Evaluation of Food Preference in Wild-caught Large-billed Crows under Captive Feeding Conditions: A Pilot Study

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ABSTRACT: Crows are omnivorous birds that feed on a wide range of natural and anthropogenic food sources. Consequently, they can cause considerable damage to crops and livestock feed; they also engage in garbage scavenging. The distribution of crow damage in environments with multiple fruits and vegetables is uneven, indicating potential food preferences. Although an understanding of food preferences is important for efforts to predict and mitigate the costs of damage caused by wild crows, few studies have investigated this phenomenon. We investigated the relationships between food preferences and foraging behaviors of wild-caught large-billed crows (*Corvus macrorhynchos*) through two experiments. Dry pet food for dogs (corn, meat powder, oils, and fats) and dried corn were used as favorable and less favorable experimental food types, respectively, based on previous field observations. In the first experiment, two feeding sites, each containing one of the food types, were placed at opposite ends of an outdoor U-shaped experimental cage (i.e., two-choice trial). In the second experiment, a single feeding site was established containing either pet food or dried corn (i.e., no-choice trial). Crows were placed in individual cages in both experiments. When both food types were available, large-billed crows foraged significantly more pet food than corn. There was no significant difference in consumption when either food type was presented alone, but total foraging duration was significantly longer for corn than for pet food. These results suggested that the amount of food consumed and foraging efficiency are good indicators of food preferences in large-billed crows under captive feeding conditions. Using this experimental approach, further studies are required to investigate the preferences of large-billed crows for a variety of food items, which will help to predict damage, improve trapping efficacy, and develop effective mitigation strategies.

KEY WORDS: *Corvus macrorhynchos*, crop damage, food choice, foraging behavior, large-billed crow, urban bird, wildlife management

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INTRODUCTION

The large-billed crow (*Corvus macrorhynchos*) is an omnivorous bird distributed in the forested regions of East Asia through Far East Asia (Madge & Burn, 1994, Iwasa et al., 2002). In Japan, conflicts between humans and crows have significantly increased with the rapid expansion of their distribution range and increase in population since the 1990s (Ueta et al. 2003). Most of the conflicts are related to their foraging behavior. For example, the cost of crop damage caused by crows was approximately 1.3 billion yen nationwide in financial year 2022, constituting approximately 50% of the total amount of damage caused by birds (Ministry of Agriculture, Forestry and Fisheries of Japan 2023). In urban areas, scattering of garbage frequently occurs at communal garbage collection stations, causing complaints from local residents about crows (Kurosawa et al. 2003, Shirai 2022). Large-scale population control is required to mitigate such damage, and the establishment of effective control strategies and measures is important to achieve this goal.

To predict and control the damage caused by foraging crows, it is important to understand their food preferences. Food resource selection in birds is influenced by a variety of factors. Food availability ultimately dictates what an animal can consume, whereas food preferences determine which available food items are actually consumed (Frazer and McWilliams 2002). Feeding preference experiments in captivity are appropriate means of examining food selection under controlled conditions, because the presence and amounts of food items can be known and thus a preference for presented items can be assessed objectively. There are two main types of experimental designs for assessing food preferences: simple- or multiple-offer experiments. Simple-offer preference experiments (non-choice) present only one food item at a time to determine whether the animal will consume the item when no other food is available (Cueto et al. 2001). Multiple-offer (choice) experiments present a test subject with multiple food items at one time and measure the consumption of each food item to identify a preference for one item over the others (Roa 1992, Cueto et al. 2001). Multiple-offer experiments are usually recommended because, during the trial, the test subject has an opportunity to express a dietary choice (Peterson and Renaud 1989). However, this approach may overestimate differences in preference (Cipollini and Levey 1997) and obscure the use of some less-preferred food items consumed when preferred items are absent. These less-preferred food items could be crucial for bird survival under natural conditions when preferred items are scarce. In contrast, simple-offer experiments could be misleading because a tested food could be consumed at higher rates than expected only because nothing else is available to eat.

Here, we combined these two experimental designs and developed techniques to evaluate the preferences of wild-caught large-billed crows. As preliminary experimental foods, we used pet food and dry corn, both of which are available to be consumed by large-billed crows. We also

attempted to extract behavioral parameters suitable for food preference evaluation from their foraging behavior.

METHODS

Subjects and General Housing

Nine wild-caught large-billed crows were used in this study. All individuals were caught in Niigata Prefecture, Japan, using baited welded wire mesh cage in 2021 and 2022; they were released within one year after completion of the experiments. The birds were housed in groups in a large outdoor cage (6 m × 6 m × 2.5 m) with ad libitum access to pet food for dogs (Vita-one, Nippon Pet Food Co., Ltd., Tokyo, Japan), drinking water, and perches for more than two weeks before the experiments began (Shirai et al. 2022). The cage was located in a remote part of the Akagi Testing Center of the Central Research Institute of Electric Power Industry, Gunma Prefecture, Japan; birds were generally disturbed only by animal care and research staff. The housing cage was visually and acoustically isolated from the experimental cage. We used numbered leg rings for ease of identification.

Experimental Procedure

Each experiment was performed with one individual at a time during the breeding season (May to June) in 2021 and 2022. Each crow was introduced to the experimental cage, a U-shaped experimental cage composed of two end spaces (2 m × 4 m × 2.5 m) connected by a corridor (2 m × 2 m × 2.5 m), 12 h prior to the beginning of the experiments to allow acclimatization to the experimental environment (Figure 1).

In this study, pet food and dry corn were used as experimental diets. Field observations have indicated that crows will forage for both pet food and dry corn (Soma and Hasegawa 2003, Kamei et al. 2011, Goto et al. 2015). The pet food includes corn, meat powder, and oils; it also contains more protein (pet food: 20.3%, dry corn: 7.6%) and fat (pet food: 8.0%, dry corn: 3.8%), whereas dry corn contains more carbohydrates (pet food: 46.7%, dry corn: 71.3%). However, the two diets have an approximately similar amount of energy per unit weight (3.5 kcal g^{-1}).

Each experiment was initiated at 06:00 because large-billed crows are mainly diurnal species (Kuroda 1984). The subjects were weighed to the nearest gram using a spring balance (No. 11000; Pesola AG) immediately prior to the start of each trial. The experimental cage was a U-shaped space that provided the birds with access to a food patch at both ends, which were connected by a space containing only water. At the beginning of each experiment, we placed 100 g of pet food and/or dry corn in a tray in two patches (hereafter referred to as the two-choice trial, Figure 1A) or a single patch (hereafter referred to as the no-choice trial, Figure 1B). The tray was sufficiently large to catch food spilled by the birds. We recorded the presence and foraging of the birds at the food patches using a digital video camera recorder (HDR-CX7; Sony Corp.). Each experiment was concluded at 18:00, and we weighed the mass (to the nearest gram) of food eaten from the patch(es) using an electronic balance (KD-184N; Tanita Corp.).

Of the nine birds, six were used in the no-choice trials and three were used in the two-choice trials. In the no-choice trials, three of the six birds were tested with pet food (pet food group), and the remaining birds were tested with dry corn (dry corn group).

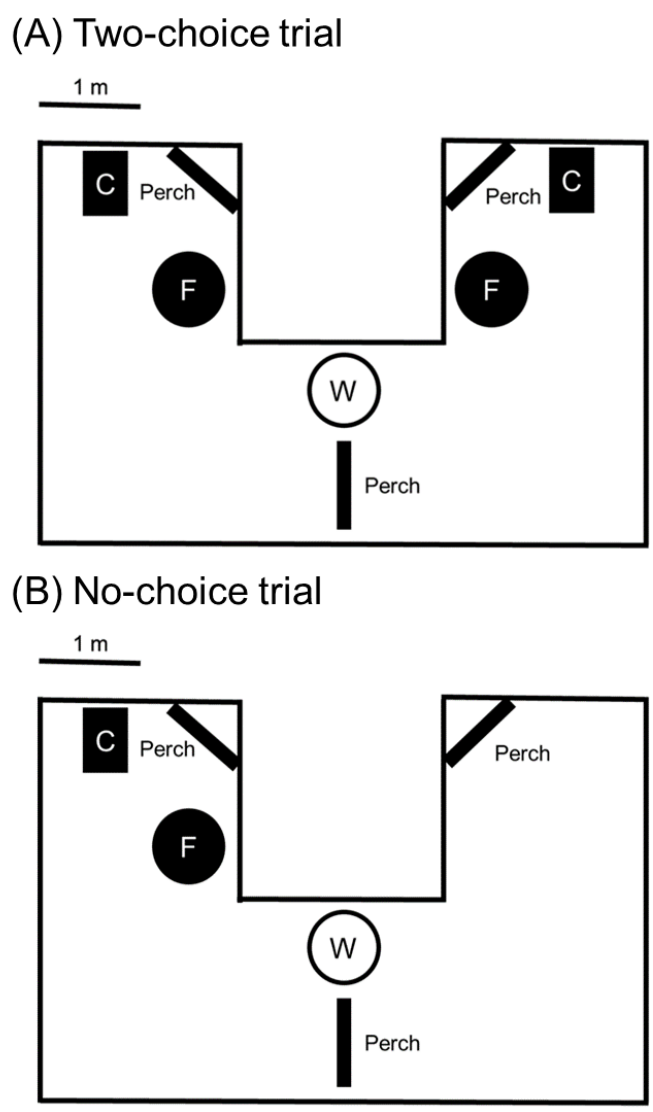

Figure 1. Plan view of the U-shaped experimental cage and experimental setting of (A) the two-choice and (B) no-choice trials. Closed "F" and open circles "W" indicate the positions of food patches and the water dish, respectively. Closed squares "C" indicate the positions of video cameras.

Data Analysis

We calculated the amount of food consumed in the 12-h trials by subtracting the weight of food remaining in the dish at the end of the trial from the 100 g initially provided. The video data obtained in each trial were used to measure the time from the start of a trial to the first landing on the food patch; this was defined as the latency time. We also measured the time spent by the crows on the food patch until they took off; the sum was recorded as the total time spent at the food patch. Foraging efficiencies on each food

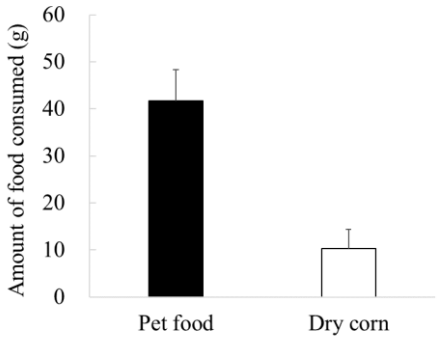

Figure 2. Food consumption of wild-caught large-billed crows during the two-choice trial. Bars represent means ± standard deviations.

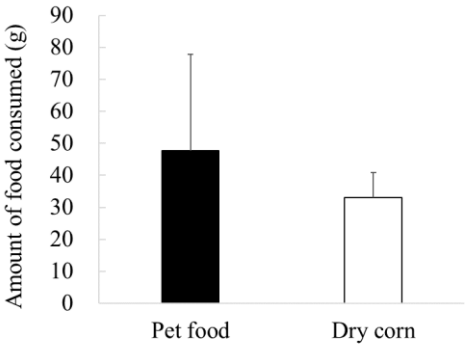

Figure 3. Food consumption of wild-caught large-billed crows during the no-choice trial. Bars represent means ± standard deviations.

in each of the experiments were calculated through division of the amount of each food consumed by the time spent at each food patch.

The amount of food consumed at each of the two patches during the two-choice trials was compared using two-tailed paired *t*-tests. Similarly, we performed comparisons between the amounts of pet food and dry corn consumed during the no-choice trials using two-tailed Student's *t*-tests. We also compared the body masses of individuals provided with pet food and dry corn in the no-choice trials using two-tailed Welch's *t*-tests. To compare behavioral parameters between food patches in each trial, we used a generalized linear model with the R package "stats". (R Development Core Team 2020). When the response variables were latency times and total foraging durations, the generalized linear model was fitted for a gamma error distribution with a log link function.

All data analyses were performed using R ver. 4.2.2 (R Development Core Team 2020). In all analyses, *P*-values < 0.05 were considered statistically significant. All values are presented as means ± standard deviations.

RESULTS

In the two-choice trial, the mean body mass of large-billed crows was 709 ± 44 g. Two of the three individuals began feeding on the food patch of pet food. The latency time in the two-choice trial was 304.0 ± 174.3 min. The total times spent at the food patches of pet food and dry corn were 6.8 ± 2.6 and 7.1 ± 3.9 min, respectively; the difference was not statistically significant ($\chi^2 = 0.02$, $P = 0.90$). On average, the crows foraged 42 ± 7 g in the food patch of pet food and 10 ± 4 g in the food patch of dry corn; the difference between food patches was statistically significant ($t = 5.36$, $P = 0.033$) (Figure 2). The foraging efficiencies were significantly higher in the food patch with pet food (6.69 ± 2.53 g min^{-1}) than in the food patch with dry corn (0.88 ± 0.72 g min^{-1}) ($\chi^2 = 4.46$, $P = 0.035$). In the no-choice trial, the body masses of the experimental birds were not different between the pet food (633 ± 10 g) and dry corn groups (718 ± 74 g) ($t = -1.98$, $P = 0.18$). Individuals in the pet food group consumed 48 ± 30 g of food during the experimental period, whereas individuals in the dry corn group consumed 33 ± 8 g; the difference between groups was not statistically significant ($t = 0.81$, $P = 0.46$) (Figure 3). The crows in the pet food and dry corn groups required 143.8 ± 174.1 and 4.2 ± 3.0 min to begin feeding, respectively; the difference was statistically significant ($\chi^2 = 13.44$, $P < 0.001$) (Figure 4). Additionally, the total time spent at the food patch was significantly longer for the dry corn group (62.6 ± 47.5 min) than for the pet food group (15.9 ± 9.7 min) ($\chi^2 = 5.56$, $P = 0.018$) (Figure 4). Foraging efficiencies were significantly higher in the pet food group (3.10 ± 0.68 g min^{-1}) than in the dry corn group (1.73 ± 1.19 g min^{-1}) ($\chi^2 = 9.06$, $P = 0.0026$).

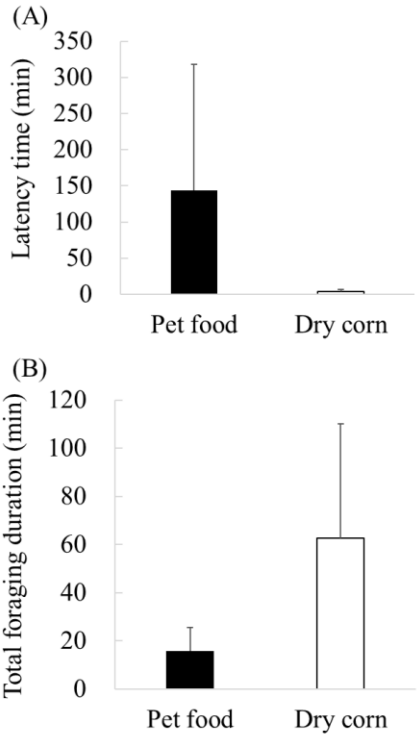

Figure 4. (A) Latency time before feeding initiation and (B) total time spent at the food patch by wild-caught large-billed crows during the no-choice trials. Bars represent means ± standard deviations.

DISCUSSION

No-choice trials showed that wild-caught large-billed crows consumed pet food and dry corn equally (Figure 2). In contrast, the results of two-choice tests indicated significantly greater consumption of pet food than dry corn (Figure 3). Therefore, the two-choice tests suggested that pet food was the preferred diet item. Large-billed crows were previously suspected to prefer high-protein, high-lipid diets (Inukai et al. 1959). Because the pet food used in the present study had higher protein and lipid contents than dry corn (see Methods), the results of the present study were consistent with these previous findings. Based on this conclusion, our results also implied that no-choice tests overestimate consumption of strictly less-preferred items, as previously suggested (Roa 1992).

In the no-choice test, there was no difference in consumption between pet food and dry corn, but the time spent in the food patch was significantly shorter when pet food was presented. In contrast, the two-choice test showed no difference in time spent in the food patch, despite significantly less corn foraging. As a result, the foraging efficiency (i.e., food consumption per unit time) of corn was consistently low throughout the trials. Previous studies often assessed the food preferences of birds using only food consumption as an indicator (e.g., Cueto et al. 2001, Dimiceli et al. 2007, El-Danasory et al. 2012), and there have been few behavioral analyses of the experimental subjects. Our results suggested that time spent feeding and foraging efficiency are important indicators for assessing the preferences of large-billed crows.

Because some birds show vigilance toward novel foods (i.e., neophobia; Greenberg 2003, Miller et al. 2022), it is possible that the differences in consumption and time spent at food patches between the two types of food were due to the effects of novelty. In our study, subjects in captivity had not experienced dry corn from trapping until the time of the experiment, whereas our subjects had already encountered pet food before the experiment (see Methods); this difference may have affected their food consumption in the two-choice trial. When pet food and dry corn were presented separately (i.e., no-choice trials), the latency was shorter for corn than for pet food; thus, the subjects behaved as if they were attracted to the novel food (i.e., neophilia). Further research is required to determine how food novelty influences the preferences of large-billed crows.

CONCLUSION

Our experimental protocol involving a combination of two-choice and no-choice trials, as well as behavioral analyses, allowed assessment of the food preferences of large-billed crows. The use of various assessment indices appears to be crucial for large-billed crows, which are considered omnivorous and plastic in their feeding preferences. An understanding of the preferred food choices of large-billed crows will be useful for trapping and attracting them to alternative sites. Information about their preferences will also contribute to the implementation of reasonable countermeasures, considering that areas with high densities of preferred foods are high-risk areas for damage by these birds. Further research is required to investigate the relative preferences of large-billed crows for different food types to predict and effectively control damage.

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