

Daily Change in Spatial Distribution of Jungle Crows in Urban Areas

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Abstract

Jungle crows (*Corvus macrorhynchos*) have increased in number in urban areas across Japan, creating various kinds of problems. In the present study, jungle crows were counted at 33 study plots located in large open spaces (>10 ha) in central Tokyo to clarify the role of urban open spaces in crows' daily flying. Three types of open spaces were recognized: ones used mainly for post-feeding rest, ones used for further foraging and/or temporary rest throughout the daytime and ones used as roosting sites. Open spaces where people fed doves or homeless cats tended to be categorized as the second type, probably because crows stayed there to get food provided for doves or cats. In the open spaces of the first two types the number of crows correlated positively with tree coverage, indicating the importance of trees as components of crows' day-time habitat.

Key words: jungle crow, open spaces, spatial distribution, urban, vegetation coverage, vegetation height

1. Introduction

Jungle crows (*Corvus macrorhynchos*) have increased in number in urban areas across Japan, creating various kinds of problems. Crow attacks on people have frequently been reported, especially during breeding seasons, probably because of their parental instincts to protect their eggs or nestlings (Higuchi & Morishita, 2000; Sugita, 2002). Scattering waste about, many individuals of the species visit waste dumps in urban areas to forage for garbage (Karasawa, 1988; Higuchi & Morishita, 2000). They could potentially pose a threat to Japanese native bird species (Azuma *et al.*, 1996). Their fecal droppings and noise may pose environmental problems to citizens.

Similar conflicts in urban areas between crows and human beings have been reported from various location of the world. For example, the house crow (*C. splendens*) has been regarded as a pest species in Mauritius (Feare & Mungroo, 1990) and Singapore (Peh & Sodhi, 2002; Soh *et al.*, 2002). The american crow (*C. brachyrhynchos*) also causes trouble in urban areas across the United States (Gorenzel & Salmon, 1995; Gorenzel *et al.*, 2002). Noise and fecal

droppings around their roosting sites were regarded as the major sources of nuisance. Direct population control measures such as capture of adult crows, use of poisoned bait or shooting have often failed (Soh *et al.*, 2002). An alternative way to manage this problem is altering the landscape characteristics to make them less conducive for nesting or roosting of crows (Gorenzel & Salmon, 1995; Soh *et al.*, 2002).

In Japan, defects in garbage collection systems have repeatedly been criticized for providing food resources to crows, and are the most important reason jungle crows have increased in urban areas (Higuchi & Morishita, 2000). Altering landscape characteristics has rarely been regarded as a measure to control crow populations. While information about crow preferences in landscape characteristics is essential for effective landscape design, our related knowledge is not enough. As for jungle crows in urban areas, preference in roosting sites is partly understood: they tend to use large wooded open spaces such as large urban parks, cemeteries, public gardens and shrine forests as roosting sites (Karasawa, 1987; 1988). It is also known that they visit the amusement districts in urban areas (*e.g.*, the Ginza district in Tokyo) early in the morning to forage for garbage put out by res-

taurants, bars, and hotels along streets (Karasawa, 1987).

For example, Karasawa (1987) reported that many crows roosted in the Meiji Shrine forest located near the center of the Tokyo metropolis. Some of them visited Ginza (Karasawa, 1987) or Shibuya (Karasawa, 1988), which are also amusement districts in Tokyo, in the morning for foraging. He also reported that after feeding in Shibuya, the crows moved to Yoyogi Park, which is a large urban park near Shibuya, to stay till evening (Karasawa, 1988). It was also reported that some individuals stayed in urban open spaces from morning to evening (Karasawa, 1988). These records suggest that urban crows use urban open spaces as their daytime habitat, though which kinds of open spaces they like is remains in question. Katoh and Nakamura (2001) answered this question partly: they reported that jungle crows tended to visit small (< 10 ha) urban parks where visitors fed doves or where vegetation coverage was rich with evergreen trees. They did not study larger urban parks, however, so the knowledge is insufficient for effective landscape planning to manage crow problems.

In the present study, we focused on large (>10 ha)

urban open spaces to survey the spatial distribution of crows and temporal changes in the spatial distribution pattern. When factors controlling the spatial pattern become clear, they will be helpful in creating effective landscape designs to manage crow problems.

2. Methods

2.1 Study plots

Censuses of jungle crows were carried out in six urban open spaces in Tokyo, namely Zoshigaya Cemetery, Toshimagaoka Imperial Graveyard, Ueno Park, Yanaka Cemetery, Hibiya Park and the Outer Garden of the Imperial Palace (Fig. 1). All of these are larger than 10 ha (Table 1).

In total, 33 study plots were located randomly within them, but the plots in Toshimagaoka Imperial Graveyard were located along the border because of limited access inside the Graveyard. The area and the number of study plots in each open space are shown in Table 1.

These open spaces are located near famous amusement districts in Tokyo, namely Ikebukuro, Ueno and Ginza (Fig. 1). During the study period, large

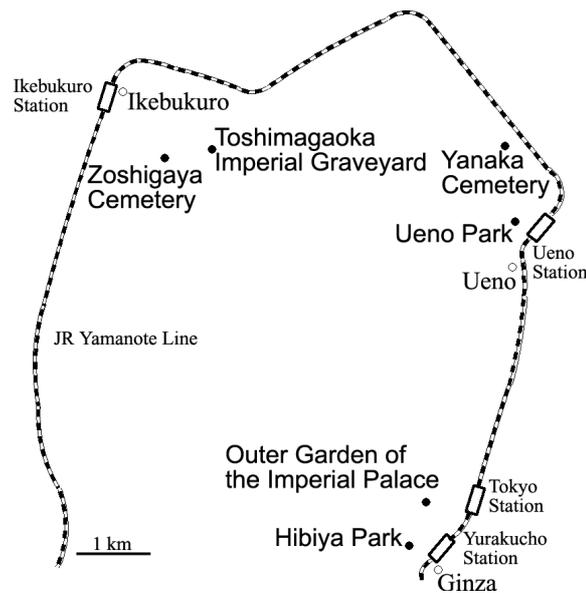


Fig. 1 Locations of the open spaces studied.

●: Open spaces studied

○: Amusement districts near the open spaces studied

Table 1 Studied open spaces.

Name of open space	Area (ha)	Number of study plots	Nearest amusement district
Zoshigaya Cemetery	10.6	5	Ikebukuro
Toshimagaoka Imperial Graveyard ¹⁾	15.2	3	Ikebukuro
Ueno Park	53.4	10	Ueno
Yanaka Cemetery	10.3	5	Ueno
Hibiya Park	16.2	5	Ginza
Outer Garden of the Imperial Palace ²⁾	29.5	5	Ginza

¹⁾ Total area of this graveyard and the neighboring Gokokuji Temple is shown.

²⁾ Nijuu-bashi area only.

amounts of garbage left on streets until late morning attracted many jungle crows to the districts every morning. It should be noted that only a few crows were observed there after 09:00. The Ikebukuro district is located near Zoshigaya Cemetery and Toshimagaoka Imperial Graveyard, while the Ueno district is near Ueno Park and Yanaka Cemetery, and the Ginza district is near Hibiya Park and the Outer Garden of the Imperial Palace (Fig. 1).

2.2 Bird censuses

At each study plot, censuses were repeated four times within a day: the first one was done between 06:00 and 09:00 JST; the second, between 09:00 and 12:00; the third, between 12:00 and 15:00; and the fourth, between 15:00 and 18:00. Censuses were not conducted in unsuitable weather conditions: strong winds or steady rainfall.

At each census the observer conducted a two-minute point count. The number of crows and rock doves (*Columba livia*) observed within a radius of 20 m from the study plot centre was recorded at each plot. Individuals flying over the plot were omitted. The number of doves reflects the degree of feeding by human beings (Katoh & Nakamura, 2001). The observation time, two minutes, was set based on precedential surveys where the 72% of crow individuals and the 92% of dove individuals were counted in the first two minutes of a ten-minute point count (Katoh & Nakamura, 2001). Observations were made from the centre of the study plots, but at the plots in Toshimagaoka Imperial Graveyard the observer conducted the census procedure outside the plots because of the limited access. All plots were censused four times (i.e., one day) between November 16 and 24, 1997, and four times between March 8 and 19, 1998.

2.3 Vegetation parameters

Vegetation coverage of trees and that of shrubs and herbs were measured visually at each study plot. The height of the tallest tree within the bird census range was measured by Blume Leiss height meter as vegetation height. Relationships between the vegetation parameters and the number of crows in each plot were analyzed by Spearman's rank correlation coefficient to avoid being influenced by outliers.

3. Results

A total of 623 individual jungle crow detections were recorded during 264 census visits to the six urban open spaces over the study period. As the results obtained in November 1997 and those obtained in March 1998 showed similar tendencies, we pooled both data sets before the subsequent analysis.

3.1 Temporal changes in the number of jungle crows

To recognize temporal changes in the number of jungle crows in the open spaces studied, percentages of detections recorded in each time zone were calculated for each open space. The results are shown in Table 2. Differences in study plot composition among the open spaces prevented us from comparing open spaces according to the average number of crows per study plot.

The results indicate that in Zoshigaya Cemetery, Ueno Park and Yanaka Cemetery the majority (64% or more) of crow detections were recorded in the morning, i.e., between 06:00 and 12:00. We categorize these open spaces as "Type 1," which crows visit mainly in the morning. In Hibiya Park and the Outer Garden of the Imperial Palace crows were recorded rather evenly among the time zones. These two open spaces are hereafter called "Type 2". Sixty-three percent of crow detections in Toshimagaoka Imperial Graveyard were recorded after 15:00, indicating that crows used the graveyard as a roosting site. This is the only "Type 3" open space in the present study.

3.2 Distribution patterns within the open spaces

At the study plots in the "Type 1" open spaces, the number of crows recorded per plot correlated positively with tree coverage, except in the time zone between 15:00 and 18:00 when there were few crows (Table 3a). As for the study plots in "Type 2" open spaces, correlation between the number of crows and tree coverage was also significant (Table 3b). The other vegetation parameters did not correlate with the number of crows, in either Type 1 or Type 2 open spaces.

Table 2 Temporal variation in recorded number of crows.

Name of open space	Time			% morning ¹⁾	
	06:00 - 9:00	09:00 - 12:00	12:00 - 15:00		15:00 - 18:00
Zoshigaya Cemetery	52	17	17	13	70
Yanaka Cemetery	33	36	18	13	69
Ueno Park	41	23	11	25	64
Hibiya Park	30	17	24	29	47
Outer Garden of the Imperial Palace	22	17	33	28	39
Toshimagaoka Imperial Graveyard	6	6	26	63	12

Numbers in the table indicate percentage of detections recorded in the time zone for each open space.

¹⁾ Percentage of detections recorded between 6:00 and 12:00 for each open space.

Table 3 Spearman's rank correlation between the number of crows and vegetation parameters.

(a) Type 1 open spaces (N=20)				
Vegetation parameters	Time			
	06:00-09:00	09:00-12:00	12:00-15:00	15:00-18:00
Tree coverage	0.57 **	0.47 *	0.62 **	0.35
Shrub and herb coverage	0.16	0.28	0.35	0.20
Vegetation height	0.33	0.10	0.31	0.44

(b) Type 2 open spaces (N=10)				
Vegetation parameters	Time			
	06:00-09:00	09:00-12:00	12:00-15:00	15:00-18:00
Tree coverage	0.76 *	0.58	0.64 *	0.79 **
Shrub and herb coverage	0.68 *	0.24	0.36	0.23
Vegetation height	0.25	0.10	-0.02	0.21

*: $P < 0.05$, **: $P < 0.01$

N: number of study plots.

4. Discussions

4.1 Roles of urban open spaces for jungle crows

It has been reported that jungle crows in Tokyo have systems of daily flights (e.g., Karasawa, 1987; 1988). The elements of the system are roosting sites, feeding sites and temporary abiding sites. We have little knowledge about the third element while we have some about the first two. Though urban open spaces are possible places for temporary stays, the details have not been studied.

The results of the present study suggest that urban open spaces may act as temporary abiding sites for jungle crows in their daily flight routines. However, the role is not equal among open spaces: some are used mainly for post-feeding rest ("Type 1" open spaces); and some are used for further foraging and/or temporary rest ("Type 2" open spaces).

Differences in vegetation parameters and other attributes among the types were not clear. Possible explanations are as follows. Crows tended to visit to the "Type 2" open spaces in the afternoon to obtain more food resources. As food provided for doves or homeless cats by human beings attracts jungle crows also (Katoh & Nakamura, 2001), open spaces where feeding of such animals is conducted may be used by

crows for foraging during the daytime. In the morning crows also stayed in the "Type 1" open spaces where tree cover was provided for their rest but food resources were not provided. If we can omit Ueno Park, this explanation matches well with the results (Table 4). Because Ueno Park is spatially heterogeneous and has both ("Type 1" and "Type 2") characteristics, this disagreement can occur.

It should be considered, however, that food supplies for crows in an open space are not constant. They can vary temporally because of temporal changes in the number and activity of open space visitors. In some open spaces crows may utilize natural food resources such as fruits, the abundance of which also varies temporally. Therefore, the type of an open space may vary, reflecting temporal changes in food resource abundance. Furthermore, human disturbance may influence open space use by jungle crows (Katoh & Nakamura, 2001). Open spaces where intense human disturbance drives crows away during the daytime may also be classified as "Type 2" because there will constantly be few crows in such open spaces.

In the present study we selected open spaces near feeding sites, which may help us to recognize the presence of "Type 1" open spaces, i.e., post-feeding

Table 4 Characteristics of the open spaces studied.

Name of open space	Temporal change pattern of crow abundance	Feeding for doves	Number of doves ¹⁾
Zoshigaya Cemetery	Type 1	No	0
Ueno Park	Type 1	Yes	15
Yanaka Cemetery	Type 1	No	0
Outer Garden of the Imperial Palace	Type 2	Yes	6
Hibiya Park	Type 2	Yes	5
Toshimagaoka Imperial Graveyard	Type 3	No	0

¹⁾ The maximum number of doves (within 8 censuses) was calculated for each plot and the median of that value within each open space was shown.

rest points. If we had studied open spaces far from feeding sites only, it would have been difficult to observe post-feeding concentration. Katoh & Nakamura (2001) studied 24 median to small open spaces that were located apart from large feeding sites and did not find post-feeding concentration. Therefore the location relative to feeding sites is also an important factor in determining the role of open spaces for jungle crows.

Some urban open spaces are known as roosting sites for jungle crows. The present study found that Toshimagaoka Imperial Graveyard is a roosting site. Other preceding observations also concluded alike (Karasawa, 1988). Denser tree coverage, sparser shrub and herb coverage and low levels of disturbance by human beings in the night have been regarded as essential conditions for open spaces used as roosting sites by jungle crows (Karasawa, 1988). The first two conditions are met in most urban open spaces while the third is not. Though the third condition was certainly met in Toshimagaoka Imperial Graveyard, it was also met in the two cemeteries. The requirements for being used as roosting sites have not been clarified enough.

4.2 Open spaces attracting jungle crows

The present study indicates that richer tree cover may attract jungle crows. This result coincides with observations in medium to small open spaces reported by Katoh and Nakamura (2001). The jungle crow is originally a woodland species (Higuchi, 1979). It is known that jungle crows tend to nest (Hamaguchi, 1996) and roost (Karasawa, 1987, 1988) in evergreen tree crowns. It has also been reported that jungle crows use higher parts of the tree for perching more frequently than lower parts (Katoh, 1996; Ichinose & Katoh, 2003). Considering these facts it could be concluded that jungle crows prefer to perch in trees and to use tree-covered places.

4.3 Suggestions for landscape design

Knowledge of open space characteristics preferred by jungle crows presents an opportunity for landscape planners and city officials to make open spaces less desirable as rest sites or roosts. Some recent studies propose landscaping guidelines for such purposes. Gorenzel and Salmon (1995) recommend using in landscaping tree species not chosen by crows in the past as roosts, avoiding tree species (especially evergreen trees) commonly used by crows, pruning trees 7.6 m in height or shorter, keeping pedestrians and parking cars away from tree canopy that is used regularly by crows, and pruning evergreen trees used as roosts to open up the canopies. Soh *et al.* (2002) also proposed that tree species used commonly by crows and other trees morphologically resembling them should be avoided, that trees with larger crown volume, thicker trunks and denser canopies should be pruned regularly, that trees with such characteristics

should be checked regularly to detect and remove crow nests, that roadside trees should be interspersed with palms or other tree varieties with less desirable characteristics for nesting to prevent crows from establishing large nesting colonies and that the design of bin centres should be improved to prevent crows from feeding.

These guidelines, however, are proposed for roadside trees, parking, and residential and/or commercial areas, not for public open spaces. Both these guidelines and the results of current studies support the idea that trees with dense crowns that tend to be used by crows should be avoided. On the other hand in public open spaces such trees are essential for their scenic beauty and amenity. In general, keeping scenic beauty and amenity have priority over crow control actions in planting design and management of urban open spaces. Therefore, we should find other approaches considering the relationship between foraging sites and open spaces. Our proposals are as follows.

(1) Large open spaces should be located distant from larger foraging sites. If the present situation does not fulfill this requirement, the situation at the foraging sites should be altered by improving garbage collection systems and bin centre designs.

(2) Feeding animals such as doves and homeless cats should be forbidden in open spaces with abundant tree cover, or this will provide crows with food resources along with suitable rest sites.

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