



Home Range and Habitat Use of the Swan Goose in Western Mongolia

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Abstract. Abstract. The Swan Goose (*Anser cygnoid*) is a large, long-necked species typically inhabiting wetlands, lakes, and agricultural fields. It is characterized by a distinctly bicolored head and neck, dark brown above and tan below, and dark bill. Formerly listed as “Vulnerable” on the IUCN Red List since 1988, the species was reclassified as “Endangered” in 2023 due to increasing threats to its breeding and wintering habitats. While extensive studies have been conducted on the migration routes, strategies, and population trends of breeding geese in Mongolia, research on their habitat use and home range across breeding, wintering, and stopover sites remains limited. In this paper, we present findings on the home range and habitat use of Swan Goose breeding in Western Mongolia. In 2018, we deployed GPS transmitters on five individuals from Uvs and Taigam Lakes. Based on GPS tracking, the average core home range (KDE 50%) was 123.6 km² at the wintering site, 87.7 km² at the breeding site, and 53.3 km² at the stopover site. Tracked Swan Geese spent 66.6% of their time on lakes, 31.5% in the river valleys, and 2% in cropland. There is a significant difference in home range size depending on their breeding and wintering sites. We determined that there is a significant difference in habitat use between breeding, wintering, and stopover sites.

Keywords: Habitat use, core home range, Kernel density estimation.

1 Introduction

The East Asian–Australasian Flyway (EAAF) is one of the world's largest migratory flyways, supporting the seasonal movements of over 50 million migratory birds annually. These birds migrate northward from their wintering grounds in Southeast Asia and Australia to their breeding sites in Russia, China, Mongolia, Japan, the Korean Peninsula, and Alaska, crossing 22 countries. The EAAF is considered the most species-rich of all global flyways. However, populations of waterbirds and shorebirds migrating along this route have been experiencing a significant decline in recent years [1]. One of these migratory waterbirds is the Swan Goose (*Anser cygnoid* Linnaeus, 1758).

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The Swan Goose was listed as "Near Threatened" on the IUCN Red List in 1988 but was listed as "Endangered" in 2023 due to numerous breeding and wintering grounds affected by threats [2]. It is categorized as "Near Threatened" on the Mongolian Red List of Birds [3]. Additionally, it is included in Appendices I and II of the Convention on the Conservation of Migratory Species (CMS).

The global wintering population of the Swan Goose (*Anser cygnoid*) is estimated to be c. 54,400 in recent years, a decline from c. 78,000 in the early 2000s [4]. Significant factors contributing to this decrease in population include hunting, habitat degradation and loss in breeding and molting wetlands, human disturbances, and prolonged droughts caused by adverse climatic conditions [5-6].

This species is endemic to East Asia [4-6]. In Mongolia, the Swan Goose was historically considered a game bird in the 1960s and 1970s. It was once abundant in the country's western regions while occurring in lower numbers in the east. However, during the 1980s, the population in western Mongolia declined while numbers increased in the central and eastern parts of the country. In recent years, eastern and northeastern Mongolia have served as core breeding areas for the species in the region [7]. In Mongolia, studies on the migration routes, strategies, and population dynamics of the Swan Goose have been relatively extensive [4-7]. However, research on habitat use and home range in breeding, wintering, and stopover sites remains limited. Therefore, this study aims to investigate the home range and habitat use of Swan Geese breeding in western Mongolia.

2 Materials and methods

2.1 Study area

In mid-July 2018, we tracked five Swan Geese undergoing flightless molt at Uvs and Taigam Lakes, which are located in their breeding sites in Western Mongolia.

Breeding sites: Uvs Lake (50°18'N 92°42'E) is a large tectonic saline lake located in the northern part of the Great Lakes in western Mongolia and a small part in the Russian locality. Covering an area of 502,462 ha and an altitude of 758-908 m above sea level. Taigam Lake (46°22'N 97°22'E) is a tectonic saline lake in the Delger soum, Govi-Altai province. It covers an area of 4,170 ha and lies at an elevation of 1,780 m above sea level.

Wintering site: Poyang Lake (29°05'N 116°17'E) is largest freshwater lake in China. It covers an area of 312,000 ha and an altitude of 16 m above sea level. The lake serves as a habitat for approximately half a million migratory birds.

Tracking:

The Swan Geese were captured using the funnel drive-trap method [8]. We deployed GSM-based transmitters to each swan goose, ensuring that the transmitters constituted less than 3% of the bird's body size [9]. In mid-July 2018, we tracked five flightless molting Swan Geese from Uvs and Taigam lakes in Western Mongolia. Specifically, one female was from Uvs Lake, and four individuals (one female and three males) were

from Taigam Lake. We used Ornitela 44-gram transmitters manufactured by Ornithology and Telemetry Applications: the body weight of birds was 2310-3260 grams. We collected location data from the transmitters every hour.

2.2 Statistical analyses: Home range

Using the R package 'adehabitatHR' with Kernel Density Estimation (95%, 70%, 50%), we estimated the home range size of the Swan Goose at breeding (early April to end of August), wintering (end of October to mid-March), and stopover sites, using tracking data collected across four seasons between 2018 and 2019. We defined stopover sites as places where the birds rest for at least 48 hours during migration. When calculating the locations, point data from birds flying were excluded. Subsequently, maps were created by QGIS 3.28. To assess differences in home range size at each site (breeding, wintering, and stopover), we used each individual's average home range size to conduct a Chi-squared test using RStudio. We examined differences in home range size between sexes at each site and conducted a Chi-squared test using RStudio.

Habitat use: To calculate the percentage of habitat use, we classified the sites providing GPS coordinates as river valleys, lakes, and cropland. Then, we compared the overall number of GPS coordinates and the number of GPS coordinates in each habitat. We conducted a Chi-squared test to examine variations in habitat use at each site.

3 Result

3.1 Home range

Tracking data from five birds fitted with transmitters ranged between 8,867 and 11,802 points per individual. The overall home ranges averaged at a Kernel Density Estimation (KDE) of 95% were 550.5 km² at wintering sites, 473.3 km² at breeding sites, and 276.1 km² at stopover sites. The core home range, estimated at KDE 50%, averaged 123.6 km² at wintering sites, 87.7 km² at breeding sites, and 53.3 km² at stopover sites (Tab 1).

Table 1. Home range size (KDE 50%, 70%, 95%)

Transmitter ID/ Captured place	Sex	Site	Home range size KDE (km ²)		
			50%	70%	95%
Orni17672/Taigam Lake	Male	Wintering	45	88.8	248.9
		Breeding	21.3	40	116.5
		Stopover	126.9	230.9	619.6
Orni181246/Taigam Lake	Male	Wintering	319.3	552.6	1291.4
		Breeding	79.3	168.4	526.5
		Stopover	2.2	4	12.2
	Female	Wintering	104.5	188.5	447.4

Orni181278/Taigam Lake		Breeding	16.1	30.2	88.1
		Stopover	24.6	49.5	191.2
		Wintering	90.4	164	441.4
Orni181238/Uvs Lake	Female	Breeding	228.8	427.9	1201.5
		Stopover	100.1	185.2	484.9
		Wintering	59	118.2	323.3
Orni181264/Taigam Lake	Female	Breeding	93	170	434
		Stopover	13	23.7	72.7

The average core home range of Swan geese was largest in the wintering site (123.6 km²) and smallest in the stopover site (53.3 km²). At the breeding site, the average core home range was 87.7 km². We determined that the core area of the wintering site is larger than the breeding and stopover site’s core area. There was a statistically significant difference between the core home range size of breeding, wintering, and stopover sites ($\chi^2= 30.33$, $df = 2$, $p<0.001$) (Fig 1).

Female geese have a larger core area (112.6 km²) than males (50.3 km²) during the breeding season, while males (182.1 km²) have a larger core area than females (84.6 km²) during the wintering site. In the stopover site, the core home range of males was 64.5 km², and the core home range of females was 45.7 km². There was a statistically significant difference between the sexes at breeding and wintering sites ($\chi^2 = 23.8$, $df = 1$, $p < 0.001$), ($\chi^2 = 35.6$, $df = 1$, $p < 0.001$). In addition, there is no statistical difference between the core areas of female and male geese at the stopover site ($\chi^2 = 3.2$, $df = 1$, $p=0.072$) (Fig 1).

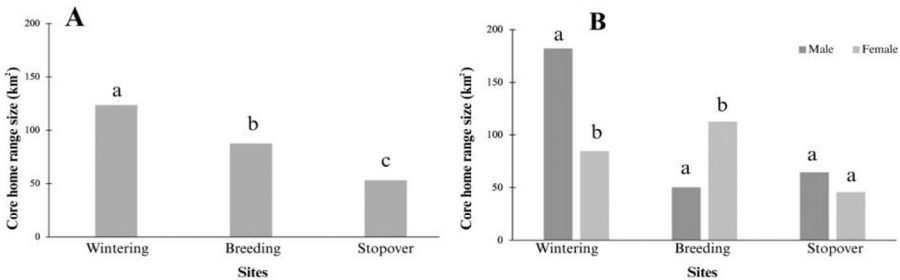


Fig. 1. **A.** Home range size (KDE 50%) at each site (wintering, breeding, stopover). **B.** Home range size (KDE 50%) of male and female birds at each site (wintering, breeding, stopover). Columns with different letters (a, b, c) indicate significant differences.

During their breeding season, the tracked birds occupied the nearby Uvs, Taigam, Gegeen Lakes, and Zavkhan River. All birds stayed at Poyang Lake during winter. While migrating to Poyang Lake, Geese used several stopover sites (Figs 2-5).

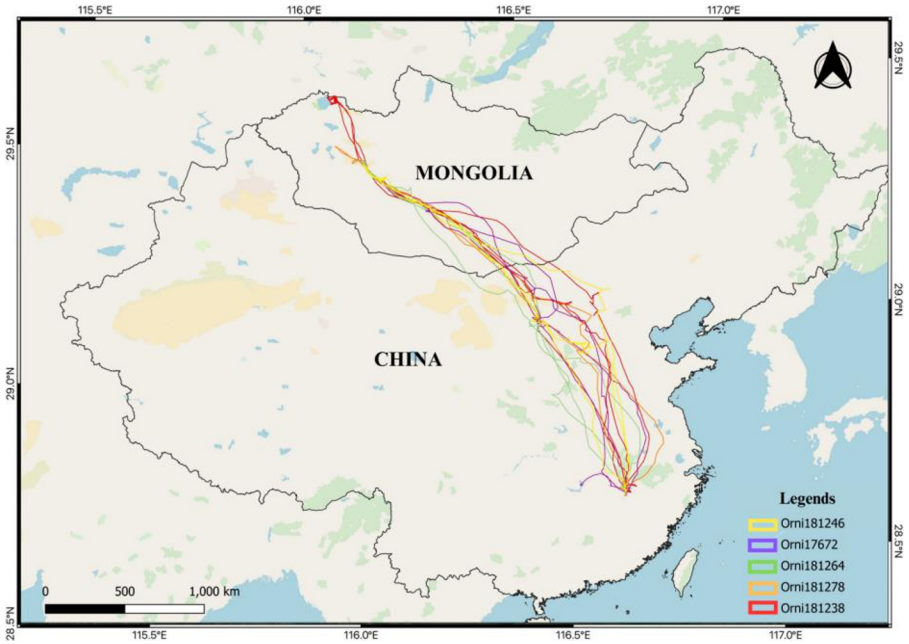


Fig. 2. Migration route from breeding sites in Mongolia to wintering sites in China

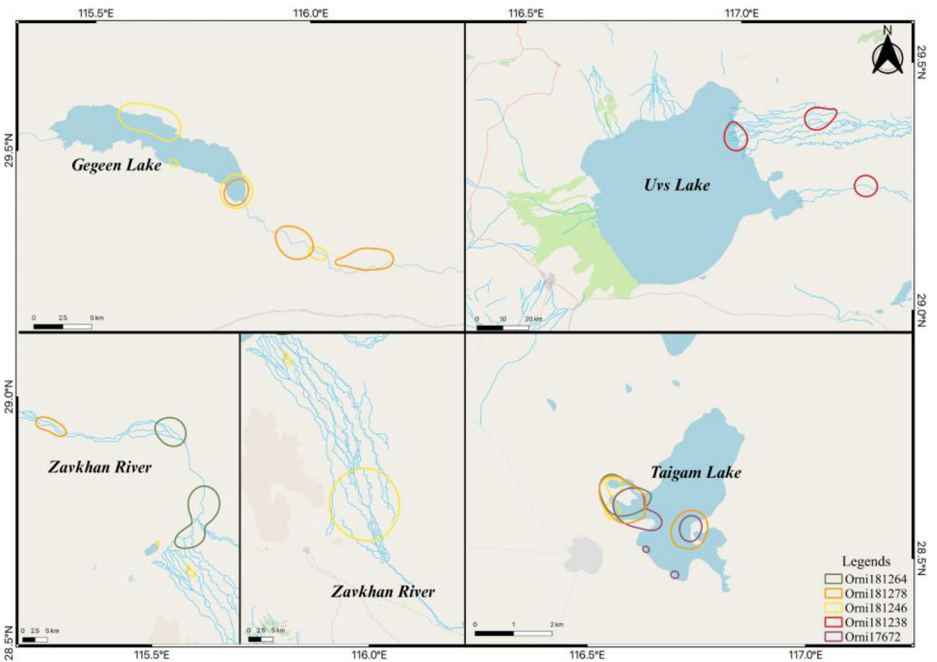


Fig. 3. Home range estimation using kernel density estimation (KDE 50%) for each individual at the breeding site (Mongolia).

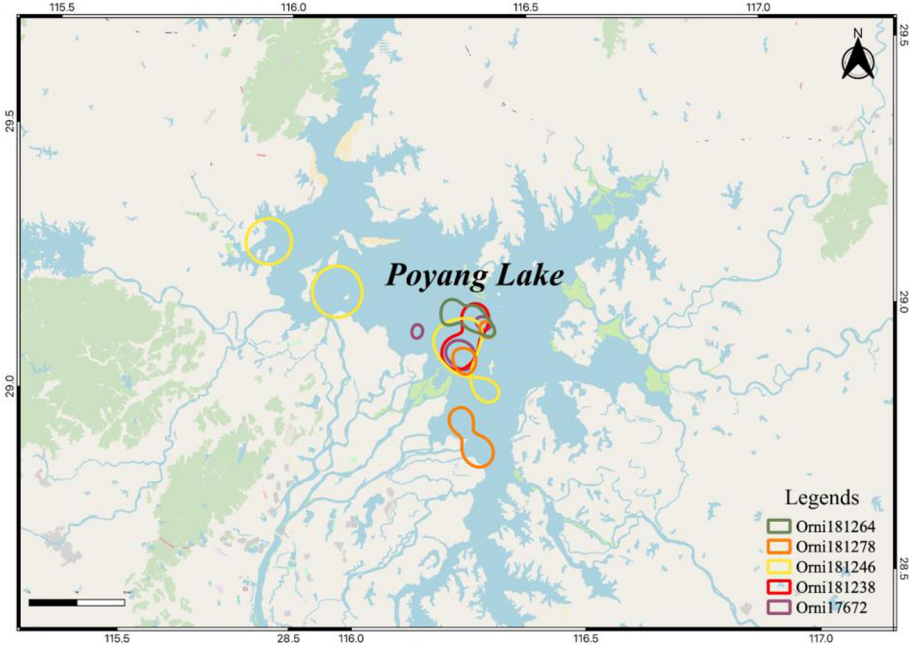


Fig. 4. Home range estimation using kernel density estimation (KDE 50%) for each individual at the wintering site (China).

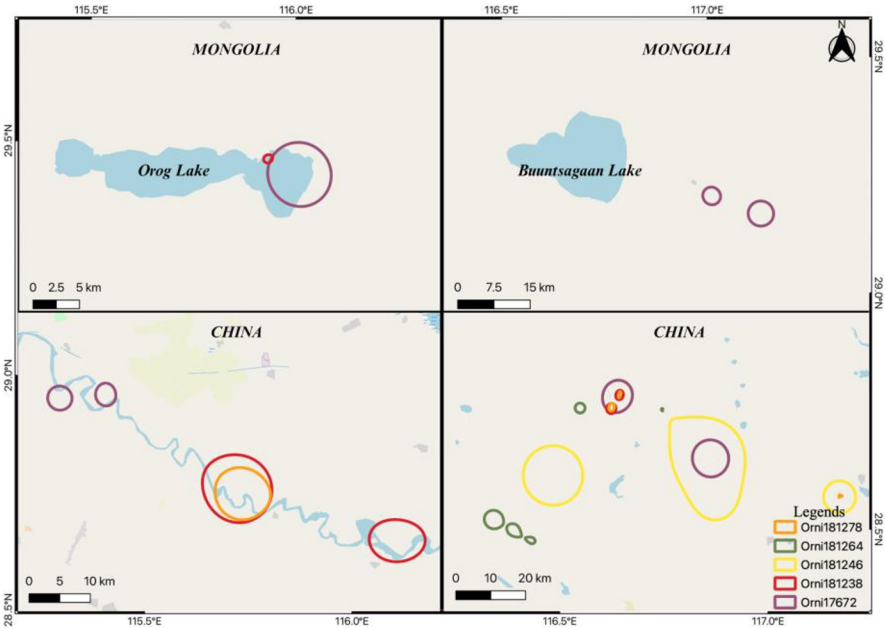


Fig. 5. Home range estimation using kernel density estimation (KDE 50%) for each individual at stopover sites (Mongolia and China).

3.2 Habitat use

We determined that the tracked Swan Geese spent 66.6% of their time in the lake, 31.4% in river valleys, and 2% in cropland. Depending on the wintering and breeding sites, habitat use was significantly different ($\chi^2=16892$, $df=2$, $p<0.001$). Swan Geese spent 55.4% of their time in river valleys and 44.6% in lakes at the breeding site. At the wintering site, they spent 99.2% of their time in lakes, 0.025% in river valleys, and 7.5% in cropland (Fig 5).

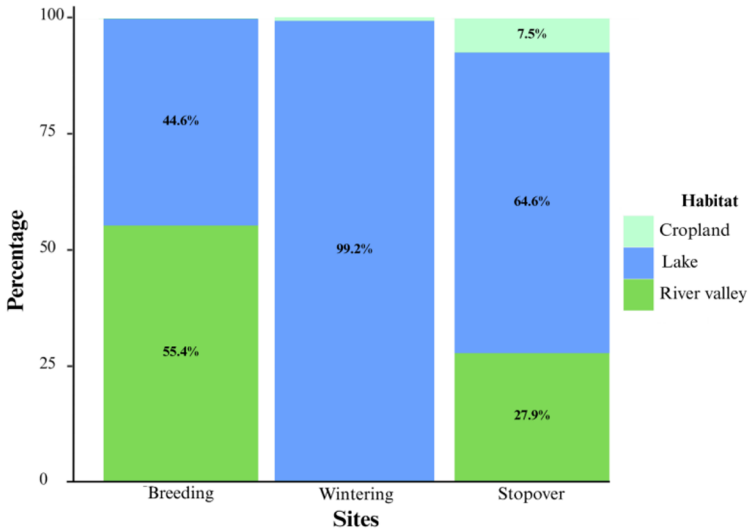


Fig. 6. Habitat use of birds

4 Discussion

Home range: Based on our study, the average core home range size of the Swan Goose varied by seasonal habitat, measuring 123.6 km² in wintering sites, 87.7 km² in breeding sites, and 53.3 km² in stopover sites. A study published in 2022 reported that the core home range (KDE 50%) of wintering Swan Geese in South Korea was, on average, 0.7 km² [10]. In this study, 270 to 1,030 GPS locations per year were used for each of the three tracked individuals. In contrast, N.Batbayar et al [5] reported a core home range (KDE 50%) of 60 km² for the five individuals wintering at Poyang and Fengsha Lakes. Compared to our findings, these discrepancies may be attributable to differences in the number of GPS locations used. Over a two-year tracking period, each of the five Swan Geese yielded between 1,720 and 4,721 GPS locations. Kernel density estimation is commonly used to estimate home range size based on GPS locations. Therefore, discrepancies from other studies may be attributable to differences in the number of GPS locations used. The size of core home ranges at wintering sites may also correlate with

the surface area of the wetlands. In our study, four tagged individuals spent their summer (breeding season) at Taigam Lake (surface area: 41.7 km²), with their home range sizes ranged from 16 km² to 93 km².

In contrast, one individual (Transmitter ID: Orni181238) spent the summer at Uvs Lake (surface area: 5,024.6 km²) and exhibited a substantially more extensive home range of 228.8 km². Similarly, a tracked Swan Goose wintering at Poyang Lake, China (surface area: 3,120 km²), had a home range size ranging from 45 km² to 319.3 km². Furthermore, Swan Goose populations were separated into continental and coastal groups [4]. The individuals we tracked belong to the continental population, whereas those studied by S.Joo et al. [10] were from the coastal population.

As a result of our study, females have a more extensive home range in breeding sites, and males have a more extensive home range in wintering sites. Although this has not been reported previously, a study on bar-headed geese (*Anser indicus*) in China found that females had more extensive home ranges during the breeding season [11]. Additionally, studies on Snow Geese (*Anser caerulescens*) have shown that females spend 75% of their daily time foraging before egg-laying, compared to 44% in males [12]. During this time, males increase vigilance while females focus on food intake. This suggests that female Swan Geese may need more extensive breeding home ranges to find sufficient food for egg-laying and chick-rearing.

Meanwhile, in wintering sites, males might require more extensive home ranges because of higher movement and energy replenishment, as male Snow Geese are known to reduce foraging and increase vigilance during the breeding season [12].

Habitat use: Our study results show that Swan Geese spent 55.4% of their time in river valleys and 44.6% in lakes at breeding sites. During the wintering season, they spent 99.2% of their time in lakes, 0.025% in river valleys, and 0.7% in croplands. In stopover sites, 64.6% of the time was spent in lakes, 27.9% in river valleys, and 7.5% in cropland. Research by C.Wang et al. Swan Goose habitat and conservation issues reported that Swan Geese spent 96.7% of their time in lakes, and 3.1% in bare land at wintering sites. At breeding sites, they spent 50.2% of their time in grasslands and 31.4% in wetlands. At stopover sites, they 44% of their time in wetlands and 35% in grasslands [13]. Furthermore, the coastal population bird of Swan Goose that breeds in South Korea mainly uses tidal flats (74.4%) and paddy fields (15.6%) [10]. These findings show the importance of wetlands and grasslands for birds of the coastal population of Swan Goose.

5 Conclusion

- We determined that the home range of the Swan Geese in wintering sites is larger than the home range of the breeding and stopover sites.
- There is a significant difference in home range size depending on their breeding and wintering sites. During the breeding season, females have a more extensive home range than males. Nevertheless, males have a more extensive home range than females in wintering sites. In stopover sites, there is no significant difference in home range between males and females.
- There is a significant difference in habitat use between breeding, wintering, and stopover sites.

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