Population trends and distribution of the Lesser Snow Goose *Anser caerulescens caerulescens* in Japan, based on 50 years of monitoring

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Abstract

Populations of the Lesser Snow Goose *Anser caerulescens caerulescens*, which historically bred and wintered in East Asia, declined from the 1800s and were almost extinct by the 1890s. In 1993, the "Restoration of Lesser Snow Goose to East Asia Project" was implemented, through cooperation by organisations from Japan, Russia and the United States of America. Since initiation of the project, Snow Geese have been regularly recorded in Japan, and numbers staging or wintering in Japan are still growing. Here, we study the population trends and distribution of Snow Geese wintering in Japan from 1971/72 (before the project commenced) to 2023/24. The mean (± s.d.) number of birds recorded in Japan over the last five winters (2019/20–2023/24) was 1,634 ± 196 geese, suggesting that a regular wintering population has become established in the country. We also collated information on colour-marked individuals. Geese marked in Anadyr (Russia) during the restoration project were found in Japan in subsequent years, suggesting that migratory traditions were also re-established. The extent to which the recent population increase recorded for Snow Geese in Japan was derived from the restoration project however remains unclear, because the exact location of the breeding grounds and migration routes of the Japanese-wintering birds are still unknown. Further studies (*e.g.* GPS tracking) therefore are required for a full evaluation of the success of this conservation initiative.

Key words: conservation translocation, migration, reintroduction, Russia, wintering population.

Translocation of birds to their original habitat for population restoration purposes has been used as a conservation measure for several goose species when populations in a certain area have severely declined or become locally extinct (Byrd & Springer 1976; Black *et al.* 1991; von Essen 1991; IUCN 1998; Kurechi & Sugawa 2021). Such

a conservation translocation programme has also been implemented for Lesser Snow Geese *Anser caerulescens caerulescens* (hereafter Snow Geese) over the past 30 years, with the aim of restoring the wintering population in East Asia (Sabano *et al.* 1996). Snow Geese breed from Wrangel Island, Russia to the north coast of Alaska and the Canadian Arctic, with the majority migrating to winter in the mid-latitude regions of North America (del Hoyo *et al.* 2014). The population which formerly wintered in East Asia was thought to breed in the continental parts of northeast Siberia, but this declined drastically from the early 1800s, possibly as a result of overhunting and habitat degradation by grazing Reindeer *Rangifer tarandus* (Takekawa *et al.* 1994). By the 1890s, the population wintering in Japan had almost disappeared, and only a few individuals were subsequently recorded as irregular visitors until the 1980s (Sabano *et al.* 1996; Ministry of the Environment Japan 2014). In 1993, the Japanese Association for Wild Geese Protection, in collaboration with the Russian Academy of Sciences, the United States National Biological Survey (now the U.S. Geological Survey) and other organisations therefore established the "Restoration of Lesser Snow Geese to East Asia Project", with the aim of restoring the breeding and wintering populations of Snow Geese in East Asia (Takekawa *et al.* 1994; Sabano *et al.* 1996).

Conservation translocation projects for migratory birds have explored several methodologies to establish desired migratory behaviour, such as using ultralight aircraft (Lishman *et al.* 1997), pairing captive-bred birds with wild birds that have experienced migration (Mini *et al.* 2013), and cross-fostering, wherein the eggs/goslings of the target species are exchanged with those of other species that share the same migration route (von Essen 1991). During the Snow Geese restoration project, the cross-fostering method and release of captive-reared chicks were implemented (Sabano *et al.* 1996). Thus in June 1993, 100 Snow Goose eggs were transported from the breeding population on Wrangel Island to Anadyr, Russia – breeding grounds of the Greater White-fronted Goose *Anser albifrons*, which is known from sightings of colour-marked individuals to migrate to Japan (S. Uemura, unpubl. data). All eggs in six Greater White-fronted Goose nests were replaced with 41 Snow Goose eggs, so that the Greater White-fronted Geese would act as foster-parents for hatching and subsequent migration to the wintering grounds. The remaining 59 Snow Goose eggs were kept in an incubator, where 45 hatched, and 43 goslings which survived to 30-days-old were fitted with blue-coloured plastic rings on their left legs before being released onto Kayak Lake, Anadyr, which is a moulting site used by Greater White-fronted Geese (Sabano *et al.* 1996). Following the initiation of the project, Snow Geese have regularly been recorded in Japan from winter 1993/94 onwards (Ministry of the Environment Japan 2014), and numbers staging and wintering in Japan have grown (Nishide & Ogasawara 2013; Matsubara & Mikami 2015; Ministry of the Environment Japan 2020).

In this study, we describe long-term trends in the numbers of Snow Geese wintering in Japan, over the past 50 years,

including periods before and after the start of the restoration project, and consider re-sightings data of colour-marked individuals, individually identified by observers reading the codes on their leg rings, to evaluate whether the restoration project contributed to the establishment of a Snow Geese population in Japan. Furthermore, we compiled count data for the locations used by the birds from autumn until the spring migration, to confirm the distribution and status of this species in Japan.

Methods

Reports of Snow Geese observed from winters 1971/72 to 2023/24 were collected from researchers, birdwatchers and members of the Japanese Association for Wild Geese Protection (established in 1970; 412 members as of April 2024), including the date, location, number of birds, age, colour/code for any leg rings and their social behaviour, such as whether the geese formed a family group. Records were collected from 372 people in 15 geographical regions (Fig. 1).

The number of birds recorded was tallied for each 10-day period within a month (early in the month = days 1–10; mid-month = days 11–20; late in the month = days 21–31). Numbers in each region were then summed to obtain the national population size estimate, with possible repeat counts (caused by the movement of some flocks during the survey) being excluded from the total. If a population increased rapidly in one area and decreased by the same amount in another area during the same 10-day period, the higher number was adopted and records with lower numbers were not included in the total count. The maximum number recorded during December–January was taken as the peak count for each winter.

Birds were recorded as adult or juvenile on the basis of their plumage characteristics, or (if observed over a long distance) as of unknown age. Juveniles were distinguished by their overall greyish plumage, which contrasted with the pure white of adult geese (Kear 2005). The percentage of juveniles was calculated as the observed number of juveniles divided by the total number of juveniles and adults that were aged (*i.e.* excluding unknown individuals). Total numbers of adults and juveniles wintering in Japan were then estimated from the numbers counted, adjusted according to the percentage of juveniles recorded. Whether increases in numbers wintering in Japan were attributable to the breeding success (number of juveniles) in the population that year was determined by a Pearson correlation analysis of the population increase rate (*i.e.* the number counted in the current year/ the number in the previous year) in relation to the percentage of juveniles recorded in that year, using data from 2003/04 winter onwards when numbers counted exceeded 10 individuals for the first time. Sightings records of colour-marked individuals were collected, with a focus on the 43 goslings marked with blue plastic leg rings in Anadyr, Russia in August 1993, during the Snow Goose restoration project (Takekawa *et al.* 1994). Other colour-marking information was also gathered regardless of the area where they were ringed, such as on Wrangel Island in the Russian arctic.

Additionally, data on the numbers and location of Snow Geese in 15 Japanese regions recorded during the five most recent

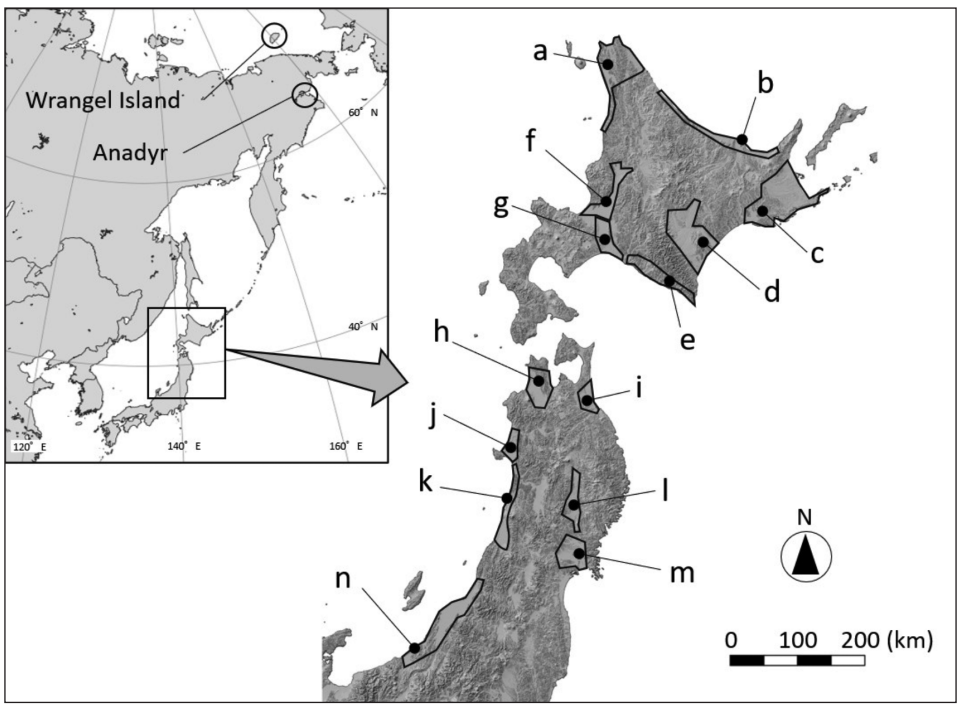

Figure 1. Location of Wrangel Island and Anadyr, Russia, where Snow Goose eggs were collected and eggs/goslings were released under the restoration project (lefthand map), and the geographical survey region where Snow Geese were seen wintering in Japan (righthand map). Locations: a = Sarobetsu/Wakkanai, b = Okhotsk, c = Konsen Plateau, d = Tokachi Plain, e = Hidaka, f = Ishikari River Basin, g = Chitose River Basin, h = Tsugaru Plain, i = Ogawahara Lake, j = Hachiro-gata, k = Akita/Yurihonjo, l = Kitakami River Basin, m = Sendai Plain, and n = Asahi-ike/Niigata Plain. Areas other than those listed above were regarded as "other areas" in Supporting Materials Table S1.

years (*i.e.* from 2019/20–2023/24 inclusive) were compiled for autumn (September–November), mid-winter (December–February) and spring (March–May), to describe seasonal variation in the distribution of the species wintering in Japan.

Results

Population trends

The number of wintering Snow Geese recorded from 1971/72 to 2023/24, and the percentage of juveniles since 1993/94, are shown in Fig. 2 (see also Appendix 1). In the decades before the restoration project started in summer 1993, Snow Geese did not winter regularly in Japan, and only 1–2 individuals were recorded sporadically (Fig. 2). In the subsequent wintering season, in 1993/94, a total of four birds (one adult and three juveniles) were recorded in Japan. Two of the juveniles were observed separately in the Sarobetsu/Wakkanai area (location "a" in Fig. 1) from early and mid-October, and

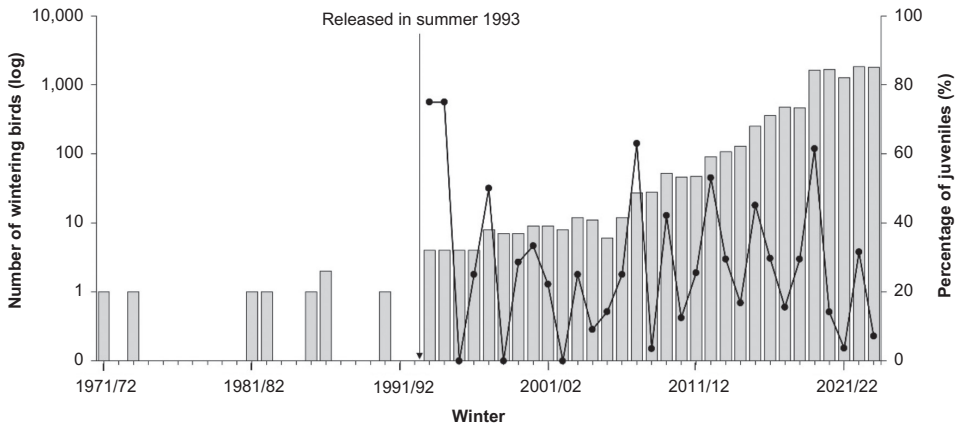

Figure 2. Number of wintering Snow Geese counted in Japan from 1971/72–2023/24 (bars) and the percentage of juveniles recorded since 1993/94 (line).

the third juvenile observed at the same time in Katano-kamoike (in Ishikawa Prefecture, Japan) from early October to mid-December. Although this third bird stayed with a flock of Greater White-fronted Geese, it did not follow specific individuals within this flock. These three juveniles spent mid-winter in Hachiro-gata (j), Sendai Plain (m) and Asahi-ike/Niigata Plain (n). The adult bird was also observed in Sendai Plain (m), from early to mid-December.

In the winters following 1993/94, several Snow Geese were regularly recorded in Japan. A group of one adult and three juveniles staying together in the same flock was seen in 1997/98 and was thought to be a family group. The number of wintering geese continued increasing and exceeded 10 in 2003/04, 50 in 2009/10 and 100 in 2013/14 (Fig. 2, Appendix 1). A sharp increase was recorded from 461 birds in 2018/19 to 1,635 in 2019/20, and > 1,000 birds continued to winter in Japan each year from 2020/21 (1,667 birds) to 2023/24 (1,777; Appendix 1). The mean (± s.d.) number of wintering birds in the most recent five years (2019/20 to 2023/24) was 1,634 ± 196 individuals.

The percentage of juveniles differed among years and averaged 26.7 ± 24.7% juveniles (range = 0–75.0%, Fig. 2). There was a positive association between the percentage of juveniles and the percentage increase in numbers counted from one year to the next (Pearson correlation: $r_{19} = 0.83$, $P < 0.001$; Fig. 3). The tipping point of percentage of juveniles (calculated from regression line, y = 3.154x + 57.904) at which the population increase rate exceeds 100% was 13.3%. When the highest population increase rate (355%) was recorded, between 2018/19 (461 individuals) and 2019/20 (1,635), the percentage of juveniles was also high, accounting for 61.4% of the population in 2019/20. Nonetheless, incoming adults must also have contributed to the total number counted in that winter.

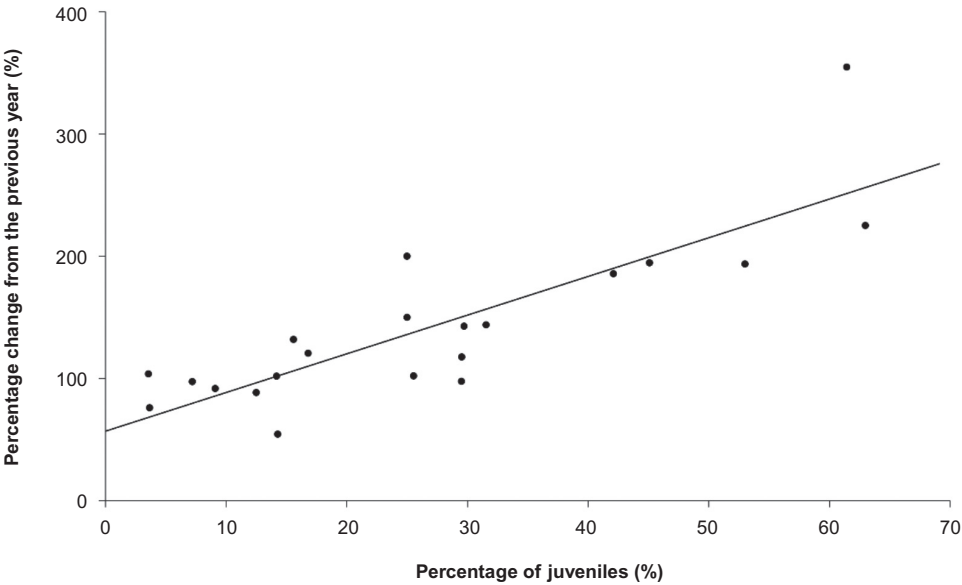

Figure 3. Correlation between the percentage change from the previous year and the percentage of juveniles recorded each winter, from 1993/94–2023/24.

Observations of colour-marked individuals

Of the 43 Snow Geese ringed in the Russian arctic as part of the restoration programme in summer 1993, two individuals were subsequently seen wintering on the East Asian-Australasian flyway, on a total of five occasions, and a third bird not associated with the project was also recorded (Table 1). The goose with blue leg ring code N76, released in Anadyr during the restoration project, was recorded at Katano-kamoike, Ishikawa, Japan, over four seasons from 1995/96 to 1998/99. However, it was recorded as being alone in all these years. Blue N58 was identified in Cholwon, South Korea in December 1997. In addition, a juvenile with white ring CLE fitted on Wrangel Island, Russia in July 1997 for a separate project, was found in a family group consisting of one adult and three juveniles at various sites in Japan during 1997/98 (Table 1).

Distribution within Japan from 2019/20 to 2023/24

The average of the maximum numbers of Snow Geese counted in each region during autumn, mid-winter and spring was calculated for the five most recent winter seasons. During autumn migration, the geese arrive at Tokachi Plain from mid-October to early November (mean ± s.d. = 1,194 ± 235) and reach Hachiro-gata in mid- to late November (1,622 ± 315), staging on the Tsugaru Plain (238 ± 178; Fig. 4). The main wintering area was Hachiro-gata, which supported on average 1,630 (± 297) geese.

Table 1. Ringing and re-sighting records of colour-marked Snow Goose, identified by their ring codes, seen wintering on the East Asian-Australasian flyway.

Ring colour	Ring code	Re-sighted		Ringing site	
		Date	Location	Date	Location
Blue	N76	4 Oct 1995–7 Mar 1996 3 Oct 1996–10 Mar 1997 29 Oct 1997–10 Mar 1998 5 Nov 1998–5 Mar 1999	Katano-Kamoike, Ishikawa Prefecture, Japan (36°19'N, 136°17'E)	2 Aug 1993	Kayak Lake, Anadyr, Russia (64°12'N, 178°10'E)
Blue	N58	23–24 Dec 1997	Cheorwon, Republic of Korea (38°18'N, 127°25'E)	2 Aug 1993	Kayak Lake, Anadyr, Russia (64°12'N, 178°10'E)
White	CLE	25 Oct 1997–19 Feb 1998	Tokachi, Hokkaido Prefecture, Japan (42°49'N, 143°37'E) Otomo-numa, Akita Prefecture, Japan (40°11'N, 140°04'E) Hachirogata, Akita Prefecture, Japan (40°01'N, 139°60'E) Fukushimagata, Niigata Prefecture, Japan (37°55'N, 139°15'E) Asahi-ike Niigata Prefecture, Japan (37°14'N, 138°22'E)	28 Jul 1997	Wrangel Island, Russia (71°27'N, 179°56'E)

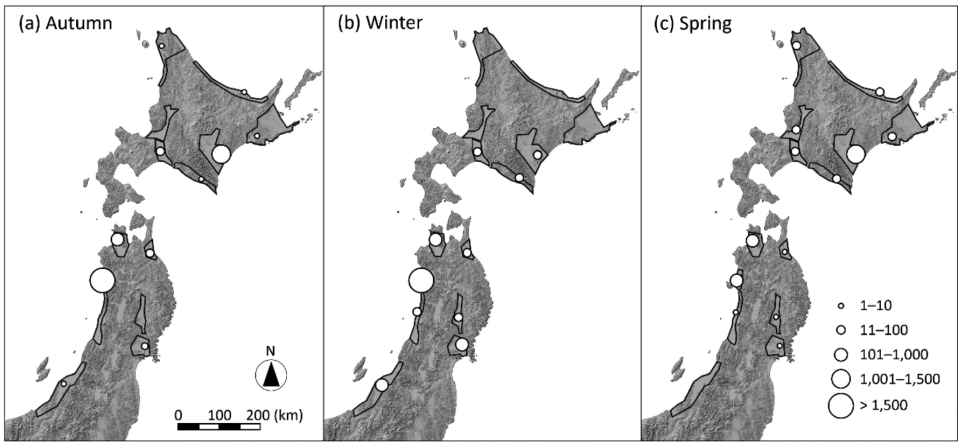

Figure 4. Distribution of Snow Goose in Japan in winters 2019/20–2023/24. Autumn = September–November; winter = December–February; spring = March–May. Circle sizes represent the average of the maximum number of wintering individuals recorded each year over the 5-year period.

The geese also stayed at Hidaka (92 ± 57) and Sendai Plain (158 ± 134). Asahi-ike/Niigata Plain was a refuge for a short period during mid-winter (342 ± 337). During spring migration, the geese stage at Tsugaru Plain in March (768 ± 486) and subsequently at Tokachi Plain in April (1,373 ± 244). They usually leave Japan in early May. Details of the numbers of Snow Geese recorded in each region from 2019/20–2023/24 inclusive are provided in the Supporting Materials (Table S1).

Discussion

Establishment of wintering populations in Japan and migration tradition

Before the restoration project commenced, the Snow Goose was an irregular visitor to Japan, with only a few individuals wintering in the country during the mid-20th century. However, following initiation of the project in 1993, Snow Geese have become regular winter visitors, with numbers first exceeding 10 birds in 2003/04, 100 in 2012/13, and over 1,000 in 2019/20. Since then > 1,000 individuals have been recorded each winter up to and including 2023/24, suggesting that there is now a regular wintering population established in Japan.

As part of the restoration programme, 43 colour-marked goslings were released onto Kayak Lake, Anadyr (Takekawa *et al.* 1994; Sabano *et al.* 1996), of which only one individual ("blue N76") was subsequently seen in Japan, but it visited for four successive seasons from 1995/96–1998/99. This provided direct evidence that a released individual from the restoration project had learned the traditional migration route. In contrast, goslings hatched from 41 eggs that were used for cross-fostering were not fitted with colour markings, so the fate of these birds is unknown. Soon after the start of the restoration project in summer 1993,

however, three juveniles were found wintering in Japan in 1993/94. Although we do not know whether these originated from the cross-fostering programme, it was the first time that several juveniles has wintered in Japan since 1971. In Sweden, similar restoration projects for Lesser White-fronted Geese *Anser erythropus* were implemented using Barnacle Geese *Branta leucopsis* as foster parents to teach migratory traditions, and 172 birds were released in Lapland, Sweden between 1981 and 1988, of which 60 (34.9%) were found to have migrated as far as Western Europe (von Essen 1991). We did not investigate the hatching rate and breeding success under cross-fostering for Snow Geese, but the fact that three juveniles wintered in Japan during 1993/94 does support the possibility that individuals raised by foster parents may have learned the migratory routes to East Asia. It should however be noted that information on the breeding sites for Snow Geese wintering in Japan remains unknown. At Velikava River (63.85°N, 176.0°E), 100 km southwest of Kayak Lake in the Anadyr lowlands, where the 43 captive-reared goslings were released in 1993, two family groups (including one bird with a blue leg ring, code unknown), successfully bred in summer 1996 (A.V. Andreev, unpubl. data). Additionally, *c.* 10 Snow Geese were observed at Kayak Lake in July 2007 (T. Ikeuchi, pers. comm.), but no breeding colonies of Snow Geese have been confirmed for the Anadyr lowlands (data up to 2023, from Working Group on Anseriformes of Northern Eurasia 2024).

While the origin of the wintering population in Japan has yet to be determined, it was suggested that their higher fecundity on the breeding grounds might at least partly account for the population growth (Weegman *et al.* 2022), and this is supported by the positive correlation between the percentage of juveniles and the increase in numbers compared with the previous year. The global populations of Snow Geese have shown an overall increasing long-term trend from the 1970s to 2015 (CAFF 2018). The Wrangel Island population (where a colour-marked Snow Goose was ringed in summer 1997, then migrated to Japan that autumn; Table 1) declined in the early 1990s, but subsequently increased from the late 1990s onwards (Baranyuk & Babiy 2020; Olson 2023). When the number of birds wintering in Japan increased rapidly from 461 in 2018/19 to 1,635 in 2019/20, with a 61.4% juvenile ratio and 355% change in the year-on-year population size, the reproductive success of the geese on Wrangel Island in 2019 was also high with the juvenile ratio in flocks just before autumn migration reaching 46.7% (Baranyuk & Babiy 2020). It is also possible that the emigration of adults occurred in certain years; for example, the number of adults in 2019/20 (630) exceeded the total number (including both adults and juveniles) of the previous year (461), suggesting that at least 169 adults emigrated from other wintering areas to Japan (Appendix 1). This was most likely from the wintering population in North America, as we have had several blue morph Snow Geese in recent years (Appendix 1), some of which may have paired with Japanese-wintering geese in the breeding range. In addition, an abundant food supply may have

promoted settlement at wintering habitats in Japan, where the amount of waste rice in fields has increased with the intensification of agriculture since the late 1990's (Shimada 1999, 2002). This is also thought to have contributed to the increased number of Greater White-fronted Geese wintering in the country (Shimada 2009). The increase in the Snow Goose population in Japan therefore is considered as a result of several factors, including both higher breeding success and emigration from other wintering areas, though further understanding of its origin and ongoing development is needed through tracking studies and DNA analysis.

Wintering status in Japan

Most of the Snow Geese wintering in Japan are concentrated in just a couple of regions throughout the season. During autumn and spring migration, nearly 1,000 birds stage on the Tokachi Plain, and subsequently on the Tsugaru Plain, whilst < 100 birds were recorded in other areas. Over 1,500 geese were counted in Hachiro-gata during mid-winter, with only small numbers at the Sendai Plain, Tokachi Plain and Hidaka at this time, although the Asahi-ike/Niigata Plain (in southern Japan) appeared to be used as a mid-winter refuge in response to changing weather conditions, such as snow cover and low temperatures on the wintering grounds (Shimada & Ueda 2006; Sawa *et al.* 2020).

According to the criteria described for identifying internationally important habitats for waterfowl (Wetlands International 2024), sites that support ≥ 1% of a regional population are regarded as being of internationally importance for a species. For the Snow Goose in Japan, whilst the 1% threshold for the East Asian population is currently put at six birds (Wetlands International 2024), the latest criteria would be 16 birds on applying the recent five-year population estimate described in our study (1,634 birds), and all 14 regions each regularly support > 16 birds. Although some of the major sites for Snow Geese (*e.g.* such as Hachiro-gata and Sendai Plain) are protected under the Ramsar Convention and/or as flyway network sites of the East Asia–Australasian Flyway Partnership (Ministry of the Environment Japan 2015), we still need to identify the specific habitats used by Snow Geese in each area and the conservation status of these habitat should be reviewed according to their importance for the species. Given that the Snow Goose is not listed as a huntable species in Japan, it is likely that direct threats related to mortality would be low, and it is possible that high survival rates during the wintering period may have contributed to the observed population growth. However, numerous wind farms have been planned and installed close to protected areas, which represent a growing new threat to waterfowl, including the Snow Goose (Rees 2012; Ura 2015; Marques *et al.* 2021).

Conclusion

We conclude that a regular wintering population of Snow Geese has become established in Japan. The re-sighting of an individual colour-ringed during the restoration project in 1993 provides direct evidence that individuals from the project

have learnt the traditional migration routes between the breeding and wintering areas. That Snow Geese were regularly seen in Japan from 1993/94 onwards also suggests that the restoration project contributed to some degree to the establishment of the wintering population. However, the breeding grounds and the origin of the Japanese-wintering Snow Geese remain unknown, and the extent to which the increase in numbers was a direct consequence of the restoration project is unclear. To identify the breeding grounds and plot the entire migration route, further research – particularly the use of GPS transmitters to track the individual movements, and also DNA analysis – are required. Furthermore, given the increase in the wintering population, it is important that the monitoring surveys be continued, to identify potential threats and promote conservation of goose habitat into the future.

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Photograph: Snow Geese in typical habitat for the species in Japan (*i.e.* rice fields), where they usually occur with Bean Geese, by Toshio Ikeuchi.

Appendix 1. The number of Snow Geese observed in Japan.

Winter	Total no. of geese	Proportion of juveniles (%)	No. aged		Notes
			Adult	Juvenile	
1971/72	1	0%	1	0	
1972/73	–	–	–	–	
1973/74	1	0%	1	0	
1974/75 to 1980/81	–	–	–	–	
1981/82	1	0%	1	0	
1982/83	1	0%	1	0	
1983/84	–	–	–	–	
1984/85	–	–	–	–	
1985/86	1	100%	0	1	
1986/87	2	50%	1	1	
1987/88 to 1989/90	–	–	–	–	
1990/91	1	0%	1	0	
1991/92	–	–	–	–	
1992/93	–	–	–	–	
1993/94	4	75%	1	3	Restoration project was implemented in summer 1993.
1994/95	4	75%	1	3	
1995/96	4	0%	4	0	Marked individual blue "N76" was observed.
1996/97	4	25%	3	1	Marked individual blue "N76" was observed.
1997/98	8	50%	4	4	Marked individuals blue "N76" and white "CLE" were observed. A family group was recorded for the first time.
1998/99	7	0%	7	0	Marked individual blue "N76" was observed.
1999/00	7	29%	5	2	
2000/01	9	33%	6	3	Two family groups were recorded for the first time.
2001/02	9	22%	7	2	
2002/03	8	0%	8	0	
2003/04	12	25%	9	3	

Appendix 1 (*continued*).

Winter	Total no. of geese	Proportion of juveniles (%)	No. aged		Notes
			Adult	Juvenile	
2004/05	11	9%	10	1	
2005/06	7	14%	6	1	
2006/07	12	25%	9	3	First observation of a blue morph Snow Goose (Sabano *et al.* 2012).
2007/08	27	63%	10	17	
2008/09	28	4%	27	1	
2009/10	52	42%	30	22	
2010/11	46	13%	40	6	
2011/12	47	26%	35	12	
2012/13	91	53%	43	48	
2013/14	107	30%	75	32	Number counted > 100 for the first time.
2014/15	139	17%	116	23	One adult blue morph goose recorded.
2015/16	251	45%	138	113	
2016/17	358	30%	252	106	
2017/18	472	16%	398	74	
2018/19	461	30%	325	136	
2019/20	1,635	61%	630	1,005	Numbers counted > 1,000 for the first time. One juvenile blue morph goose recorded.
2020/21	1,667	14%	1,431	236	One adult blue morph goose recorded.
2021/22	1,268	4%	1,222	46	One adult blue morph goose recorded.
2022/23	1,823	32%	1,248	575	Two adults and three juveniles blue morph geese recorded.
2023/24	1,777	7%	1,649	128	Five adults and five juveniles blue morph geese recorded.