Population Change of Jungle Crows in Tokyo

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Abstract

We conducted a literature survey on changes in population and distribution of jungle crows (*Corvus macrorhynchos*) in Tokyo and analyzed possible factors affecting the changes. The number of crows in five major roosts in central Tokyo drastically increased in the mid-1980s through the mid-1990s, leveling off and/or slightly decreasing afterwards. In 2001 and 2002, 33 crow roost sites were observed in Tokyo. Although the histories of these minor roosts are poorly known, some of them were established, or increased in roosting numbers, in the 1990s. Therefore, the increase in crow population in Tokyo has not stopped but entered a different phase.

The period during which the crows started to increase was synchronous with that when domestic garbage began to be disposed in plastic bags for pickup, but not when the amount of food scraps in the garbage reached its peak. Considering that buckets with tight lids prevent crows from scavenging the food scraps inside the container, but that flimsy plastic bags allow crows easy access to the food scraps, these results suggests that the population of crows in Tokyo was more affected by the change in availability of food scraps than their quantity.

The distribution of breeding jungle crows increased at urban sites in the 1990s and decreased in woodlands compared to the 1970s. Jungle crows came to breed in areas with less vegetation cover and higher urbanization rates, which led to the increase in distribution.

Key words: *Corvus macrorhynchos*, distribution, garbage, jungle crow, population increase, roost

1. Introduction

Scavenging by jungle crows (*Corvus macrorhynchos*) has increased in central Tokyo, resulting in noticeable messes around temporary garbage disposal sites, and causing conflicts between humans and crows in this highly urbanized environment (Kurosawa *et al*., 2000, 2001, 2003). Attendant with this phenomenon is an increase in the population of jungle crows, which is attributed to a sharp rise in the amount of food scraps readily available for the flying scavengers (Kurosawa *et al*., 2000). An increase in the crow population of Tokyo has been suggested based on occasional counts in a few large roosting sites (Kawachi, 2000). It is essential, however, to determine the current status of crows in Tokyo and the factors that may have affected the population changes in order to consider measures to solve the conflicts between humans and crows.

Tokyo has experienced several drastic changes in environment since 1945: a rise from the ashes after large-scale air raids in 1945, rapid urbanization in the 1960s associated with the high growth rate of the Japanese economy, and severe pollution of the air and water due to industrial waste and household refuse in the 1970s. In the 1980s, however, as the environment was remediated and the trees on the streets grew, wildlife, especially birds and insects, started to return to central Tokyo (Tokyo Environmental Pollution Bureau, 1998). Considering this major change in the environment, it is of great interest to see how the Jungle Crow population and habitat use have changed.

Here we report on the changes in the population and the distribution of jungle crows in Tokyo based on counts at the roost sites and results of the breeding surveys. Considering additional information, includ-

ing vegetation maps and changes in the amount of garbage in the city, we discuss possible causes of these observed changes.

2. Methods

2.1 Change in the roosting population and related factors

We collected data on the population of roosting crows in Tokyo mainly from published reports. There were five roost sites occasionally monitored in downtown Tokyo: the Institute for Nature Study, Meiji Shrine, Toshimagaoka Cemetery, Rikugien Park, and Ueno Park (Kuroda, 1972; Obara *et al*., 1982; Urban Bird Society of Japan, 1988; Karasawa *et al*., 1991, 1996; Environment Agency, 1992; Hisai *et al*., 2000; Tokyo Metropolitan Government, 2002, 2003). Among data from the counts conducted between December and February, we used the average numbers of roosting crows when more than one count was carried out during a single period. The winter of 1998 represents the period from December 1998 to February 1999.

Since jungle crows in an urbanized area are frequently observed to scavenge food scraps at garbage stations (Kurosawa *et al*., 2000, 2001, 2003), they probably rely on food scraps in central Tokyo. Therefore, we looked at the amount of garbage in this city listed in the Tokyo Statistical Yearbook as a factor responsible for the change in crow population.

2.2 Changes in breeding distribution and affecting factors

We used breeding bird surveys conducted by the Environmental Pollution Bureau of Tokyo (1980) and the Environmental Conservation Bureau of Tokyo (1998), for analysis of changes in the breeding distribution of jungle crows in Tokyo.

We included data from bird surveys conducted in the 1970s (1973, 1974 and 1978) and 1990s (1997). We also distributed a questionnaire to local bird-watchers asking for their observation records on the probabilities of breeding birds as well as a literature review. We divided the area of Tokyo into 1.1×0.9 km grids. The survey grids were distributed equally in Tokyo, resulting in 317 grids in total in the 1970s and 324 in the 1990s. One bird census route of approximately 1 km in length was set up in each of these grids. The surveys were carried out twice during May to June (August at the latest). Walking along the census routes at a speed of approximately 2 km/hr, survey workers recorded the species, the number and the breeding status of birds observed or heard on the routes. Jungle crows were recorded as breeding birds when their nests, nest-building, food carrying or the occurrence of a pair in a likely habitat were observed on the census routes. The same criteria were used in the questionnaire. We compared the numbers of jungle crows either observed or recorded in the questionnaire of both periods of the 1970s and 1990s for the distribution. The analysis of the distribution was made on the results from the grids where the surveys were conducted in both the 1970s and 1990s.

In order to investigate the factors affecting the observed distributional changes, we firstly divided the study area into three categories: (1) jungle crows breeding in the 1990s, (2) the crows breeding in both periods, and (3) the crows ceasing to breed in the 1990s. We then analyzed the changes in habitats among these categories. Secondly, we used vegetation maps to examine the habitat preferences of jungle crows. This analysis, conducted for both the 1970s and 1990s, would detect any change in crow habitat preference. The habitat factors were classified by TWINSPAN (Hill, 1979), and the crows were represented by maximum frequency of occurrence in each class. Habitat groupings were conducted a maximum of three times, and the vegetation characteristics were classed into 0, 20, 40, 60, 80 and 100%. When a group contained < 20 grids, the calculation was halted.

We also analyzed other factors affecting the breeding of crows, such as vegetation coverage (%) and urbanization (%) in 20% intervals, so as to see their effects on the distribution of crows.

The vegetation maps for 1974 and 1998 were made and published by the Tokyo Government (Environmental Conservation Bureau of Tokyo, 2003). We input these maps with the geographic information system (GIS) using ArcView software (ESRI) and measured the areas of each habitat group: woodlands, other stands of tall vegetation, farmlands (rice paddies, grasslands, and crop fields combined), wetlands, park-like habitats (park and residential areas with rich vegetation), and urbanized areas. The vegetation coverage represented the areas of woodland and parkland combined.

Since the survey grids were made on the third-level grid on a national map with a latitude-longitude basis, they have slight differences in the areas of the north and south boundaries. For the analysis, therefore, the proportion of each habitat group was used after excluding those where information on vegetation was incomplete.

3. Results and Discussions

3.1 Changes in the roosting population of crows and related factors

Figure 1 shows the population change of crows at the five major roosts in central Tokyo. The crows increased in the 1980s through the 1990s. An especially sharp increase occurred between 1995 and 1998, which then leveled off and/or slightly decreased.

The distribution of known crow roosts as of 2001 and 2002 in and around Tokyo is shown in Fig. 2. It indicates the presence of numerous minor roost sites

besides those monitored sites, which are indicated in red. The history of these smaller roosts is mostly unknown except for a few cases. For instance, the crow roost at Hitachi Central Research Center in central-western Tokyo was first observed in 1990 (Nanae Kato, pers. comm.) and held about 600 crows in Dec. 2001. Another roost site in Dairokudaiba on the waterfront of central Tokyo did not have a crow roost in Dec. 1996 (Masae Narusue & Nanae Kato, pers. comm.). The crows started to use this site for roosting between 1998 and 2000, when 300 crows were counted in Dec. 2001. In Hamarikyu Park, central-eastern Tokyo 200-300 crows roosted in 1996 (Masae Narusue & Nanae Kato, pers. comm.), and the number of roosting crows increased, with 700 crows in Dec. 2001 and 855 in Dec. 2002. There is a report that jungle crows started to increase in Chiba Prefecture, east of Tokyo in 1994 (Koshikawa, 1999).

Similarly, jungle crows increased in Kanagawa Prefecture, south of Tokyo. In a survey between 1983 and 1985, approximately 11,000 crows (jungle and carrion crows *C. corone* combined) were counted (Roost Research Group, 1986), whereas about 41,000 crows were counted in 2001, indicating a four-fold increase (Wild Bird Society of Japan, 2001). The change was most prominent in the urbanized areas east of the Sagami River, showing a six-fold increase. On the other hand, the rural and natural areas, west of the river had no increase in crow population.

These data suggest that the increase in jungle crows roosting at the major roost sites in central Tokyo has slowed or stopped. It may not, however, mean that the increase in the overall crow population has peaked, when the increase of smaller roost sites as well as the spread of jungle crows into the neighboring prefectures is considered. It may suggest that the increase of the crow population in central Tokyo has entered into a different phase.

The amount of garbage in Tokyo increased between the 1960s and the 1970s, and then leveled off until 1989, when it started gradually to decrease (Fig. 3). In order to determine the effect of garbage on the crows, it is more appropriate to quantify food scraps in garbage as an index of food resources for the crows. The published statistics on the proportion of food scraps in garbage (dry weight) dealt with the period of 1974 to 1998. It showed that the proportion fluctuated from approximately 20% between 1974 and 1979, decreasing to about 15% in 1980, and stabilizing until 1998 with only a few changes between the years (Tokyo Cleaning Bureau, 1993; Oki *et al*., 1993; Mimori *et al*., 1994). The amount of food scraps hit a peak in 1980 and then leveled off until 1990, when it started to decrease. It is unlikely, therefore, that the increase in food scraps had a direct bearing on the population explosion of crows from the 1980s to 1990s.

A major change occurred in the garbage collection system in 1986. Garbage was put out in plastic bags, instead of conventional dustbins at garbage stations on the streets (Kurosawa *et al*., 2003). This coincided with the time that Japanese women started to join the labor force, resulting in fewer homemakers available to retrieve the dustbins from the garbage stations after

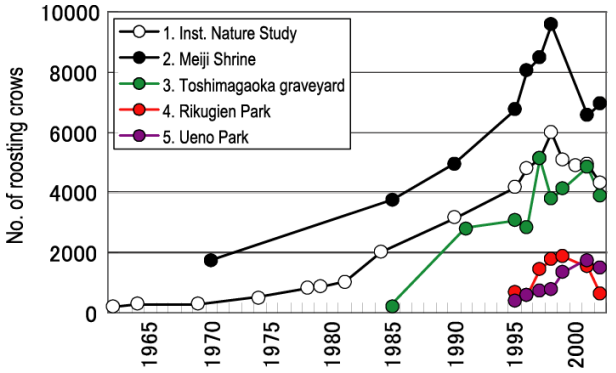

Fig. 1 Annual changes in the number of crows counted at five major roosts in Tokyo (from Kuroda, 1972; Obara *et al*., 1982; Urban-bird Society of Japan, 1988; Karasawa *et al*., 1991, 1996; Environment Agency, 1992; Hisai *et al*., 2000; Tokyo Metropolitan Government, 2002, 2003). The count of Toshimagaoka Cemetary in 1985 was probably an underestimate, where a minimum of 1,000 crows were expected (Fumio Nakamura, pers. comm.). The same numbers in Fig. 1 and Fig. 2 represent the same roost sites.

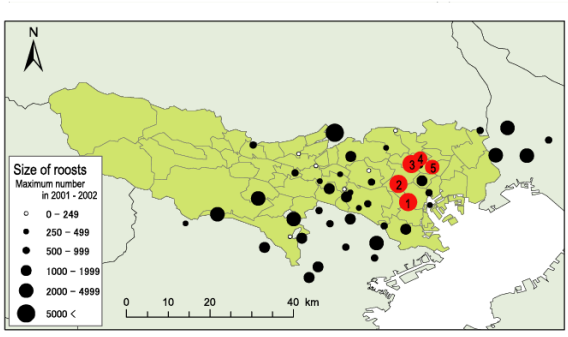

Fig. 2 The distribution of crow roost sites in and around Tokyo (made from the data of Tokyo 2002, and 2003). Red dots represent the five major roost sites in Fig. 1.

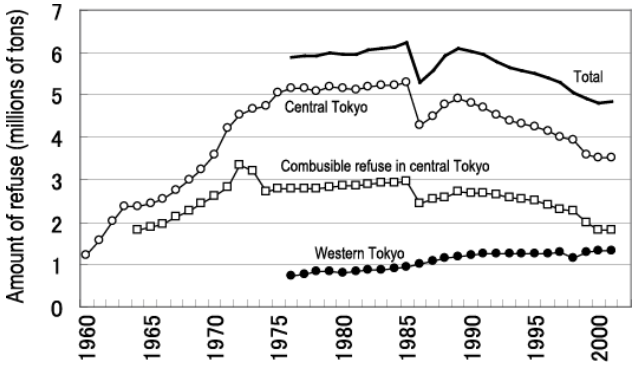

Fig. 3 Annual changes in quantity of garbage in Tokyo (from Tokyo Statistical Yearbook).

the garbage was collected. As a result, most of the dustbins were left out on the streets throughout the day of garbage collection, obstructing traffic (Saitoh, 1999). The easy availability of disposable plastic bags, associated with the advent of supermarkets, encouraged people to put their garbage in plastic bags at garbage stations. The Cleaning Bureau of Tokyo made a compromise and allowed the use of "plastic bags in dustbins." This compromise opened the door for the use of plastic bags without dustbins, leading to a rapid spread of garbage disposal in plastic bags. Then in 1993, Tokyo banned the use of dark plastic bags, designating transparent bags instead. This measure was taken to enhance the recycling of waste materials because see-through bags enabled garbage collectors to ensure that the contents were correctly classified (Saitoh, 1999).

The time that the crows started to increase roughly coincided with the start of plastic bag use for garbage disposal, which was in 1986. The actual increase in the crow population started earlier than 1986. However, plastic bag use preceded the official permission of 1986. A field survey showed that garbage in plastic bags was frequently scavenged (Kurosawa *et al*., 2000), because flimsy plastic bags are easy for crows to puncture, while buckets with lids prevent crows from scavenging. It is highly likely, therefore, that food scraps in plastic bags that are readily available for crows have allowed their population to increase in Tokyo.

The use of transparent plastic bags from 1993 also probably facilitated scavenging by crows, because food scraps in the bags are recognizable from outside. For example, Kurosawa *et al*. (2001) reported that garbage in transparent plastic bags was scavenged more frequently compared to that in colored bags. Therefore, the use of transparent bags facilitated the foraging of crows. Another peak in the crow population occurred between 1995, two years after the introduction of transparent bags, and 1998. We do not have, however, any direct evidence showing that the use of transparent bags was responsible for this rise in crow population.

3.2 Changes in the breeding distribution

The breeding distribution of jungle crows is shown in Fig. 4. The grids in which jungle crows bred increased from 145 in the 1970s, to 181 in the 1990s. There was a significant increase of 36 grids measured in proportion (53% to 66% ; $\chi^2 = 9.87$, df = 1, $P < 0.01$). In the 1990s, breeding Jungle Crows increased in southwestern Tokyo close to Kanagawa Prefecture, and in eastern Tokyo close to Chiba Prefecture. On the other hand, the natural areas of western Tokyo, at a higher elevation, have lost breeding crows in several grids in the 1990s. When we

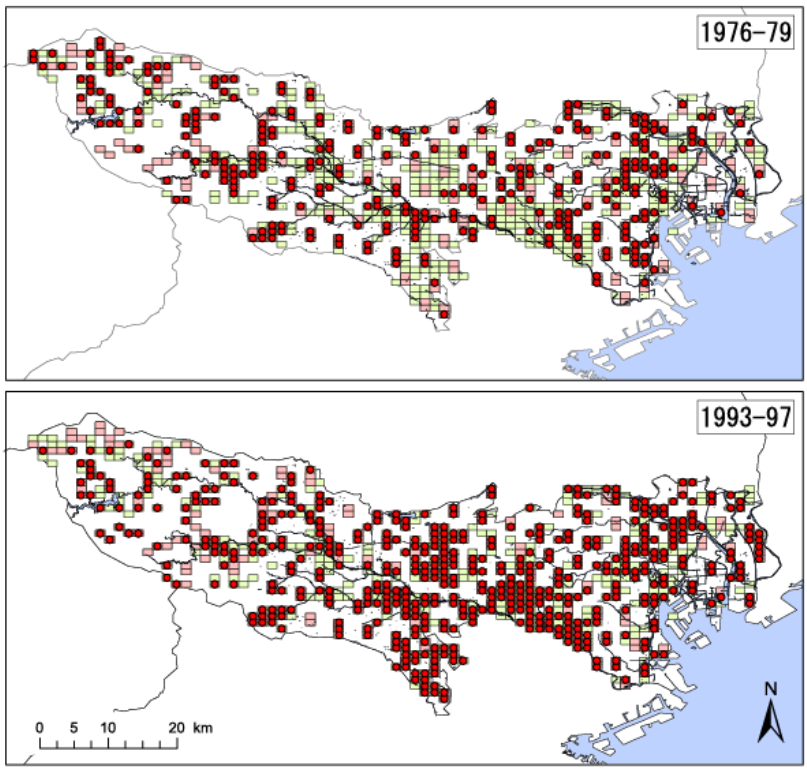

Fig. 4 Differences in the breeding distribution of jungle crows in the 1970s and the 1990s. (from Environmental Pollution Bureau, 1980; and Environmental Conservation Bureau, 1998). Red dots indicate grids where jungle crows were confirmed to breed, pink grids show the areas surveyed in both periods, and green grids show the areas where inquiries were made in both periods.

compared the changes in vegetation, no obvious trend was detected among those grids with a crow increase, crow decrease, or no change (Fig. 5).

The vegetation characteristics of the study areas were classified into six groups by TWINSPAN; urban sites, urban sites with park-like sites, residential sites with farmlands, farmlands, wooded sites mixed with farms and residential sites, and woodland sites. The frequency of grids where jungle crows were confirmed to breed was greater in the wood-farm-residential sites than in the urban sites in the 1970s. On the other hand in the 1990s, the frequency of grids was larger in urban and farmland sites than in the woodland sites (Fig. 6). When habitat differences were compared between the two periods, in the 1990s jungle crows were present in a greater frequency of grids classified as urban sites ($\chi^2 = 12.29$, df = 1, $P < 0.001$), park-like urban sites ($\chi^2 = 6.69$, df = 1, $P < 0.01$), and residential sites with farmlands ($\chi^2 = 7.09$, df = 1, $P < 0.05$). On the other hand, a lower frequency of grids had jungle crows in woodlands ($\chi^2 = 4.25$, df = 1, $P < 0.05$). There was no change in the frequency of breeding jungle crows in farmlands ($\chi^2 = 1.70$, df = 1, P = 0.19), or in woodlands mixed with other habitats ($\chi^2 = 1.47$, df = 1, P = 0.22).

We compared differences in habitats within the two periods to determine the factors affecting breeding jungle crows. We chose the rate of urbanization and the vegetation coverage (woodland and park-like sites combined). The habitats where vegetation coverage was between 60 and 80% showed the highest frequency of breeding jungle crows in the 1970s, while they bred less frequently in the habitats with either more or less vegetation cover. In the 1990s, on the other hand, jungle crows bred in 60% of the habitats with vegetation cover between 0% and 80%, with the highest percentage occurring in those with 40 - 60% coverage. In the 1990s, breeding was significantly more frequent in the areas with scarce vegetation cover (0 - 20% and 20 - 40%), ($\chi^2 = 16.96$, df = 1, $P < 0.0001$, $\chi^2 = 5.46$, df = 1, P = 0.019, respectively). Urbanization had a negative effect on the breeding density of crows in the 1970s, with the highest density in habitats with only 0 - 20% urbanization. In the 1990s, however, the reverse effect was observed. The breeding density of jungle crows was lowest in areas with 0 - 20% urbanization, and 60% of the breeding areas were within sites showing higher

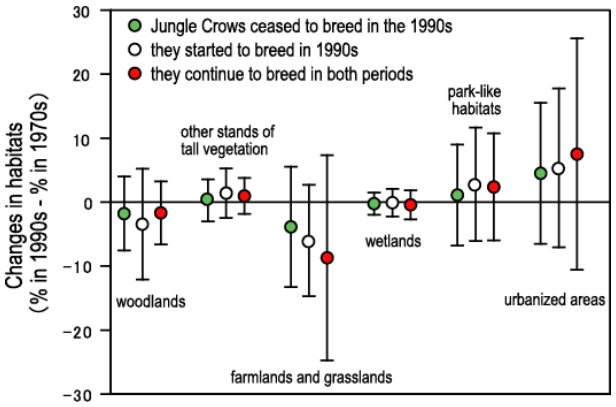

Fig. 5 Changes in habitats, (1) jungle crows ceased to breed in the 1990s (green dot: N = 82), (2) they started to breed in 1990s (red dot: N = 46), and (3) they continued to breed in both periods (open dot: N = 99).

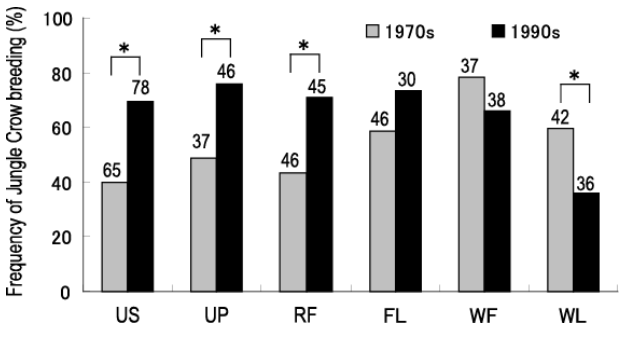

Fig. 6 Differences in the frequency of jungle crow breeding in each habitat class in the 1970s and in the 1990s. US: urban site, UP: urban site with park-like site, RF: residential site with farmland, FL: farmland, WF: wooded site mixed with farms and residential sites, WL: woodland. The value above the bar shows the sample size, * indicates a significant result.

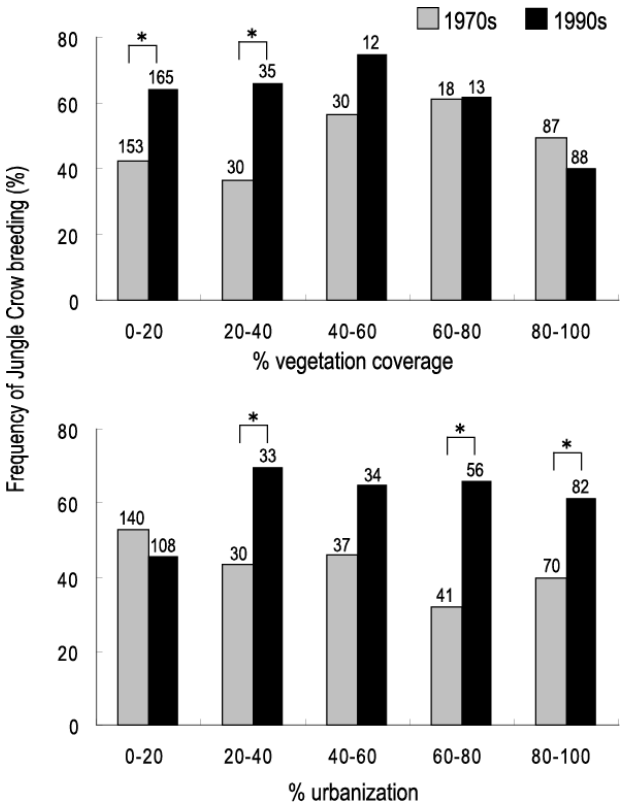

Fig. 7 Differences in the frequency of breeding jungle crow at sites with varying vegetation coverage (above) and urbanization rates (below) in the 1970s (grey bar) and the 1990s (dark bar). The value above the bar shows the sample size, * indicates a significant result.

urbanization rates (Fig. 7). The habitats with urbanization rates of 20 - 40%, 60 - 80%, and 80 - 100% showed a significantly higher breeding density in the 1990s ($\chi^2 = 4.46$, df = 1, P = 0.035, $\chi^2 = 11.19$, df = 1, P < 0.001, $\chi^2 = 6.65$, df = 1, P = 0.001, respectively).

The results thus suggest that jungle crows broadened their breeding habitat preference in the 1990s compared to the 1970s, and they came to breed in areas with less vegetation cover and higher urbanization rates, which led to the spread of their distribution. One of the major factors which caused this change was probably the increased availability of food scraps in the urbanized areas, as was shown previously in this paper. Also possible are hypotheses that the increased population caused crows to breed in less suitable habitat, the trees on the streets in Tokyo grew up in the period from the 1970s to the 1990s, providing crows with nest sites, and jungle crows became less afraid of humans due to "nature education," resulting in their breeding closer to humans. We have yet to know which of these factors has had the greatest effect on the change of the breeding distribution of jungle crows in Tokyo. It is likely that some or all of the above factors combined to affect the jungle crow distribution in Tokyo. In order to consider solutions to man-crow conflicts in urbanized areas, it is essential to identify the major factors that have contributed to the increased breeding range of jungle crows. Further study on this matter is required.

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References

Environment Agency (1992) *Study of Countermeasures against Damages Caused by Domestic Pigeons and Crows*. Environment Agency, Tokyo. (in Japanese)

Environmental Conservation Bureau of Tokyo (1998) *Breeding Bird Survey in Tokyo 1993-1997*. Tokyo Metropolitan Government, Tokyo. (in Japanese)

Environmental Conservation Bureau of Tokyo (2003) *Actual Vegetation Map of Tokyo in CD-ROM*. Tokyo Metropolitan Government, Tokyo. (in Japanese)

Environmental Pollution Bureau of Tokyo (1980) *Bird Survey in Tokyo 1973-1978*. Tokyo Metropolitan Government, Tokyo. (in Japanese)

Hill, M.O. (1979) *TWINSPAN, a FORTRAN Program for Arranging Multivariate Data in an Ordered Two-way Table by Classification of the Individuals and Attributes*. Cornell University, Ithaca.

Hisai, N., M. Yano, T. Sugawara, S. Hagiwara and M. Mutoh (2003) A Study on Methods of Damage Prevention and Population Management for Coexistence of People and Wildlife in Urban and Rural Areas (I) A Study on Measures of Coexistence in the relation between Human Activity and Crows Life in Urban Environment. *In*: *Comprehensive Research on Management and Conservation of Natural Environment*, Ministry of the Environment, Japan, Tokyo, pp.87-I-1 – 87-I-8. (in Japanese with English summary)

Karasawa, K., S. Yamane, S. Koshikawa and S. Takinoiri (1991) Bird census of crows at communal roost in the central Tokyo 1990. *Urban Birds*, 8(1): 17-25. (In Japanese)

Karasawa, K., S. Yamane, S. Koshikawa and S. Takinoiri (1996) Census of crows at communal roosts in the central Tokyo Japan 1995 (III). *Urban Birds*, 13(1): 2-23. (in Japanese)

Kawachi, H. (2000) Crows. *In*: H. Kawachi and H. Endo, eds., *Crows and Rats*, Iwanami Shoten, Tokyo, pp.2-74. (in Japanese)

Koshikawa, S. (1999) Japanese Jungle Crows are invading Chiba Prefecture. *Urban Birds*, 16(2): 58-62. (in Japanese)

Kuroda, N. (1972) Crows in Tokyo, a continuous observation. *J. Yamashina, Inst. for Ornithol*., 6: 507-550. (in Japanese with English summary)

Kurosawa, R., Y. Kanai and M. Matsuda (2003) Conflict between Human and Crows in Greater Tokyo. *Global Environmental Research*, 7(2): 139-147.

Kurosawa, R., M. Narusue, H. Kawachi and K. Suzuki (2000) The relationship between Jungle Crows *Corvus macrorhynchos* and garbage in Tokyo. *Strix*, 18: 71-78. (in Japanese with English summary)

Kurosawa, R., M. Narusue, H. Kawachi, and K. Suzuki (2001) Relation of Jungle Crows and garbage in Tokyo II –Comparison between summer and winter seasons–. *Strix*, 19: 71-79. (in Japanese with English summary)

Mimori, K., T. Oikawa, T. Masuko, M. Okukado, T. Hasegawa, T. Onda and N. Tanigawa (1994) Survey on the garbage characteristic and destinations (April 1998 – March 2000). *Report of Tokyo Metropolitan Cleaning Division*, (28): 40-48. (in Japanese)

Obara, S., N. Sakamoto and S. Chiba (1982) A note on the birds of the National Park for Nature Study (supplement 1979-1981). *Miscellaneous Reports of the National Park for Nature Study*, (13): 13-26. (in Japanese with English summary)

Oki, H., N. Tanigawa, Y. Kanda, T. Takemoto, M. Okukado, S. Oyama, T. Hasegawa and S. Awa (1993) Survey on the garbage characteristic and destinations (April 1997 – March 1999). *Report of Tokyo Metropolitan Cleaning Division*, (27): 3-26. (in Japanese)

Roost Research Group. (1986) On communal roost of Crows (*Corvus macrorhynchos* and *C. corone*) in Kanagawa Prefecture. *Strix*, 5: 17-22. (in Japanese with English summary)

Saitoh, M. (1999) The Garbage collection methods in Tokyo in 1999. *A report of the Symposium "How should We Deal with the Crow Problems in Tokyo ? (2)"*, Tokyo Chapter, the Wild Bird Society of Japan, Tokyo, pp.23-25. (in Japanese with English summary)

Tokyo Cleaning Bureau. (1993) *Amount and Characteristic of Garbage in Tokyo*. Tokyo Cleaning Bureau, Tokyo. (in Japanese)

Tokyo Metropolitan Government. (2002) *Counts of Roosting Crows in Tokyo in 2001*. Tokyo Metropolitan Government, Tokyo. (in Japanese)

Tokyo Metropolitan Government. (2003) *Counts of Roosting Crows in Tokyo in 2002*. Tokyo Metropolitan Government, Tokyo. (in Japanese)

Urban Bird Society of Japan. (1988) *Ecological study of urban birds in the Tokyo metropolis*. Urban Bird Society of Japan, Wako city. (in Japanese)
Wild Bird Society of Japan. (2001) *Bird Distribution Survey in 2000*. Kanagawa Prefecture Agricultural Division, Yokohama. (in Japanese)

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