PNIE PROCEEDINGS OF THE NATIONAL INSTITUTE OF ECOLOGY OF THE REPUBLIC OF KOREA

Original Articles

PNIE 2021;2(4):285-292
https://doi.org/10.22920/PNIE.2021.2.4.285
pISSN 2765-2203, eISSN 2765-2211

Patterns of Habitat Use and Home Range of a GPS Tracking White-naped Crane *Grus vipio* in Cheorwon, Korea

Kisup Lee[1], In-Ki Kwon[2]*

[1] Waterbird Network Korea, Seoul, Korea
[2] Research Center for Endangered Species, National Institute of Ecology, Yeongyang, Korea

ABSTRACT

We investigated habitat use and home range of a rescued and released white-naped crane using GPS tracking technology in Cheorwon, South Korea, from October 2016 to March 2017. Four types of roosting sites were identified: frozen reservoirs, paddy fields, rivers, and wetlands. Upon arrival, the white-naped crane preferred wetlands in the Demilitarized Zone (DMZ). In late wintering season, it showed a tendency to change main roosting sites in the following order: rice paddies, rivers, and frozen reservoirs. Among 14 sleeping places, Civilian Control Zone (CCZ) with various type of available habitats was more preferred than the DMZ. Places outside of CCZ were rarely used due to anthropogenic disturbances during the night. The tracked white-naped crane widely chose daytime feeding sites while moving around all over rice paddies in the CCZ. Mean diurnal movement distance was 10.5 km with a maximum of 24.8 km. Its home range measured with Minimum Convex Polygon (MCP) and Kernel Density Estimation (KDE) was 172.30 km^2 with MCP, 159.60 km^2 with KDE 95%, 132.48 km^2 with KDE 90%, and 42.45 km^2 with KDE 50%. All estimated values of home ranges were higher in the early and later winter than those in the middle period.

Keywords: *Grus vipio*, Cranes, Habitat use, Home range, Movement, Cheorwon

Introduction

As one of internationally endangered birds in the East Asian region, the white-naped crane has been listed in the Red List of International Union for Conservation of Nature's (IUCN) (BirdLife International, 2018). It is legally protected in South Korea as an Endangered Species Rank II by the Ministry of Environment and as the Natural Monument No. 203 by the Cultural Heritage Administration. Its breeding areas include southeast Russia, northeast China, and eastern Mongolia (BirdLife International, 2018; Gilbert *et al*., 2016). Its wintering grounds are distributed in South Korea, Japan, and central and eastern China (BirdLife International, 2018; Higuchi *et al*., 1996; 2004). In South Korea, wintering sites of the white-naped crane include Cheorwon, Yeoncheon, Paju, the Han River Estuary, and Junam Reservoir, while the greatest number goes to the Demilitarized Zone (DMZ) and the Civilian Control Zone (CCZ) in Cheorwon Basin (Lee *et al*., 2001; National Institute of Biological Resources (NIBR), 2020). In general, cranes are known to choose their roosting sites in wetlands or in shallow water (BirdLife International, 2018). White-naped cranes choose their sleeping sites in wetlands, rivers, and reservoirs in DMZ (Pae, 1994; 2000; Yoo *et al*., 2011). They forage in rice paddies during the day and gather back to a certain resting place in the evening, where tens or hundreds of them sleep together (Pae, 2000; Yoo, 2004; Yoo *et al*., 2009b).

Previous studies of white-naped cranes in Choerwon have examined the distribution and density of the wintering population, behavioral responses to disturbances, habitat use, and micro feeding site preference (Lee *et al*., 2001; 2007; Yoo *et al*., 2007; 2009a; 2011; 2014a; 2014b; 2015).

Received June 30, 2021; **Revised** October 12, 2021; **Accepted** October 13, 2021

***Corresponding author:** In-Ki Kwon
e-mail bfskwon@nie.re.kr
https://orcid.org/0000-0003-4000-3380

However, due to spatiotemporal limitations to access both DMZ and CCZ with the lack of individual-based tracking research, little is known about patterns of their habitat use, home range, and daily travel distances. GPS tracking method is appr opriate to study migratory animals. It has been used to collect data of migration routes, stopover sites, and movement distances (Harris *et al*., 2000; Higuchi *et al*., 1998; 2004). As recent technological advancement allows researchers to collect precise location data with short-term intervals, GPS tracking is widely used in regional scale habitat use studies. The objective of this study was to utilize GPS tracking to determine habitat use patterns of a white-naped crane in both roosting and feeding sites and its home ranges in Cheorwon, Korea during the wintering period.

Materials and Methods

Target individual and methods

After the Gyeonggi-do Wildlife Rescue Center rescued and treated a white-naped crane that was straggled by power line collision, it was released to Jinwi Stream, Pyeongtaek, on March 22, 2016. From body measurement, feather moult, and DNA analysis, we confirmed that it was a young female crane at two years old. Before releasing the bird, we attached a GPS telemetry (WT-200, GPS-Wideband Code Division Multiple Access Telemetry System built-in Solar System, KoEco, Korea) to the back of the crane using Teflon tape harnesses (Higuchi *et al*., 1996). The device was set to store GPS data 12 times a day (every two hours). We also attached a white band (engraved letter as K01) for individual marking on its leg. On April 10th, 2016, the released K01 migrated northward to the breeding grounds and spent the summer in Dalnerechensk and Lake Khanka in Russia. It came to its wintering ground, Cheorwon, on October 24th, 2016. After that, the bird stayed in Cheorwon Basin continuously during the winter. It migrated again to Russia on March 16th, 2017. From every fieldwork during the study period, we observed that K01 stayed within a flock (from tens to hundreds) without a mate or juveniles.

Data analysis

In order to figure out K01's habitat preferences, we put the acquired coordinate data on Google Earth's satellite map and classified the information by regional types (DMZ, CCZ, or outside CCZ) and habitat types (feeding and roosting sites). By classifying nighttime roosting sites into four habitat types (wetlands, reservoir, paddy fields, and rivers), we analyzed the frequency of habitat use. For regional classification, the entire habitat was grouped into four categories: the Sapsongbong (SSB) region (also known as the Ice Cream Hill) in the middle, the Daema-ri (DMR) region on the west (including Sanmyeong Lake), the Yugok-ri (YGR) region on the east (including Togyo Reservoir), and the Hantan River (HTR) region on the south outside the CCZ (Fig. 1). Its daily movement distance was calculated by summing all distances between GPS coordinate collected every two hours. To measure its home range, we used Minimum Convex Polygon (MCP) and Kernel Density Estimation (KDE). We calculated 50%, 90%, and 95% KDE and examined changes of home range

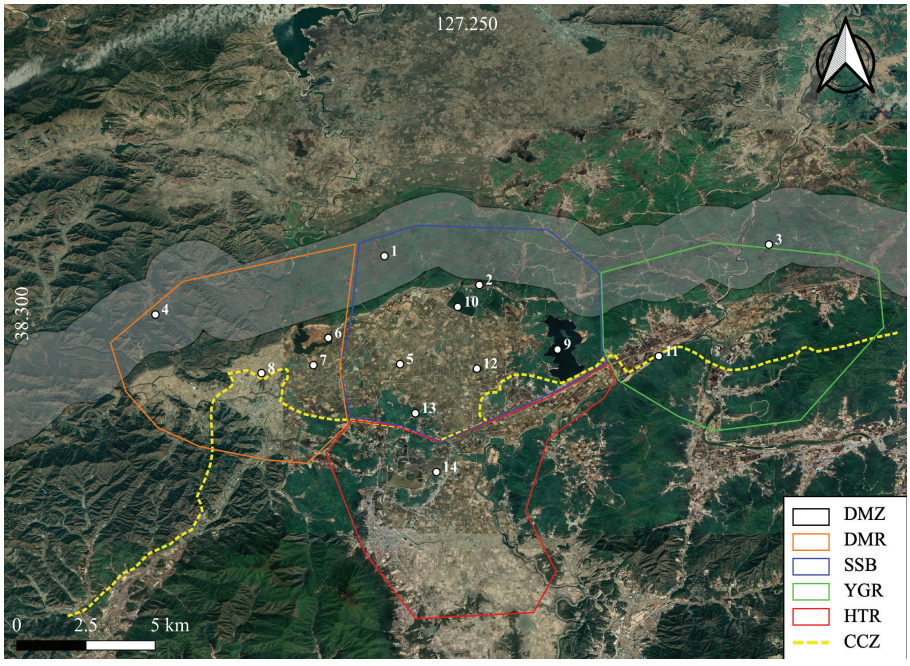

Fig. 1. Map of the study site and four regional classifications (DMR: Daema-ri, SSB: Sapsongbong; YGR: Yugok-ri; HTR: Hantan River) in Cheorwon, Korea. Numbers indicate sleeping places of a GPS tracked white naped crane during wintering period in Table 2.

areas by having five periods with four weeks intervals since October 24, 2016. The analysis was performed using R version 3.5.1 (R Development Core Team, 2018) and QGIS version 3.16 (QGIS Development Team, 2021).

Results and Discussion

From October 24th, 2016 to March 16th, 2017, we expected 1,712 GPS coordinates from a total of 143 days. We were able to collect 1,677 data points (98.0%). Although data was intermittently lost at night from 8 PM to 6 AM, we collected all expected daytime coordinates from 10 AM to 6 PM. During the study period, the total movement distance of K01 was 1,515.05 km.

Habitat use

K01 was mostly located in the CCZ (n = 1235, 72.2%), followed by the DMZ (n = 346, 20.2%) and the outside area of CCZ (n = 96, 5.6%). K01 chose the DMR the most as feeding and roosting places (n = 838, 50.0%; Table 1). The SSB was the second most frequent choice (n = 617, 36.8%). As a feeding place, SBB (n = 292, 44.1%) and DMR (n = 305, 46.1%) were similarly preferred. The frequency of using HTR outside the CCZ was the lowest (5.7%).

Patterns of habitat use in roosting and feeding sites

Most of the time, K01 started to move to its roosting places at around 6 PM and arrived at the destination by 8 PM at the latest. For 140 days (97.9%) out of a total of 143 days, it stayed within a 100 m of its sleeping place during the night. In three cases, K01 flew away more than 1 km from its sleeping places. A total of 14 sleeping places were identified (Table 2, Fig. 1). There were four sites where the bird stayed more than 20 days out of a total 143 days: the Yeokgok River (27 days, 18.9%), the Togyo Reservoir (26 days, 18.2%), the Baekma paddy field (23 days, 18.2%), and the Sanmyeong Lake (22 days, 15.4%). Among the four types of roosting places (reservoir, rice, paddy, river, and wetland), the most preferred sleeping places were frozen reservoirs where the bird stayed for 52 days (36.4%). The next preferred sleeping places were paddy fields, where K01 stayed for 36 days (25.2%). In particular, it stayed the longest for 23 days (16.1%) at a paddy field near the DMR within the CCZ. The third preferred sleeping places were rivers where the bird stayed for 34 days (23.8%). The wetlands were all located in the DMZ. They were used by the for 21 days (14.7%). The wetland habitat was a small-sized wetland with areas of 0.01~0.03 km^2 or a palustrine wetland. K01 showed a tendency to change its roosting sites over time. During the first one to two weeks upon arrival, it used wetlands in DMZ for sleeping places. However, up to the 9th week since then, it had a high tendency to use flooded rice paddies. After the temperature fell below the freezing point, K01 preferred rivers and reservoirs but avoided frozen paddy fields and wetlands. In the later period, when the ice started to melt down, K01 chose wetlands and paddy fields more frequently. During the day between 8 AM and 6 PM, K01 mainly foraged in rice paddies (Fig. 2). It is well known that white-naped cranes take post-harvest remained grains from the paddy fields during the wintering period and prefer vegetable food types compared to red-crowned cranes (Koo, 1980). Although its movement to feeding sites started around 8 AM, the bird tended to stay in the roosting sites longer from late December to mid-February when the temperature was low. The foraging duration was short (8 hours) between December and January or 6 hours when the temperature was low. After February, the bird stayed in feeding sites even at 6 PM, with its foraging duration getting longer up to 12 hours. Besides the elongated daytime, we assume that this might be a behavioral strategy so that it can store more energy in preparation for the long-distance migration to breeding grounds (Zhou *et al*., 2010).

Movement distance

During the overwintering period, K01 moved 10.72 ± 5.12 (SD) km per day on average (n = 140, range, 1.80~26.27 km). From 8 AM to 8 PM, its average daytime movement

Table 1. Frequency of daytime feeding and nighttime roosting sites in four regions used by a GPS-tracked white-naped crane in Cheorwon, Korea during 2016-2017 wintering season

Region	Frequency		
	Daytime Feeding site (%)	Nighttime roosting site (%)	Total(%)
SSB	305(46.1)	533(52.5)	838(50.0)
DMR	292(44.1)	325(32.0)	617(36.8)
YGR	23(3.5)	103(10.1)	126(7.5)
HTR	42(6.3)	54(5.3)	96(5.7)
Total	662(39.5)	1015(60.5)	1677(100.0)

Table 2. Sleeping places, habitat type, and total days spent the night of a GPS tracked white-naped crane in Cheorwon, Korea during 2016-2017 wintering season

	Sleeping places	Location	Habitat type	Total days spent the night (%)
1	Woljeong	DMZ	Wetland	13(9.1)
2	Pyeonghwa	DMZ	Wetland	1(0.7)
3	Seungni	DMZ	Wetland	7(4.9)
4	Yeokgok	DMZ	River	27(18.9)
5	Seogureung	CCZ	Rice paddy	3(2.1)
6	Sanmyeong 1	CCZ	Reservoir	22(15.4)
7	Sanmyeong 2	CCZ	Rice paddy	2(1.4)
8	Baekma	CCZ	Rice paddy	23(16.1)
9	Togyoji	CCZ	Reservoir	26(18.2)
10	Gangsanji	CCZ	Reservoir	1(0.7)
11	Hantan	CCZ	River	7(4.9)
12	Hagalji	CCZ	Reservoir	3(2.1)
13	Gwanwoori	CCZ	Rice paddy	1(0.7)
14	Hak reservoir	Outside	Rice paddy	7(4.9)
		Total		143(100.0)

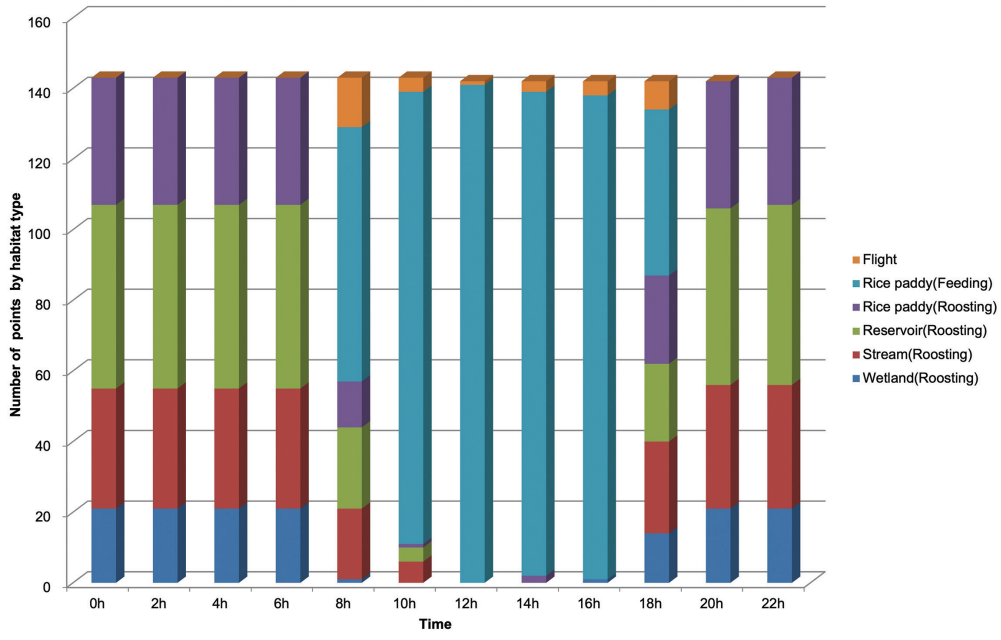

Fig. 2. Habitat type used at 2-hour intervals for a GPS tracked white-naped crane in Cheorwon, Korea during 2016-2017 wintering season.

distance was 10.54 ± 5.01 km (n = 140, range, 1.77~24.81 km). Its average nighttime movement distance between 10 PM to 6 AM was 0.18 ± 0.70 km (n = 140, range, 0.02~7.46 km). Average daily total movement distance varied over the study period (One-way ANOVA, $F_{4,135}$ =14,67, $P < 0.001$; Table 3). During the first 4 weeks, the average daily total movement distance was 11.9 ± 5.89 km (n = 28) and the average distance to sleeping places (3.78 ± 4.62km) was slightly far compared to other periods of 4 weeks (One-way ANOVA, $F_{4,135}$ =2,87, $P < 0.05$; Table 3). However, during the second period of four weeks, average distance to sleeping places decreased (1.34 ± 1.72 km, n = 28), resulting in a shorter average daily total movement distance (6.33 ± 3.00 km, n = 28). While the average distance to sleeping places became very short (as short as 1.11 ± 1.48 km, n = 28) during the fourth 4 weeks, the average daily total movement distance was increased (14.53 ± 4.18 km, n = 28).

Table 3. Summary of average movement (± SD) distance of daytime (8 AM to 8 PM), nighttime (10 PM to 6 AM), daily total, and the distance between the sleeping and the last daytime feeding places of a GPS tracked white-naped crane with four weeks intervals in Cheorwon, Korea during 2016-2017 wintering season

Period	Movement distance (km)			Distance between the sleeping and the last daytime feeding places (km)*	n
	Daytime***	Nighttime[n.s.]	Daily total***		
1st (Oct 25 ~ Nov 21, 2016)	11.81 ± 5.90	0.09 ± 0.06	11.90 ± 5.89	3.78 ± 4.62	28
2nd (Nov 22 ~ Dec 19, 2016)	6.26 ±3.00	0.08 ± 0.10	6.33 ± 3.00	1.34 ± 1.72	28
3rd (Dec 20, 2016 ~ Jan 16, 2017)	8.91 ±3.19	0.08 ± 0.08	8.99 ± 3.15	2.24 ± 4.08	28
4th (Jan 17 ~ Feb 13, 2017)	14.11 ±4.22	0.42 ± 1.40	14.53 ± 4.18	1.11 ± 1.48	28
5th (Feb 14 ~ Mar 13, 2017)	11.63 ±4.42	0.22 ± 0.67	11.85 ± 4.79	2.97 ± 4.18	28
Overall	10.54 ± 5.01	0.18 ± 0.70	10.72 ± 5.12	2.29 ± 3.58	140

† One-way ANOVA

Home range

Home range of K01 was calculated to be 172.30 km^2 for MCP, 159.60 km^2 for KDE 95%, 132.48 km^2 for KDE 90%, and 42.45 km^2 for KDE 50%). Areas and geographical distribution were varied over the study period (Table 4; Fig. 3). Moreover, despite individual tracking results, K01 inhabited most of the known habitats of white-naped cranes in Cheorwon (Yoo *et al*., 2014b). The reason might be because K01 belonged to a nonbreeding flock during the wintering season. The core habitat area (KDE 50%, 59.99 km^2) was the most extensive during the first 4 weeks after arrival. However, during the second 4 weeks, its core habitat area sharply decreased to 5.54 km^2 as it slept in flooded rice paddies within the CCZ and foraged on nearby farmlands. In the third 4 weeks, its core habitat area increased to 26.28 km^2 while moving to other sleeping places. In the fourth 4 weeks, its core habitat area decreased to 14.81 km^2. However, during the fifth 4 weeks between late February and mid-March before northward migration, its core habitat area again increased significantly to 38.85 km^2. Its foraging area might have increased due to shortage of food resources (e.g., remained grains) and competition with geese species (Zhu *et al*., 2020).

Conservation implications

It is known that white-naped cranes select wetlands or rivers for its roosting sites (Lee *et al*., 2001; Pae, 1994; Yoo, 2004). In the Izumi overwintering sites in Japan, white-naped cranes mostly take artificial paddy fields as their feeding and sleeping places (Higuchi *et al*., 1996). Higuchi *et al*. (1996) have reported that the DMZ in Cheorwon is an important habitat for white-naped cranes. However, their habitat use pattern in Cheorwon could not be identified because a satellite tracking method (ARGOS PTT) with a minimum location accuracy of 150 m was used. Yoo *et al*. (2011) have revealed that not only wetlands in the DMZ, but also frozen reservoirs are their important rooting sites based on field observation. Although the present study was conducted on a single bird, it was the first study that utilized GPS tracking method to understand spatio-temporal habitat use of a white-naped crane in Cheorwon. This study found that the most preferred sleeping places in Cheorwon were frozen reservoirs (Table 2). It can be speculated that the reservoir is a good roosting site because it provides an open view for surveillance. The reflection from both snow and ice also help them detect predators. In particular, the reservoirs in CCZ were more preferred because

Table 4 . Summary of home range of a GPS-tracked white-naped crane in Cheorwon at four-week intervals during 2016-2017 wintering season

Period	Home range (km^2)			
	MCP	KDE 95%	KDE 90%	KDE 50%
1st (Oct 25 ~ Nov 21, 2016)	164.88	231.02	188.23	59.99
2nd (Nov 22 ~ Dec 19, 2016)	40.72	25.55	20.54	5.54
3rd (Dec 20, 2016 ~ Jan 16, 2017)	81.83	110.06	85.84	26.28
4th (Jan 17 ~ Feb 13, 2017)	46.10	62.62	50.59	14.81
5th (Feb 14 ~ Mar 13, 2017)	157.57	168.23	135.08	38.85
Total	172.30	159.60	132.48	42.45

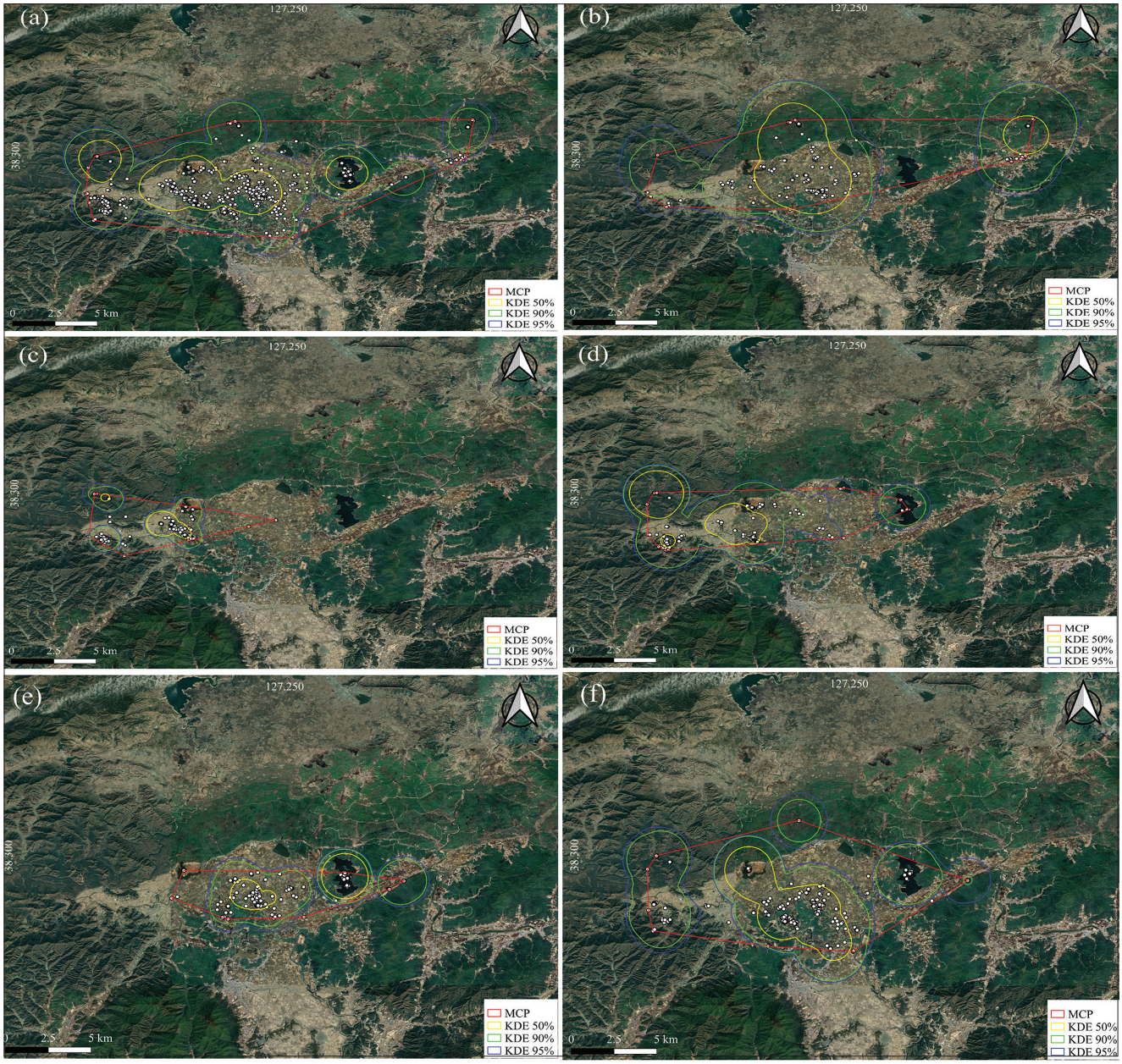

Fig. 3. Home range of a GPS tracked white-naped crane during 2016-2017 wintering season. Home range was analyzed by dividing it into 4-week intervals: (a) overall period, (b) Oct. 4 ~ Nov. 21, 2016 (c) Nov. 22 ~ Dec. 19, 2016, (d) Dec. 20, 2016 ~ Jan. 16, 2017, (e) Jan. 17 ~ Feb. 13, 2017, (f) Feb. 14 ~ Mar. 16, 2017.

human access was limited during the nighttime (Yoo *et al*., 2014a). However, during the early wintering period (October and November), the reservoir does not freeze. Thus, its use as a sleeping place was limited. The second preferred sleeping places were flooded rice paddies because of the openness for surveillance (Pae, 1994; 2000) and the close proximity to feeding sites (Yoo *et al*., 2011; 2015). Unlike reservoirs, paddy fields were frequently used in the early and late winter, while their availability decreased during mid-winter when water froze or dried. In March, despite many disturbances (e.g., vehicle, noise, presence of people, cultivation), K01 used flooded paddy fields outside the CCZ because these paddy fields were dried out and frozen reservoirs were melted out in the CCZ. Thus, creating flooded paddy fields in the CCZ in early spring can help white-naped cranes inhabit this region safely. The river as the third preferred habitat is wide. It has rapids that do not freeze. Thus, it was frequently used in January and February. Wetlands in the DMZ were frequently used in October and November. In this period, DMZ wetlands could provide

good resting places while there are lots of anthropogenic disturbance by harvest in the CCZ. However, cranes rarely used wetlands in the DMZ during the mid-winter. These DMZ wetlands are far from feeding sites. They are smaller in area than rice paddies and reservoirs, making it difficult to defend against predators. In conclusion, in order to protect cranes, it is necessary to create and manage various types of habitats at different time periods. In particular, it is important to focus on conservation of habitats within the CCZ.

Conflict of Interest

The authors declare that they have no competing interests.

Acknowledgments

We would like to thank Si-Young Yoo (Gyeonggi Wildlife Rescue Center), Kyung-Yeon Eo (Seoul Zoo), and Yong-Gu Yeo (Seoul Zoo) for their support. We also would like to thank Dal-Ho Kim (KoEco) and Soo-Ho Kim (Cheorwon Wildlife Rescue Center) for their help in field research.

References

BirdLife International. (2018). *Antigone vipio. The IUCN Red List of Threatened Species 2018*. e.T22692073A131-927305. doi:10.2305/IUCN.UK.2018-2.RLTS. T2269207-3A131927305.en

Gilbert, M., Buuveibaatar, B., Fine, A.E., Jambal, L., and Strindberg, S. (2016). Declining breeding populations of White-naped Cranes in Eastern Mongolia, a ten-year update. *Bird Conservation International*, 26, 490-504. doi;10.1017/S0959270915000301

Harris, J., Liying, S., Higuchi, H., Ueta, M., Zhang Z., Zhang, Y., et al. (2000). Migratory stopover and wintering locations in eastern China used by White-naped Cranes *Grus vipio* and Hooded Cranes *G. monacha* as determined by satellite tracking. *Forktail*, 16, 93-99.

Higuchi, H., Ozaki, K., Fujita, G., Minton, J., Ueta, M., Soma, M., *et al*. (1996). Satellite tracking of White naped Cranes migration and importance of the Korean Demilitarized Zone. *Conservation Biology*, 10, 806812. doi:10.1046/J.1523-1739.1996.10030806.X

Higuchi, H., Pierre, J.P., Krever, V., Andronov, V., Fujita, G., Ozaki, K., et al. (2004). Using remote technology in conservation: Satellite tracking White-naped Cranes in Russia and Asia. *Conservation Biology*, 18, 136147. doi:10.1111/j.1523-1739.2004.00034.x

Higuchi, H., Shibaev, Y., Minton, J., Ozaki, K., Surmach, S., Fujita, G., *et al*. (1998). Satellite tracking of the migration of the Red-crowned Crane *Grus japonensis. Ecological Research*, 13, 273-282. doi:10.1046/j.1440-1703.1998.00271.x

Koo, T.H. (1980). Crane Ecology. *Nature Conservation*, 32, 32-33.

Lee, S.D., Jabłoński, P.G., and Higuchi, H. (2007). Effect of heterospecifics on foraging of endangered red crowned and white-naped cranes in the Korean Demilitarized Zone. *Ecological Research*, 22, 635-640. doi:10.1007/s11284-006-0067-z

Lee, W.S., Rhim, S.J., and Park, C.R. (2001). Habitat use of cranes in Cheolwon Basin, Korea. *Korean Journal of Ecology*, 24, 77-80.

NIBR. (2020). *2019-2020 Winter Waterbird Census of Korea*. Incheon: National Institute of Biological Resources.

Pae, S.H. (1994). *Wintering ecology of Red-crowned Crane Grus japonensis and White-naped Crane Grus vipio in Cholwon basin, Korea* (Master's thesis). Kyung Hee University, Seoul.

Pae, S.H. (2000). *A study on habitat use of wintering cranes in DMZ, Korea: with carrying capacity and spatial distribution analysis using GIS* (Doctoral dissertation). Kyung Hee University, Seoul.

QGIS Development Team. (2021). *QGIS Geographic Information System*. Open Source Geospatial Foundation Project. Retrieved June 19, 2021 from http://qgis.osgeo.org

R Development Core Team. (2018). *R: A language and environment for statistical computing*. *Vienna: R foundation for statistical computing*. Retrieved June 15, 2021 from http://www.R-project.org/

Yoo, S.H. (2004). *Some factors affecting the distribution of Grus japonensis and Grus vipio behavioral aspects of family group* (Master's thesis). Kyung Hee University, Seoul.

Yoo, S.H., Jung, H.Y., Kim, K.S., Yu, D.S., Kim, N.S., Kim, H.J., *et al*. (2015). The change of core habitats of the cranes due to release of the civilian control zone; CCZ and construction disturbance. *Journal of Environmental Impact Assessment*, 24, 301-316. doi:10.14249/eia.2015.24.4.301

Yoo, S.H., Kim, I.K., Lee, H.S., and Lee, K.S. (2009 a). Micro feeding site preference of wintering cranes by topography and vegetation in Cheorwon Basin, *Korea. Korean Journal of Environment and Ecology*, 23, 418-430.

Yoo, S.H., Kim, J.H., and Lee, K.S. (2014a). Distribution aspects of the wintering Red-crowned Crane and White-naped Crane according to the anthropogenic factors in the Cheorwon, Korea. *Korean Journal of Environment and Ecology*, 28, 516-522. doi:10.13047/KJEE.2014.28.5.516

Yoo, S.H., Kwon, H.S., Park, J.J., and Park, J.C. (2011). Spatial distribution of feeding site and the relationship between density and environmental factors (roosting site, road and residence) of cranes in Cheorwon Basin, Korea. *Korean Journal of Environment and Ecology*, 25, 516-525. doi:10.13047/KJEE.2014.28.5.516

Yoo, S.H., Lee, K.S., Kim, H.J., Hur, W.H., Kim, J.H., and Park, J.H. (2014 b). Distribution model of the wintering Red-crowned Crane and White-naped Crane in Cheorwon, Korea. *Korean Journal of Environment and Ecology*, 47, 282-291. doi:10.11614/KSL.2014.47.4.282

Yoo, S.H., Lee, K.S., Kim, I.K., Kang, T.H., and Lee, H.S. (2009b). Research on the size, formation and tendency to evade road of the feeding flocks of crane species: centering on the effect of road vs. traffic condition. *Korean Journal of Environment and Ecology*, 23, 41-49.

Yoo, S.H., Lee, K.S., and Yoo, J .C. (2007). Reaction to the vehicle and trade-off between vehicular interruption and food resources of cranes. *Korean Journal of Environment and Ecology*, 21, 526-535.

Zhou, B., Zhou, L., Chen, J., Cheng, Y., and Xu, W. (2010). Diurnal time-activity budgets of wintering Hooded Cranes (*Grus monacha*) in Shengjin Lake, China. *Waterbirds*, 33, 110-115. doi:10.1675/063.033.0114

Zhu, Z., Zhou, L., Yu, C., Cheng, L., Xu, W., and Song , Y. (2020). Do geese facilitate or compete with wintering Hooded Cranes (*Grus monacha*) for forage resources? *Diversity*, 12, 105. doi:10.3390/d12030105