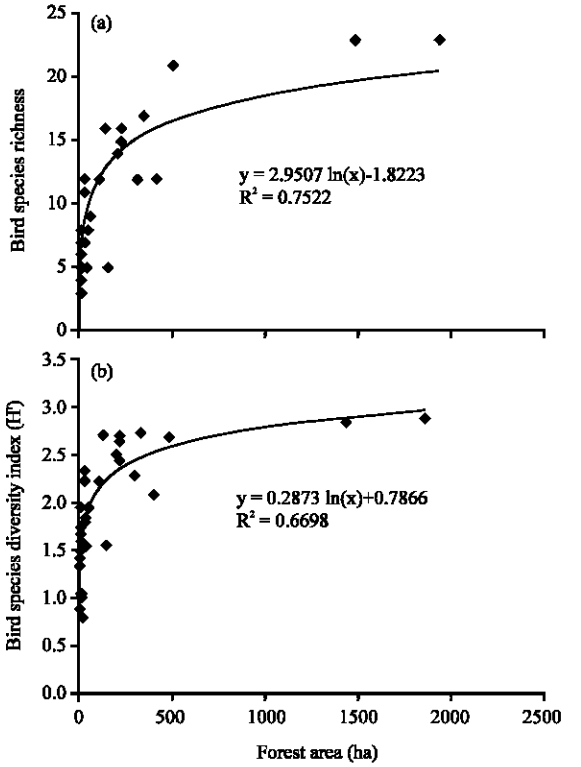

Fig. 2: Relationships between the number of bird species and forest area and a) between bird species diversity index (H') and forest area; b) in the breeding season within urban forests in Daejeon Metropolitan, South Korea

In the breeding season, the regression equation for the number of bird species in urban forest areas of Daejeon Metropolitan, South Korea was y = 2.9507 ln(x)-1.8223. The coefficient of determination (R^2) was 0.7522. The regression equation for the bird species diversity index (H') was y = 0.2873 ln(x)+0.7866. R^2 was 0.6698 (Fig. 2).

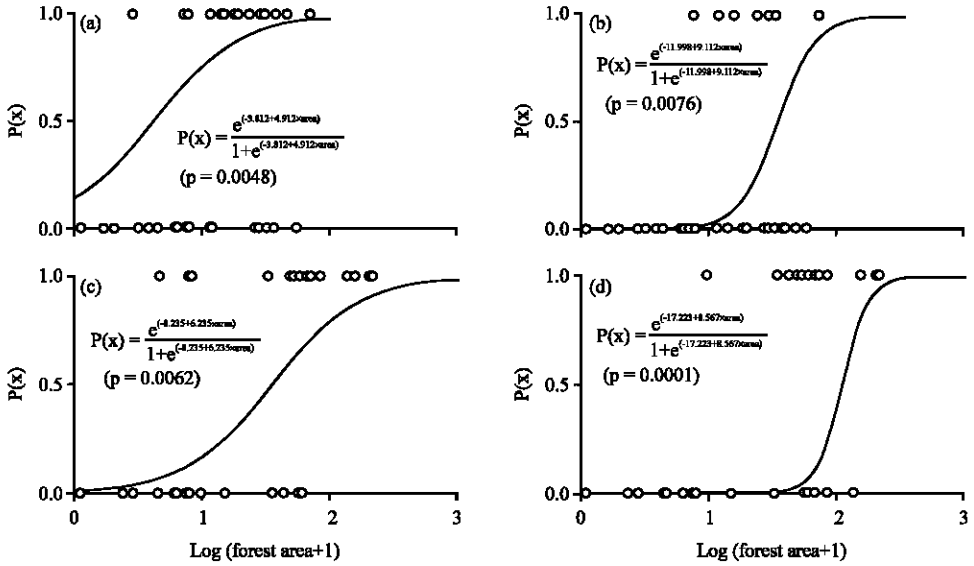

Fig. 3: Relationship between presence or absence of bird species and forest area; a) long-tailed tit (*Aegithalos caudatus*); b) Indian cuckoo (*Cuculus micropterus*); c) black-naped oriole (*Oriolus chinensis*); d) yellow-throated bunting (*Emberiza elegans*) in the breeding season within urban forests in Daejeon Metropolitan, South Korea

To understand the relationship between forest area and each bird species, logistic regressions between presence or absence of bird species and forest area were performed. The number of long-tailed tits (*Aegithalos caudatus*), Indian cuckoos (*Cuculus micropterus*), black-naped orioles (*Oriolus chinensis*) and yellow-throated buntings (*Emberiza elegans*) were significantly related with the forest area in this study (Fig. 3).

DISCUSSION

The nature of the matrix and edges are important for birds within remnant habitat patches (Donovan *et al*., 1997; Austen *et al*., 2001). As the forest area increases, the number of bird species and bird species diversity indices (H') increased in this study. Moreover, the species composition also changed. In forest areas, some birds were added or omitted.

The changes in landscape due to fragmentation affect urban birds. In this study, the number of long-tailed tits, Indian cuckoos, black-naped orioles and yellow-throated buntings increased with increase in the urban forest area. Large forest patches provide highly diverse habitats for birds (Fernandez-Juricic and Telleria, 1999). An understanding of species-specific characteristics related with sensitivity to urbanization is essential to clarify avian community dynamics (Crooks *et al*., 2004).

Total habitat patch size and core area may be significant indicators of the numbers of forest dwelling bird species detected in urban forests indicating that forest coverage and configuration are important (Austen *et al*., 2001). The spatial arrangement of remnant forest patches may also be an important determinant of bird communities (Brotons and Herrando, 2001).

In general, forest patches and parks in urban areas have less vegetation coverage compared to natural forest areas. In addition, the vertical structure of foliage is simpler (Fernandez-Juricic and Jokimaki, 2001). Higher habitat complexity in urban forests increases bird diversity in urban areas (Savard *et al*., 2000). The supply of nesting resources such as artificial nest boxes may increase the colonization of urban areas by various cavity-nesting birds (Rhim *et al*., 2011; Son *et al*., 2012).

Small-scale habitat structures such as dead wood and large trees are critical for habitat quality (Essen *et al*., 1997). Old trees with large trunks are important for hole nesting species (Enoksson *et al*., 1995). Thus, various habitat components can affect nesting and foraging guild structures in bird communities (Lee *et al*., 2011).

Urbanization and related process are major cause of landscape change and are a threat to biodiversity in urban areas (Wilcox and Murphy, 1985; Clergeau *et al*., 2001; Fernandez-Juricic and Jokimaki, 2001). The conservation goals may differ depending on the needs of people and the degree of habitat modification. For urban bird communities, increases in bird species diversity, ecological process diversity and genetic heterogeneity of

populations can be considered as goals of conservation. Thus, it is especially important to conserve and manage the factors affecting birds in urban forests.

CONCLUSION

The aim of this study was to explore the effect of forest fragmentation due to urbanization on breeding bird communities for the conservation and management of birds. Researchers examined the species-area relationships in urban forests in Daejeon Metropolitan, South Korea.

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