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Interactions between Urban Stream Structure and Waterbird Community Composition

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ABSTRACT

This study sought to clarify the relationship between stream structure and waterbird community composition in the Jungnangcheon stream, Seoul metropolitan district, South Korea from February 2018 to November 2020. Stream structure was assessed along the stream corridor. There were differences in water width, depth, transparency, flow, bed materials, form of levee, and number of bends. The major waterbirds were cormorants, large wading birds, dabbling ducks, diving ducks, gulls, and small wading birds. The multiple linear regression analysis revealed close relationships between stream structure variables and major waterbirds. Waterbird community conservation requires wetland-based management programs that are applied to habitat complexes at the landscape scale to support the needs of waterbirds. The results of this study can help with the conservation of habitats and landscapes in urban streams. Further research should be conducted on the conservation of waterbirds and their habitat in the future.

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KJK and SJR designed the study, performed field work, analyzed the data, and wrote the manuscript.

Key words
Conservation, Habitat, Management, Urban stream, Wetlands

INTRODUCTION

Globally, there has been a dramatic increase in urban land area over the last decade (Seto *et al*., 2011; Andrade *et al*., 2018). Most of the human population inhabits cities and towns (Fuller and Gaston, 2009). The development of natural areas has affected behavior and the distribution of biota in urban ecosystems (Marzluff *et al*., 2001; Keten *et al*., 2020). Land use and biodiversity patterns have been changed by urbanization on a global scale (Dallimer *et al*., 2012).

Cities are usually built around rivers because of the benefits of food and transport (Groffman *et al*., 2003). Moreover, river and stream corridors are critically influenced by settlement (Rottenborn, 1999). River and stream wetlands are important in terms of landscape, ecology, and social benefits. These are crucial breeding, stopover, and wintering sites for many birds (Mitsch and Gosselink, 2000). Riparian areas provide wood debris, support biodiversity, ecological corridors, and food and cover for birds (Dallimer *et al*., 2012; Murgui and Hedblom, 2017; Keten *et al*., 2020). However, cities have been built and expanded along rivers and streams in the occupied habitats of waterbirds, which has reduced the population of waterbirds and their habitats (Kang *et al*., 2015).

Birds are a widely distributed group of animals that are sensitive to habitat disturbance (Xu *et al*., 2022). They are considered a good indicator of biodiversity because of their diverse and specific habitat needs, well known ecological information, and location in the food chain (Anderson and Davis, 2013). Waterbirds are the most important ecologically assets in wetlands (Wen *et al*., 2011). The degradation and loss of wetlands have negatively impacted waterbirds. The maintenance of high-quality habitats is an important issue in waterbird conservation (Taft *et al*., 2002; Ma *et al*., 2010).

Seoul is the capital city of South Korea. It is a metropolitan area with over 10,000,000 inhabitants. The Hangang river flows through Seoul. There are several branch streams around the Hangang river. This river and its branch streams are good habitats for waterbirds. The Jungnangcheon stream is a branch stream located in the northern part of the Hangang river (Seoul District Administration, Ministry of Land, Infrastructure and Transport, 2012).

In this study, we aimed to demonstrate the patterns of the waterbird community along this urban stream. The objective of our study was to clarify the avian species abundance, richness, and composition in relation to stream structure along the Jungnangcheon stream, Seoul, South Korea.

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MATERIALS AND METHODS

This study was conducted from February 2018 to November 2020 in the Jungnangcheon stream, Seoul, South Korea (Fig. 1). The Jungnanycheon flows for 36 km in a north to south direction. It has a drainage area of 296 km^2. This stream flows into the Hangang river, which flows in the Yellow Sea (Seoul District Administration, Ministry of Land, Infrastructure and Transport, 2012). The Hangang river is a watershed for populations that include the Seoul Metropolitan area. The mean annual precipitation is 1,362.3 mm. The mean annual temperature is 12.1°C.

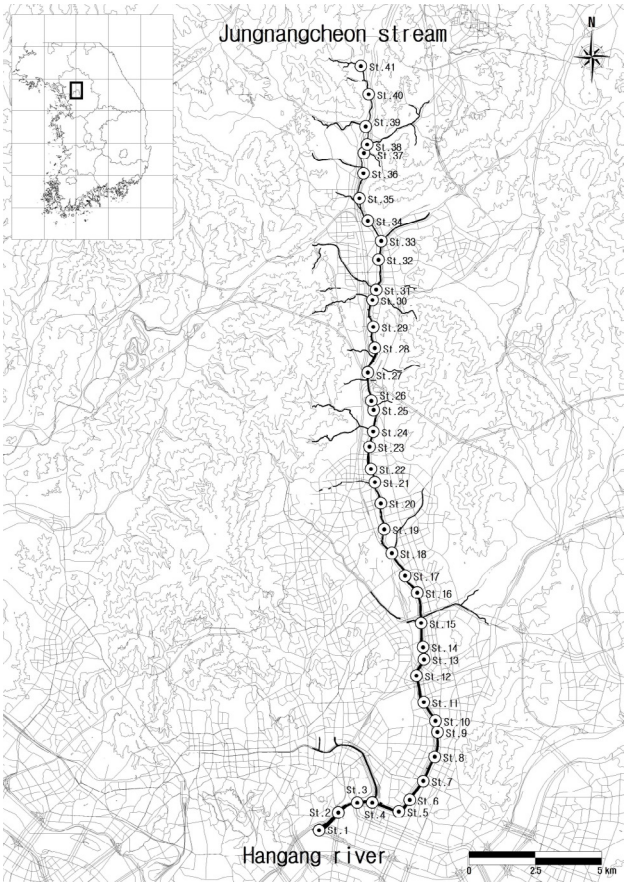

Fig. 1. Location of study plots in the Jungnangcheon stream, Seoul, South Korea.

Stream structure variables were sampled along the stream corridor. The 41 plots (250-m radius) were centered along the Jungnangcheon stream. The first sampling point was located at 37° 32′ 36.08″ N, 127° 1′ 39.25″ E (st. 1) and the final was at 37° 48′ 11.41″ N, 127° 2′ 44.96″ E (st. 41). Each plot was randomly selected in the study area. In each plot, we measured water width (m), water depth (cm), transparency of water (cloudy, moderate, clear), form of water flow (riffle, run, pool), bed material of water (sand, gravel, boulder, cobble), levee structure (concrete, stone, natural), and number of bends (Table I).

We conducted point counts of waterbirds in the center of each of the 41 sampling plots. Bird surveys were conducted in February, May, August, and November from 2018 to 2020. Twelve birds surveys were carried out in the study area. Surveys were performed by point count methodology (Bibby *et al*., 1992). Avian species were identified by sound and sight (Mullarney *et al*., 1999; Keten *et al*., 2020). Waterbirds were categorized into cormorants, large wading birds, dabbling ducks, diving ducks, gulls, and small wading birds (Table II).

Bird species richness and total abundance were analyzed. We used multiple linear regression analysis to assess the relationship between stream structure and waterbirds. Stream structure variables included water width, water depth, transparency, water flow, bed material, levee form, and number of bends.

RESULTS

Mean water width was 78.9 cm (range, 24–136 cm). Mean water depth was 62.8 cm (range, 30–110 cm). Transparency was most often moderate (63.4%), followed by clear (26.8%), and cloudy (9.8%). The water flow was running in 70–80% and pooling in less than 10% of samples. Most of bed material was sand. The levee form was dominantly stone and natural. The number of dominant bends was < 2 (Fig. 2).

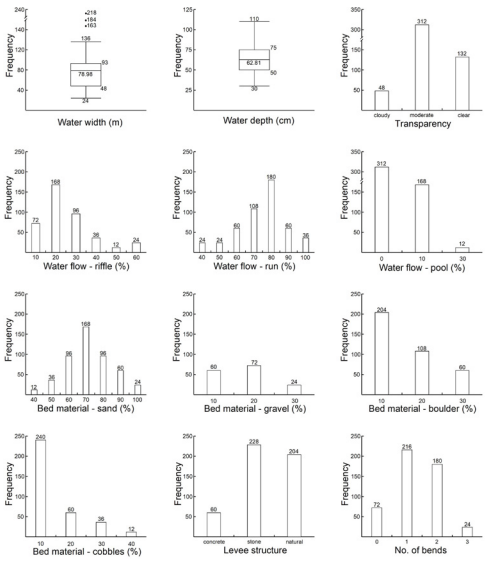

Fig. 2. Stream structure characteristics of the Jungnangcheon stream, Seoul, South Korea.

Table I. Stream structure variables in this study.

Variable	Description			
Water width	m			
Water depth	cm			
Transparency	cloudy	moderate	clear	
Water flow	riffle (%)	run (%)	pool (%)	
Bed material (particle size, cm)	sand (%) (0.2–0.4)	gravel (%) (0.4–6.4)	boulder (%) (6.4–25.6)	cobbles (%) (≥ 25.6)
Levee structure	concrete	stone	natural	
No. of bends	0	1	2	3

Table II. Major group of waterbirds in this study.

Variable	Family name	Classification group	Species
Cormorants	Phalacrocoracidae	Cormorants	*Phalacrocorax carbo*
Large wading birds	Ardeidae	Heons	*Nycticorax nycticorax, Butorides striata*
		Egrets	*Bubulcus ibis, Ardea alba alba, Ardea alba modesta, Egretta intermedia, Egretta garzetta, Ardea cinerea*
Dabbling ducks	Anatidae	Dabbling Ducks	*Aix galericulata, Anas platyrhynchos, Anas poecilorhyncha, Anas clypeata, Anas crecca, Anas strepera, Anas acuta*
Diving ducks	Anatidae	Diving Ducks	*Aythya ferina, Aythya fuligula*
		Mergansers	*Mergus merganser*
Gulls	Laridae	Gulls	*Larus argentatus, Larus crassirostris*
Small wading birds	Charadriidae	Plovers	*Charadrius dubius, Charadrius placidus*
	Scolopacidae	Sandpipers	*Tringa ochropus, Actitis hypoleucos*
	Motacillidae	Wagtails	*Motacilla cinerea, Motacilla alba, Motacilla alba lugens*

We recorded 8,117 individuals from 33 bird species including 6 resident (18%), 11 summer visitor (33%), and 16 winter visitor (49%). The Eastern spot-billed duck (*Anas zonorhyncha*), mallard (*Anas platyrhynchos*), great cormorant (*Phalacrocorax carbo*), Eurasian teal (*Anas crecca*), and mandarin duck (*Aix galericulata*) were the dominant bird species in our study.

The number of species was higher in large wading birds, dabbling ducks, and small wading birds, and lower in cormorants and gulls. There was higher number of individuals in dabbling ducks and lower in small wading birds (Fig. 3)

The multiple linear regression analysis revealed that the presences of cormorants was associated with water width. Boulder (bed material) and the number of bends was associated with the presence of large wading birds. Dabbling ducks was associated with water width, transparency, levee form, and number of bends. Water depth and the number of bends were associated with the occurrence of diving ducks. Gulls and small wading birds were associated with water width and run (water flow), respectively (Table III).

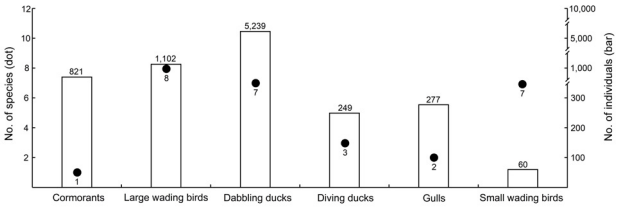

Fig. 3. The observed number of species and individuals of six waterbird groups in the Jungnangcheon stream, Seoul, South Korea from February 2018 to November 2020.

DISCUSSION

Food, water, space, and cover are major factors in habitat selection for wildlife (Jiang *et al*., 2012; Jin and Qin, 2020). Water flow, topography, food availability, and human disturbance have a primary influence on habitat selection in waterbirds (Mckinney *et al*., 2007). The variation in habitat requirements among waterbirds suggests that wetland conservation should be based on region-specific information of waterbird communities (Ma *et al*., 2010).

Table III. Results of the multiple linear regression analysis between stream structure and major waterbirds in Jungnangcheon stream, Seoul, South Korea.

Variable	Site 01 ~ Site 41 (N=492)											
	Cormorants		Large wading birds		Dabbling ducks		Diving ducks		Gulls		Small wading birds	
	B	t(p)	B	t(p)	B	t(p)	B	t(p)	B	t(p)	B	t(p)
Water width (m)	0.073	7.047***	0.064	1.359	0.186	7.694***	0.011	3.52***	0.016	3.183**	0.076	1.678
Water depth (cm)	-0.002	-0.037	0.004	0.074	-0.040	-0.766	-0.078	-1.482	-0.097	-1.895	0.078	1.707
Transparency (cloudy/ moderate/ clear)	0.058	1.338	0.061	1.330	9.817	5.195***	0.053	1.189	0.044	0.992	0.012	0.261
Water flow												
Riffle (%)	0.032	0.723	-0.038	-0.715	0.036	0.678	-0.038	-0.769	-0.001	-0.027	-0.084	-0.767
Run (%)	-0.015	-0.352	0.078	1.550	0.004	0.075	0.069	1.435	0.002	0.053	-0.076	-2.435*
Pool (%)	-0.041	-0.938	-0.075	-1.671	-0.074	-1.613	-0.063	-1.384	-0.003	-0.057	0.035	0.767
Bed material												
Sand (%)	0.004	0.101	-0.036	-0.590	-0.036	-0.856	-0.017	-0.390	-0.021	-0.471	0.025	0.526
Gravel (%)	0.037	0.837	0.021	0.470	-0.031	-0.674	-0.020	-0.429	0.034	0.724	-0.023	-0.499
Boulder (%)	0.002	0.050	0.612	2.772**	0.075	1.638	0.068	1.429	0.058	1.204	0.010	0.215
Cobbles (%)	-0.061	-1.415	0.028	0.602	-0.026	-0.597	-0.030	-0.668	-0.053	-1.171	0.000	-0.002
Levee form (concrete/ stone/ natural)	0.021	0.486	0.013	0.278	6.955	4.241***	0.033	0.734	0.011	0.248	-0.063	-1.353
No. of bends (ea)	-0.043	-0.995	1.213	4.500***	4.769	3.643***	0.466	2.873**	0.045	1.008	0.002	0.034
Constant	-4.132		-0.107		-47.57		-0.939		-0.667		0.773	
F(p)	49.657***		14.924***		24.939***		9.304***		10.129**		5.930*	
adj. R^2	0.090		0.054		0.163		0.033		0.018		0.010	
Durbin-Watson	2.102		1.945		1.830		2.052		2.062		2.021	

*p<.05, **p<.01, ***p<.001

Previous studies have shown that agricultural, industrial, and urbanizing development degrade the aquatic condition of urban streams. This decreases the populations of many water birds in urban areas (Zhang *et al*., 2012). Thus, a good aquatic environment is essential for habitat of waterbirds (Jin and Qin, 2020). The loss of habitat variables caused by urbanization may be an important factor in the decline of waterbird populations (Wilson, 2010).

Urbanization has led the demand for construction. Vegetative and natural areas are reduced or even lost due to urbanization. Dams, canalization, and many hydraulic facilities reduce the habitat heterogeneity of rivers and streams (Souza *et al*., 2019). Thus, the intensity of urbanization is an essential factor for waterbirds (Zhang *et al*., 2016). In addition, hydrology is one of the most important factors in determining the maintenance and development of stream functions and structure (Euliss *et al*., 2008). Hydrology greatly influences the response of waterbirds to stream dynamics (Hoover, 2009).

Many studies have shown that water width and depth are critical variables for waterbirds (Isola *et al*., 2002). In our study, cormorants, dabbling ducks, and diving ducks were influenced by water width because of human activity. There are higher frequencies of walking, running, and cycling along the stream. Moreover, the stream structure, such as levee form and number of bends, affected dabbling ducks, diving ducks, and large wading birds. Levees in wetlands are used as roosting, preening, resting sites by waterbirds (Warnock *et al*., 2002). Topography combination and spatial heterogeneity can provide accessible habitats for waterbird diversity (Taft *et al*., 2002; Li *et al*., 2019).

Waterbird community conservation requires the application of wetland-based management programs to habitat complexes at the landscape scale for the needs of waterbirds (Ma *et al*., 2010). Moreover, social conditions and needs influence how urban streams are managed. Information exchanges and communication between scientists, managers of stream management practices, and the public are required (Nakamura *et al*., 2006).

The results of this study can help with the conservation

of habitats and landscapes in urban streams. We examined the correlation between different stream structural factors and the waterbird community in the Jungnangcheon stream; however, we did not consider the effect of multiple factors on waterbirds. Further research should be conducted to assess the best conservation and management of waterbirds and their habitat.

Statement of conflict of interest

The authors have declared no conflict of interests.

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