Unexpected Side-effects of Winter Feeding: Learning from Mahalanobis Distances Factor Analysis in the case of Red-crowned Cranes in Hokkaido, Japan

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Abstract: Winter feeding has become a critical approach to sustain animals in high latitude, but little literature has investigated possible side-effects in terms of ecological niches. To explore whether winter feeding might affect species distributions at regional scale, we employed a novel spatial model, Mahalanobis Distances Factor Analysis, in the case of Red-crowned Cranes (*Grus japonensis*) in Hokkaido, Japan. This model features better prediction ability with more explicit ecological significance compared to conventional methods. Furthermore, particularly innovative is that axes are used to define ecological niches, with a minimal set of habitual variables to calculate habitat suitability in the algorithm. In results, winter feeding seemed to considerably impact the distributions, suggesting heavy dependence of human food supplies of the focal species. Besides, most of the other human influence variables, such as human population and road, tended to be relatively less associated with the occurrence localities, implying decreased sensitivity to human proximity. Taken together, the focal species might possibly survive in the adverse climate at the cost of diminished innate ability. In other words, winter feeding could impair the ability of self-sustaining in the wilderness, which can also take place but may remain hidden in similar cases around the globe. Contingency plans should thus be considered to minimize the side-effects of winter feeding for effective biodiversity conservation.

Keywords*: Mahalanobis Distances Factor Analysis; presence-only models; distributions; cranes; winter feeding*

1. INTRODUCTION

Winter feeding has seen growing popularity among avian species, many of which have thus been able to survive in adverse climate in high latitude [Wilson et al. 2007; Jones, et al. 2008; Robb et al. 2008]. For instance, Newton [1979] indicated that artificial feeding plays a critical role in sustaining eagles in North Europe. Similarly, human supplies were evidenced as a major factor to support chickadees in North America [Wilson 2001]. However, although most publications to date have supported benefits of winter feeding, little attention has been paid to the possible side-effects.

Among the published examples discussing subsequent effects of winter feeding, many have reviewed in terms of ethology [Boukhriss et al. 2007; Gillings et al. 2007; Lee et al. 2007]. Recently, the influences induced by winter feeding have been increasingly reported in the context of species distributions [Yoo 2004; Shimada et al. 2008]. On one hand, some publications lend support to the distribution alterations affected by food supplementations [Siriwardena et al. 2007; Roth and Vetter 2008a]. Most of them focus on research of small birds, using field observation at local scale. On the other hand, other studies show little impacts on range shifts caused by food supplies, particularly for large birds with broad home range [Kane et al. 2007; Roth and Lima 2007; Roth et al. 2008b]. Above all, previous research has demonstrated conflicting results in this regard.

To explore whether food supplementations may lead to distribution alterations for large birds, we conducted this research in the case of the winter feeding of Red-crowned Cranes (*Grus japonensis*) in Hokkaido, Japan. As averagely tall as 160 cm, the adult cranes are one of the large avian species in the world. Moreover, food supplies have persisted for more than 50 years in harsh winter, which may have contributed to the recovery from near-extinction [Masatomi 2000]. In this research, we examined the relationship between winter feeding and species distributions at regional scale, using Mahalanobis Distances Factor Analysis (abbreviated as MADIFA hereafter) [Calenge et al. 2008]. This model innovates the use of axes to explain the roles of habitual factors in species distributions [Calenge et al. 2008]. The results will suggest the interaction between food supplementations and species ranges for large birds by novel approaches at macro scale. Also, they may stimulate insights on improving distribution monitoring for recovered or reintroduced species in the world.

2. METHODS

2.1 Study area

We studied the wintering distributions of Red-crowned Cranes in Hokkaido. This island is located in the northern border of Japan [41° 21' - 45° 33'N, 139° 20' - 148° 53'E], with the area of 78,328 km^2. Consequently, the winter in Hokkaido, which we defined as the period from December to the ensuing March, features low temperature. Meanwhile, snow cover also remains from late autumn to early spring, whose daily maximum value attained 200 cm [Japan Meteorological Agency 2008].

2.2 Species Data

Among the census records which have been accumulated for 25 years, the latest report was selected as species data in this research [Masatomi et al. 1985, 2006]. It comprises 121 wintering grounds, which were digitalized as one layer of ArcGIS at a resolution of 1 km^2 [ESRI 2008]. Besides, this research focused on presence-only data alone, because accurate absence data were hard to obtain due to harsh conditions of winter climate and high mobility of target species.

2.3 Habitual Variables

Determining habitual variables corroborated by previous literature were selected [Masatomi 2000] and classified as natural and artificial groups. The former group encompassed conditions summarizing local geography and winter seasonality, including altitude, slope, winter minimum temperature, winter temperature range, sunlight sum, seasonal precipitation sum, maximum snow cover, and seasonal snow sum. On the other hand, the latter group contained proxies capturing human development, consisted of feeding stations, human population, human density, and road length.

2.4 Model

Based on Mahalanobis Distances, MADIFA features the employment of axes to characterize ecological niches [Calenge et al. 2008]. As extended from principal component analysis, this algorithm provides an alternative to explain the association between environmental conditions and species distributions. Additionally, it generates clear graphic presentations to evaluate significance of each habitual variable, which is distinct from Ecological Niche Factor Analysis, a model with the identical theory base [Hirzel et al. 2002]. Here, this research was conducted using R 2.10.1 [R Development Core Team 2009] and the R-package “adehabitat” [Calenge 2006].

3. RESULTS

According to the findings in this research, our results suggest supplementary feeding as one of the main habitual variables accounting for the wintering distributions of the focal species. The high correlation between winter feeding and the horizontal axis exhibits that the closeness of the distributions to the locations of food supplies (Figure 1).

Rather unexpected was the association between the ranges and other environmental factors reflecting artificial developments. As shown in Fig. 1, the correlations between the axis and human population, human density, and road explain the possible impacts brought by those variables in the wintering distributions.

4. DISCUSSION

Roth and Lima [2007] revealed that the movements might be less associated with resource feeders, by field observations of raptor flights at local scale. Comparatively, this research explores potential effects incurred by food supplies, using computer analyses of wader distributions at regional scale. It seems clear that the outcomes here and those in the above study differ, albeit both species of interest feature large birds.

This research was consistent with the results attained by long-term field observations, which suggest altered distributions affected by winter feeding [Masatomi 2000]. However, different from most of the field work in micro habitats, it evidenced such tendency by computer analyses using synthesized data within regional extent. From the viewpoint of methodology, this research also suggests ecological niche models as alternatives for species with broad movement ranges, which can comprehensively examine whether range shifts may occur in response to human interventions in the perspective of macroecology.

In addition to distribution alterations, this study also unveiled other detrimental but less marked effects associated with food supplies in the wilderness. Compared to the breeding grounds where human approach is strictly prohibited [Masatomi 2000], wintering habitats of the focal species seem to be less influenced by human population, human density, and road according to the findings in this research. In other words, the species of interest might become more tolerant but less vigilant of human proximity in search of food in the harsh climates. Furthermore, it implies that survivals on winter feeding may cost the decrease of innate ability in the wilderness.

5. CONCLUSIONS

As it has become popular to sustain endangered or threatened species with artificial interventions such as supplementary foods, some side-effects may remain hidden but surface later in the process of recoveries or reintroductions. For example, population bottlenecks are commonly regarded as top priority in this regard. When such problems have been mitigated, other issues which could be less noticeable initially may become impending. Here, this research exemplified a case study concerning distribution monitoring. To deal with the subsequent effects, contingency plans should be taken into account to adjust current conservation strategies and to support the focal species with better self-sustaining ability in the wilderness.

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8. FIGURE

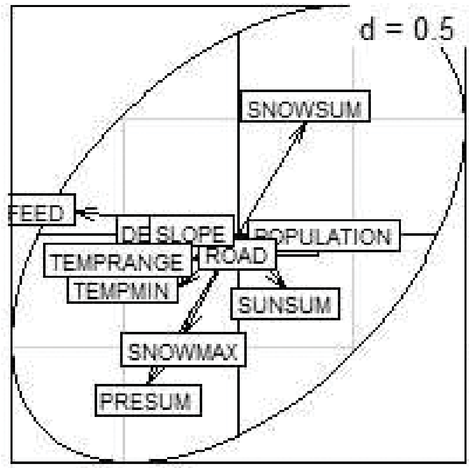

Figure 1 Graph of the correlation between the x-axis and the habitual variables.