Health Risk Analysis

Spoon-billed Sandpiper (*Calidris pygmea*) Headstarting Project in Meinypil'gyno, Chukotka

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Executive Summary

This Health Risk Analysis (HRA) aims to identify and review critical health vulnerability points for Spoon-billed sandpiper (*Calidris pygmaea*) (SBS) in the headstarting (HS) programme in Russia. It builds on established principals of HRAs from other WWT HS projects (e.g. Black-tailed godwit (*Limosa limosa limosa*) HS in Norfolk (United Kingdom), Beckmann, K. *et al.,* 2017 and Eurasian curlew (*Numenius arquata*) Dartmoor Recovery Project, Lopez, R. 2023), recommended translocation guidelines (e.g. Lee, R *et al.* 2012) and lessons learned from the SBS HS programme conducted 2012-2021 and WWT's SBS conservation breeding programme operational 2011 - 2024.

This HRA was compiled twelve (12) years after the SBS HS programme began in 2012 and thirteen (13) years after SBS conservation breeding management began at WWT Slimbridge, Gloucestershire, United Kingdom. Therefore, apart from the preparations for the initial conservation breeding project in 2011, this HRA also incorporates updated protocols and health hazards that were identified more recently. This ensures it's relevance to the current knowledge of HS practices for the species and the current epidemiological landscape.

Disease threats to wildlife populations, zoonotic risks and how these overlap with translocated SBS are covered herein. The exploration of hazards (infectious and non-infectious) mentioned at different stages of the HS process is intended to structure and prioritise management actions and biosecurity measures. These efforts will contribute to the overall success of the Chukotka-based HS programme and serve as a reference for other similar HS projects in the area.

From an epidemiological perspective emerging novel pathogens are ever occurring. Specific importance is given to the new Eurasian strains of highly pathogenic avian influenza virus (HPAIV) which caused global mass mortalities in avian species and mortalities in mammalian species including human beings from 2020 to 2024. The evolving dynamics of HPAIV means health and safety regulations and limitations need to be considered particularly when positive cases occur in the surrounding areas of any HS project. This could entail following obligatory HPAIV screening regimes by the relevant authorities and not only routine screening before release, as currently practiced at some locations, stricter quarantine measures, limitations on egg collection, restrictions on travel with eggs or birds, the postponement of releases or even the suspension of the programme entirely.

This document also includes recommendations for risk mitigation planning, advocating a proactive approach, as well as recommendations for response planning, leading to reactive management. Establishing ongoing, clear channels of communication with all involved parties is also highlighted as an important element for a successful SBS HS programme.

1. Problem Description

1.1 Background and context

The SBS belongs to the Scolopacidae family. Its distinctive spatula-shaped beak, present on hatch, gives it a unique appearance within its taxonomic group (BirdLife International, 2021). This species is part of the 2% of migratory waterbirds that use the East Asian-Australasian Flyway (EAAF) that are listed as 'Critically Endangered' on the IUCN Red List of Threatened Species (Mundkur and Langendoen, 2022). The SBS breeds in northeast Russia and migrates to wintering grounds in southeast Asia, with numerous stopovers along the way. This extensive migration covers over 8,000 km (WWT, 2013), which highlights not only the species' remarkable migratory behaviour but also the significant challenge of addressing and mitigating the numerous threats it faces along the way.

Since 2003 and on-going, annual breeding surveys have been carried out in the Chukotka region of northeast Russia to monitor the number of breeding pairs of SBS and to individually mark birds. This helps estimate the species' global population status through subsequent resightings and assess the potential impact of known threats. Monitoring has evidenced a persistent decline from an approximate 2000 breeding pairs in the 1970s to 200 in 2010 (Table 1) (Zöckler, Syroechkovskiy and Atkinson, 2010). However, species restoration efforts, such as HS programmes, hunting legislation changes and habitat protection may have buffered this decline with an estimate of 210 - 228 breeding pairs recorded in 2014 and a further 471 mature individuals in the latest 2020 expedition report (Clements *et al.*, 2021)[1].

Table 1 – Population trends in SBS breeding pairs in Chukotka, Russia

Period	Estimate (in pairs)	Comment	Source
1970s	2,000 - 2,800	Based on estimates from a limited number of surveys	Flint and Kondratiev 1977
2000	< 1,000	Based on an expedition into the breeding areas in 2000 and extrapolation from previous estimates	Tomkovich *et al.* 2010
2002	560 - 900	Based on additional surveys in 2002, indicating a general decline of 75 - 80 % since the mid-1970s	Syroechkovskiy *et al.* 2010
2003	402 - 572	Based on surveys carried out up to 2003 with a 30% error range for unaccounted pairs in areas not yet surveyed	Syroechkovskiy 2005
2009	120 - 200	Estimate based on 70% survey coverage of the known range	Zöckler, Syroechkovskiy and Atkinson, 2010

(Zöckler, Syroechkovskiy and Atkinson, 2010; and Green *et al.*, 2021)

HS is a conservation tool aimed at mitigating threats faced by a species during early life stages (eggs, nestlings, and/or pre-fledging). It involves the licensed collection of wild eggs, followed by artificial incubation and the rearing of chicks from hatching to release at pre-fledging or fledging age. The release can occur at a site to reinforce an existing population or may require translocation. The latter involves moving the chicks to a different location from where the eggs were collected. This could be in close proximity to a habitat with an existing SBS population, a newly designated site where reintroduction is being attempted due to suitability or historic geographic distribution (Braidwood *et*

[1] An updated report estimates 443 mature SBS individuals globally, with a 5% annual decline rate (Green *et al.*, 2024)

al., 2018), or part of an assisted migration when natural dispersal is limited and human intervention is required (McLachlan *et al*., 2007).

1.2 HRA goal

HRAs are part of the pre-project stages that look into the potential ecological impact a species recovery project or programme may have on an ecosystem and the epidemiological risks the intervention may encounter. The overarching goal of this HRA is to highlight key potential health risks and mitigation strategies for SBS HS from egg collection to chick release in northeastern Russia.

Specific goals:

- To recognise the vulnerability of SBS to disease hazards;
- To determine the main health risks to translocated SBS chicks during the incubation, hatching and hand-rearing phases, i.e. to identify critical control points in the translocation pathway;
- To include not only the shared general perspective of protecting SBS while in captivity from threats in the wild but also to mitigate health risks to wild species during HS and translocation actions;
- To discuss acceptable levels of risk and establish protocols for practical mitigation strategies; and
- To reference certain new hazards discovered in the SBS conservation breeding programme in the UK and lessons learnt from similar projects.

1.3 HRA scope

Meinypil’gyno (Chukotka, northeast Russia):

1. Wild breeding colony from known surrounding breeding sites where eggs will originate from;
2. Incubation facilities;
3. Rearing facilities post-hatch; and
4. Release site.

1.4 HRA focus

1. SBS from the breeding colony: risk at origin;
2. SBS at initial rearing stages: hatchlings and risk during rearing; and
3. SBS at release sites: travel risks and risk during rearing.

Between 2012 and 2022, the SBS HS programme was carried out in the village of Meinypil’gyno, located on the shores of the Bering Sea in the Chukotka region of northeast Russia. Between 2003 and 2005 there was a general refurbishment of the village where all the old buildings and houses were demolished and new ones built in their place. Each year, one of these buildings served as the base for HS activities, specifically for egg incubation and the initial stages of indoor rearing, although the specific building used varied from year to year.

Project development and implementation in Russia was undertaken by WWT and BirdsRussia with support from the EAAFP SBS Task Force.

1.5 Operational framework

The HS programme is implemented by experienced Arctic wader field workers and aviculturists who survey known SBS breeding areas surrounding Meinypil'gyno (Figure 1). Nests were located, and unmarked adult SBS caught for marking during the egg collection process. Eggs were collected once nests were confirmed to have a full first clutch and transported to Meinypil'gyno in portable incubators via all-terrain vehicles or 4x4's (off-road vehicles) and/or motorised boats. Nests with partial clutches at risk of predation may also be considered for egg collection, with dummies placed in the nest until the female completes her clutch.

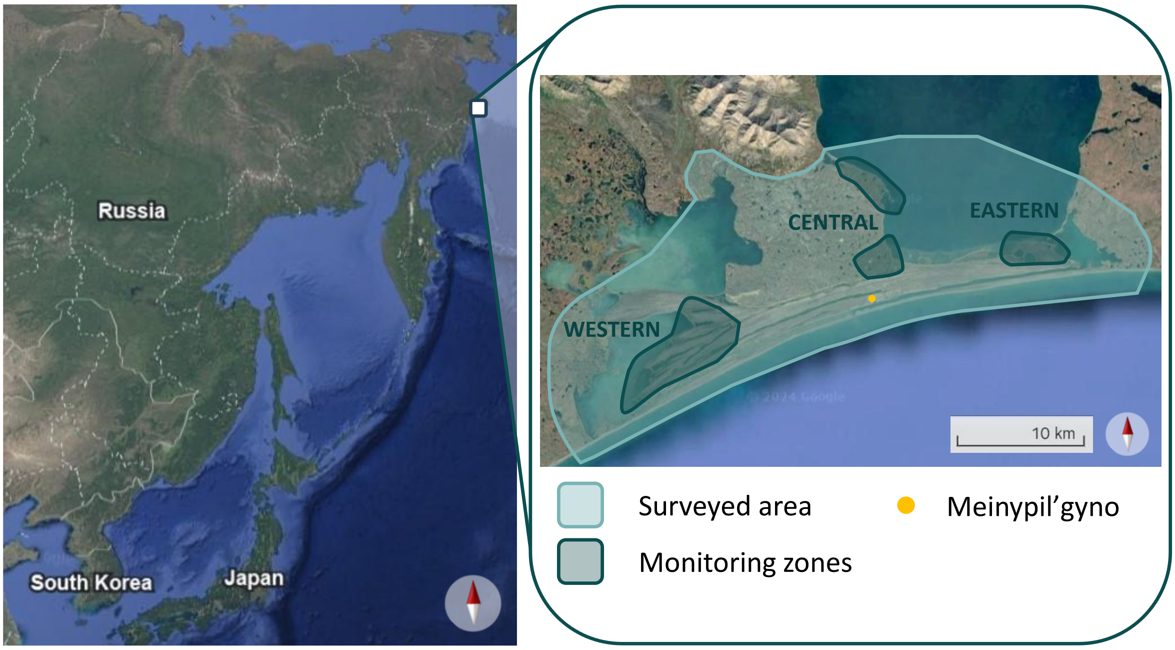


Figure 1 – Programme location and activity zones

Artificial egg incubation and early chick rearing occurs in Meinypil'gyno. Around one-week post-hatch, chicks moved to an outdoor aviary (a netted polytunnel) on natural tundra habitat outside of the village. Chicks were fed a commercially produced, artificial diet (extruded pellet and soft food) known to provide shorebirds with essential nutrients. This was supplemented with invertebrates sourced from the surrounding tundra landscape. At approximately 17-24 days old (fledging age), fledgling chicks underwent a 'soft release,' with the aviary door opened for them to explore at their own pace, typically taking 1 to 2 hours to all leave the aviary. Artificial food was provided for a few hours post-release, and surrounding pools were stocked with natural live food prior to each release.

In 2021, a different 'direct release' method was trialled, following the HS protocol developed for Black-tailed godwits in the UK (Hiscock *et al.*, 2021). This method enabled older chicks to be released at different locations (approx. 10km from the rearing site) while younger chicks continued to be raised in the soft release aviary. For a direct release, an area was selected, and small corrals were set up with easily removable 'doors'. The chicks were then transported in boxes and placed inside the corrals for 10-15 minutes, allowing visual checks after transport. Subsequently, the doors were opened, and the birds are free to walk out at their own pace. This method is considered less stressful than a more direct 'hard release', where birds are released directly from transport boxes after being removed from the aviaries.

An annual timeline (Figure 2) with approximate dates was developed based on known migratory dynamics, breeding behaviour, SBS biology, and human carers' travel logistics.

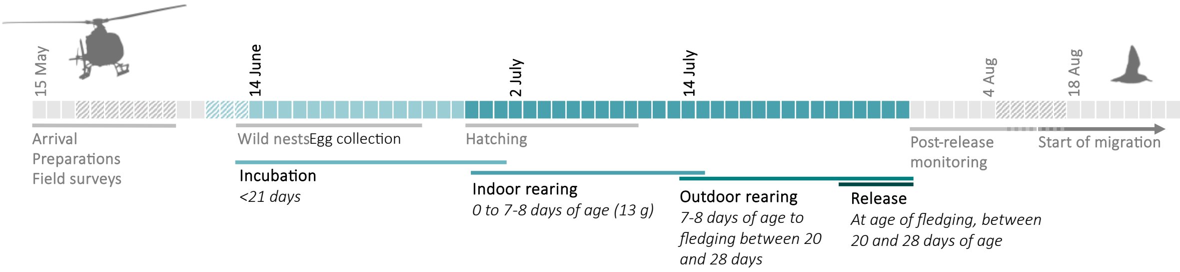


Figure 2 – Tentative timeline of the programme's duration and different stages which may vary based on the progress and real-time conditions

1.6 Biosecurity relevance

'One Health' is a developing concept that involves a complex, interrelation epidemiological framework of interfaces. This model recognises the interconnectedness of health across species and ecosystems (Prata, Ribeiro and Rocha-Santos, 2022), which highlights the fragility between negligible anthropogenic impact and leaving a damaging footprint within an ecosystem (even if with conservation-based intentions). If cautionary and biosecurity measures are not considered there is a risk of the HS programme interfering with the epidemiological balance of the area. Understanding the drivers of spill-over and the dynamics of disease transmission or spread allows us to analyse the factors contributing to disease development, as well as implement adequate targeted risk mitigation measures.

Pathogenic agents of concern are varied and extensive. The degree of each agent's pathogenicity is important to understand, as is its environmental load, hence the importance of measures that are intended to not only avoid SBS being exposed to pathogens, but also to minimise or dilute the presence of expected ubiquitous microorganisms, and to prevent HS birds being a source of infection to the wild population and humans involved in the project (Figure 3).

HPAIV, including the highly contagious strains H5N8 and H5N1, has been consistently detected throughout the summer of 2021 in poultry, as well as in free-ranging and captive wild birds across Russia (Adlhoch *et al.,* 2022). More significantly, since 2021, HPAIV resulted in an avian panzootic of unprecedented global magnitude affecting every continent (Klaassen and Wille, 2023).

Although reservoirs of HPAIV H5 are endemic in Asia, extensive reassortments of different strains, increasing virulence, and shifts in dominant genotypes have all contributed to this worldwide episodic dissemination (Xie *et al.,* 2023). With the current epidemiological landscape, HRA and contingency planning must consider potential viral emergence in remote regions, such as northeast Russia. Additionally, HPAIV H5 has highlighted the importance of awareness of how a low-risk situation can escalate to an extremely high-risk one, potentially leading to the sudden termination of projects and negatively impacting species-focussed conservation efforts.

Viral pandemics such as avian influenza, swine flu, and coronavirus have highlighted the importance of hygiene in controlling the spread of disease. During these outbreaks the enhanced awareness and public health recommendations of basic hygiene practices like handwashing in both professional and public settings not only reduced the spread of viruses but also of zoonotic enteric pathogens (Ray *et al.*, 2021). However, public awareness of the risks associated with zoonotic enteric pathogens when interacting with animals remains generally low (Xu *et al.,* 2018). Although faecal-oral transmission is the most common route of infection when working with animals (Hernandez *et al.,* 2020), it is still important to equally consider other routes of disease spread, as preventing, monitoring, and tracing cross-contamination is essential for identifying any breaches. This includes ensuring proper hygiene compliance during egg collection, incubation, chick-rearing protocols, and staff hygiene practices.

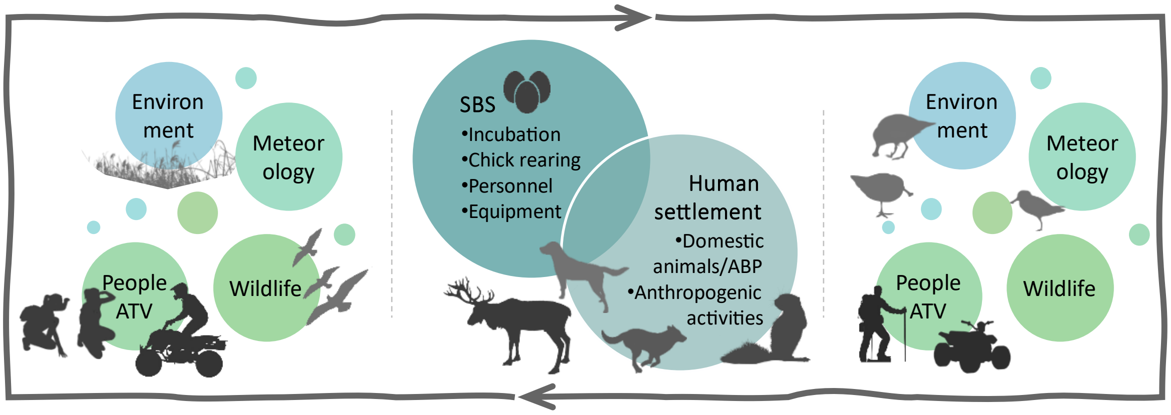


Figure 3 – Representation of interactions between the different epidemiological interfaces: hosts (SBS/wildlife/humans), pathogens and environment at each main phase

Each stage within a HS process will require a set of biosecurity measures according to the risks and disease hazards involved; however, even though the hazards vary there is a repetitive core set-up that should ensure a first-line barrier at each stage which acts as the prime form of disease prevention. HS practitioners need to be aware that although the main target for these biosecurity protocols is the target species - in this case, the SBS - they are also intended to protect staff from zoonotic infections and any incursion of disease into the wild population.

1.7 Acceptable risk?

Owing to the huge economic, animal welfare, potential zoonotic, and, importantly, conservation impact of avian influenza, there is zero-tolerance associated with this disease in European and Asian countries. It causes mass mortalities in many seabird, shorebird and wildfowl species (Klaassen and Wille, 2023). Therefore risks for this pathogen must be mitigated as much as possible.

The acceptable risk for introduction of zoonotic bacterial pathogens such as Salmonella and Campylobacter into incubation and rearing facilities is moderate. This is because effective control measures can feasibly be implemented to reduce the likelihood of introduction and proliferation of both. While Salmonella poses a higher risk of morbidity (symptomatic presentation) and mortality compared to Campylobacter, both pathogens can be managed through these preventive measures. Routine faecal sampling and bacteriology assessment prior to bird moves between HS stages should be considered.

1.8 Assumptions

- All incubation and rearing equipment/materials are tried and tested, prior to the start of the project;
- Egg source is from a healthy population of breeding SBS unless the evidence, at the time, suggests otherwise;

- Necessary precautions are taken to minimise the risk of transmissible diseases to the SBS population of interest: both the wild breeding pairs that have their eggs collected, as well as, during the incubation, hatching, and rearing processes for the HS chicks;
- Avian influenza is likely to be present along the flyway based on seasonality trends. Mitigation measures should be considered for a high risk status; and
- Husbandry, clinical and postmortem examination knowledge acquired from captive SBS at WWT is applicable to the HS SBS population in Russia.

1.9 Limitations

While data on disease in SBS is limited, available data gathered within designated breeding areas (Straw, Australasian Wader Studies Group and Wetlands International, 2005) and information compiled from the WWT's conservation breeding programme for SBS provides helpful insights into the potential environmental and health threats for the species. Incorporating findings from studies and research on closely related Calidrid species found in the Chukotka region, has helped narrow the knowledge gap. Additionally, reviewing current health hazards encountered in other shorebird species, albeit in other geographical locations or captive settings, within the current epidemiological landscape and changing climate, has further enriched the understanding of potential health hazards and levels of risk.

1.10 Sources of uncertainty

The HRA intends to address and cover sources of uncertainty that influence risk estimations and management.

Source of uncertainty in 'Hazard identification':

- Identification of other hazards (agricultural, chemicals, in surrounding areas, etc.);
- Potential effects of political conflict; and
- Immobilisation and handling risks (e.g. distance covered for nest search, egg collection) and transport risks (e.g. hazards during travel).

Source of uncertainty in the 'Risk assessment':

- Influence of time on data accuracy;
- Fluctuating global epidemiology dynamics and epizootic emergence;
- Lack of understanding of disease susceptibility;
- Epidemiology and disease pathogenesis; and
- Likelihood of an identified or unidentified hazard causing population-level impacts.

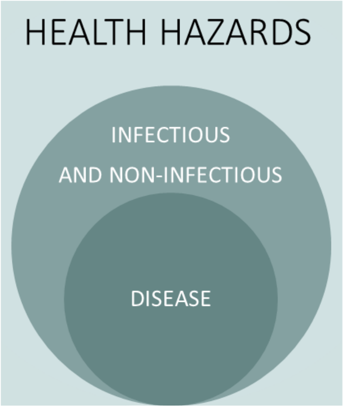
To reduce sources of uncertainty, it is common for data from captive populations or translocation cohorts to be used, as it is easier to obtain this data rather than from wild populations. Albeit, this may lead to a data imbalance, which can affect the relevance and accuracy of an HRA. Therefore, while in this HRA data from a captive SBS collection is used as guidance to minimise limitations and uncertainties, information gathered from wild populations of SBS and analogue species along the EAAF will also be equally valuable and included.

Once these uncertainties have been identified and categorised, they can help shape the future research priorities, guiding effective decision-making and ultimately contributing to the implementation and review of the HRA.

2. Hazard Identification

Biosecurity measures and hygiene protocols will focus on specific infectious hazards known to affect wildlife, captive animals, and humans; however, some hazards or threats that don't have an infectious component but can affect bird health will also need to be addressed and controlled.

The criteria used for the selection of hazards are based on the following definitions:



- Disease: An acute and/or chronic alteration to vital biological processes that affects the health of the birds, characterised by the development of symptoms caused by infectious or non-infectious agents. This refers to changes in the physiology and internal functions of healthy individuals, with disease manifesting from alterations in cellular function and/or structure, leading to disruptions in the performance of physiological body systems (Gunnarsson, 2006).
- Infectious: Referring to viral, bacterial, fungal and parasitic pathogens with a life cycle that can extend beyond a single individual and spread within a flock. This spread can occur through direct contact or indirect contact due to the pathogen's environmental resilience, allowing for transmission within a short timeframe. These pathogens can affect one species or cross species boundaries, potentially causing illness or remaining asymptomatic depending on the host and the stage of the pathogen's life cycle (Aguirre, Ostfeld and Daszak, 2012).
- Non-infectious: Referring to agents or conditions that primarily (but not limited to) impact an individual bird rather than spreading through a flock. This can include toxins or contaminants, nutritional disorders, trauma, or be management/husbandry related.
- Health hazard: A threat to the physical integrity, health or safety of the SBS caused by infectious and/or non-infectious agents. Ultimately, a health hazard has the potential of causing disease.

2.1 Classification of hazards

Health hazards have been categorised into infectious (Table 2) and non-infectious hazards (Table 3), considering both geographic and species relevance. The hazards were identified through a literature review which included tracking and field monitoring data, to narrow down relevant hazards based on migratory routes, known epidemiological threats, and other mortality aetiologies along these routes.

This classification allows for targeted mitigation strategies tailored to the specific needs and vulnerabilities of the SBS during HS processes ensuring comprehensive protection against potential threats at the release sites but also consideration of those present along the flyway.

Table 2 – List of infectious health hazards, classified by viral, bacterial, fungal and parasitic agents

Index	Pathogen/Disease	Zoonotic?	In wild birds? (Europe and northeast Russia)	In captive birds? (Russia)	Charadriiformes susceptible to infection?	Epidemiological comments	Primary references
		Yes/No	Yes/No/No Evidence Found	Yes/No/No Evidence Found	Yes/No		
	VIRUSES						
	Orthomyxoviridae: Influenza A virus						
1	Low pathogenic avian influenza (LPAIV)	**Y**	**Y**	**Y**	**Y**	Charadriiformes (shorebirds) sampled (> 9,400 birds) eastern continental USA), as well as in Argentina, Chile, and Bermuda. AIV virus was isolated from 290 birds.	(Hanson *et al.*, 2008)
						Wildfowl and shorebirds documented as the primary LPAIV reservoirs.	(Fouchier and Munster, 2009); (Cromie *et al.*, 2012)
						LPAIV can be divided into two main phylogenetic lineages: the Eurasian and American lineages. Some ducks and shorebirds cross the Bering Strait during migration or have breeding ranges that include both far eastern Russian and northwestern America.	(Verhagen, Munster and Fouchier, 2011)
						Cases of LPAI H9N2 (lineage Y280) in commercial poultry were reported in northeast Russia in years 2012, 2017 and 2018.	(Irza, 2019)
						HPAI H5N8 clade 2.3.4.4b virus detected in Germany shares six gene segments with the HPAI H5N8 virus in Eurasia, Asia, and Africa and two gene segments with LPAI H3N8, detected in wild birds of Russia. It is thought the Egyptian-like HPAI H5N8 virus possibly reached bird breeding and staging areas in Siberia in early 2020 then spread in wild bird populations, and reassorted with LPAIV.	(Sobolev *et al.*, 2021)

2	High pathogenic avian influenza (HPAIV)	**Y**	**Y**	**Y**	**Y**	Charadriiformes are considered one of the primary reservoirs of avian influenza. Dunlin (*Calidris alpina*) are highly susceptible to infection with HPAIV H5N1. If they become infected, they are most likely to suffer mortality within 3–5 days.	(Hall *et al.*, 2011)
						Chukotka Peninsula, Kamchatka Peninsula, Taymyr Peninsula, the Kuril Islands, and Sakhalin Island. Cloacal swabs collected from birds captured by cannon netting, funnel traps, and hand-held nets and birds that were shot dead. Droppings from single-species gull colonies also collected. 41 of 5,678 samples tested positive for AIV. Anseriformes had the highest AIV prevalence, 1.49%. Followed by Ardeidae (1.23%), Laridae (0.64%) and Rallidae showed the lowest AIV prevalence (0.61%).	(Sivay *et al.*, 2012)
						Wild aquatic birds migrate to and congregate in Siberian wetlands for breeding and moulting. Major wild aquatic bird migration routes overlap in Siberia, connecting this area to the wintering grounds of Eurasia and Africa and Australasia. This converging flyways act as pathways for the dissemination of HPAIV during southward autumn migration of wildfowl, as seen in the spread of H5N1 clade 2.2 in 2005-2006 and H5N8 clade 2.3.4.4 in 2014.	(Lee *et al.,* 2017)
						May 2018: First cases reported in small holdings and backyards in Kurskaya Oblast. Affected species: domesticated chickens, ducks, geese, guinea fowl. Live bird trade played a key role in secondary spread. In total 82 HPAI outbreaks were reported in poultry in 2018 in 15 regions of the virus to other regions.	(Irza, 2019)
						H5 HPAIVs isolated from environment water collected in the Izumi plain, Kagoshima, Japan. Large wintering site for cranes and wildfowl.	(Okuya *et al*., 2022)

						HPAI H5N1 events in non-poultry species, including wild birds, have been reported by WOAH across Europe.	(Freath *et al.*, 2023)
						In summer 2020, two genetically distinct HPAI H5N8 viral lineages were detected in Russia and Kazakhstan.	(Zhang *et al*., 2023)
	Poxviridae: Avipoxvirus						
3	Avian pox	**N**	**Y**	**NEF**	**Y**	Infection appears uncommon in shorebirds, though should presume susceptible: disease documented in a Royal tern (*Thalasseus maximus*).	(Jacobson *et al.,* 1980)
						Avian pox was diagnosed in three sanderlings (*Calidris alba*) on Sanibel Island, Florida (USA) in February 1997. Poxvirus infection was confirmed by cytology, histopathology, and electron microscopy. First report of poxvirus infection in Sanderlings.	(Kreuder *et al*., 1999)
						Avian pox in Charadriiformes is rare. Wild species often become infected in captivity. Pox outbreaks are commonly reported at aviaries, rehabilitation centres, and other places where confinement provides close contact among birds.	(Friend and Franson, 1999)
						Present in Russia in 2002. Wild hosts include sanderlings and dunlins.	(LaPointe, 2010)
						Avian pox has been identified as an important risk factor in the conservation of small and endangered populations, particularly in island bird species.	(Gyuranecz *et al*., 2013)
						Avian pox virus identified in a captive Pied avocet (*Recurvirostra avosetta*) after tarsal joint mass removal and sent for histopathology.	(WWT, Living Collection Health Report, 2020 - internal report)

	Paramyxoviridae: Avian paramyxoviruses						
4	*Avulavirinae: Orthoavulavirus:* e.g. Avian Paramyxovirus 1 (PMV-1, AAvV-1). Newcastle disease in captive birds	**Y** Mild and self-limiting. Can cause conjunctivitis.	**Y**	**Y**	**Y**	Flyway assessment of birds. Similar species sampled concluded rate of infection in similar small waders: Sharp-tailed sandpiper (*Calidris acuminata);* Red-kneed dotterel (*Erythrogonys cinctus*) and Black-fronted plover (*Charadrius melanops*) to be low.	(Garnett and Flanagan, 1989)
						Waders represent a reservoir for certain viral pathogens, especially for PMV. PMV-1 was detected in two dunlins and the Common sandpiper (*Actitis hypoleucos*).	(Hlinak *et al.*, 2006)
						Wild migratory birds from orders Anseriformes and Charadriiformes can carry Newcastle disease virus (NDV) and could transfer pathogenic variants of this virus to the Russian territory.	(Glushchenko *et al*., 2016)
						Migratory wildfowl and shorebirds including orders Charadriiformes, Strigiformes, and Pelecaniformes are susceptible to NDV. These species are typically carriers of lentogenic (low virulence) and mesogenic (moderate virulence) strains.	(OIE, 2019)
						An outbreak of highly pathogenic AAvV-1 (Newcastle disease virus) was described in the Moscow region of Russia, in the summer of 2022. The outbreak was in a single backyard, located remote from other poultry farms. Introduction likely by wild birds. The virus was extremely pathogenic and contagious in chickens.	(Rtishchev *et al.,* 2023)
	Reoviridae:						
5	Reoviruses / reo-like viruses	**N**	**Y**	**NEF**	**Y**	Reo-like virus detected in Dunlins and Spotted redshanks (*Tringa erythropus*) in Germany.	(Hlinak *et al*., 2006)
						Reovirus associated with mortality of an Upland sandpiper (*Bartramia longicauda*).	(Sandercock *et al*., 2008)
	Coronaviridae: Coronavirus						
6	Coronavirus (CoVs)	**N** Hu to pets/wildlife	**Y**	**NEF**	**Y**	Detected in faeces from an apparently healthy Ruddy turnstone (*Arenaria interpres*) in Delawere Bay.	(Honkavuori *et al*., 2014)

						Detected in a Black-headed gull (*Chroicocephalus ridibundus*) in Sweden.	(Wille *et al.,* 2016)
						Wild birds from all continents except Antarctica are known to carry CoVs. The major wild birds found with different types of CoVs in the studied countries are Anseriformes (12, 75%) and Charadriiformes (9, 56.2%), among others.	(Rahman *et al*., 2020)
						Sakhalin Island is a migration site for Anseriformes and Charadriiformes of the EAAF. Co-circulation and co-infection cases of avian CoVs, PMV, and avian influenza A virus in wild duck species, which have their breeding areas in Siberia.	(Kirill Sharshov *et al.,* 2023)
	Flaviviridae: Flaviviruses (arboviruses)						
7	West Nile virus (WNV)	**Y**	**Y**	**Y**	**Y**	Reported outbreaks in 1999 included Volgograd, Russia with a zoonotic concern) –Three affected cities: Bucharest (Romania), New York (USA), and Volgograd (Russia), are located near large bodies of water and on bird migration pathways.	(Platonov, 2001)
						Wild birds in northeast Russia positive for antibodies to WNV were in the orders Anseriformes, Charadriiformes, Columbiformes, and Pelecaniformes.	(Kariwa *et al.,* 2013)
						Widespread avian mortality is not generally a reported feature of WNV in Europe. Charadriiformes not the host species typically associated with infection.	(Brugman *et al.,* 2012); (Michel *et al.,* 2018)
8	Usutu virus (USUV)	**Y**	**Y**	**N**	**Y**	Charadriiformes: USUV RNA positive in captive Inca terns (*Larosterna inca*) and Yellow-legged gulls (*Larus michahellis*).	(Ziegler *et al.,* 2015); (Clé *et al*., 2019)
						USUV was detected in numerous passerines in Greater London (UK) in 2020, with the previous UK detection occurring in 2013. Passerines and Strigiformes are more susceptible; however, it can affect a wide range of wild avian species.	(Folly *et al.*, 2020)
						Potential for arboviruses such as usutu virus to spread across the Territory of the Russian Federation via avian migratory flyways.	(Naidenova *et al.*, 2023)

	Avian herpesviruses						
9	Alphaherpesviruses	**N**	**Y**	**Y**	**Y - Laridae**	Herpesviruses were detected in oropharyngeal and/or cloacal swabs in 34 (7.5%) birds belonging to 11 species from six different avian orders: Accipitriformes, Charadriiformes, Columbiformes, Falconiformes, Passeriformes, and Strigiformes.	(Žlabravec *et al*., 2022)
	BACTERIA						
10	*Pasteurella multocida* (avian cholera)	**Assume N**	**Y**	**Y**	**Y**	Shorebirds amongst species affected by disease. Pelagic outbreak of avian cholera in N American gulls. Outbreak in China.	(Wang *et al*., 2009); (Friend and Franson, 1999)
						Baikal teal share breeding areas with SBS. Registered carriers of Avian cholera (2003 - Korea).	(Kwon and Kang, 2003)
11	*Campylobacter spp* (campylobacteriosis)	**Y**	**Y**	**Y**	**Y**	Samples taken from 781 wild birds (*Anatidae*, *Scolopacidae*, and *Laridae*). Gulls were reported with a highest prevalence Campylobacter rate of 25%.	(Keller *et al.,* 2011)
						Campylobacter spp. is carried by most mammals and birds and are commonly found in water sources. Commensal bacterium in waterbirds.	(Cromie *et al*., 2012)
						Migratory shorebirds are important reservoirs of pathogenic *Campylobacter* species.	(Ryu *et al.*, 2014)
						Migratory shorebirds, such as Calidrid species, exhibit high *Campylobacter* prevalence, likely due to the immune pressure and environmental changes during migration. However, the impact on their health remains unclear.	(Zhang, Yang and Zhu, 2021)
12	*Salmonella spp.* (salmonellosis)	**Y**	**Y**	**Y**	**Y**	Isolated from various species of ducks, mute swans (*Cygnus olor*), various species of gulls and terns, American coot (*Fulica americana)*, Double-crested cormorant (*Nannopterum auritum)*, Eared grebe (*Podiceps nigricollis*), and several species of egrets and herons (Ardeidae).	(Wuthe *et al.*, 1972)

						Salmonellosis outbreaks have also been reported in colonial nesting birds, such as gulls and terns. Birds of prey can become infected with *Salmonella spp*. bacteria from prey items.	(Cromie *et al.*, 2012)
						The prevalence and risk of *Salmonella enterica* in migratory birds from South Korea suggest these birds may spread pathogenic and antimicrobial-resistant *Salmonella,* with the potential of causing sporadic infections in poultry.	(Wei *et al.*, 2020)
13	*Clostridium perfringens* (necrotic enteritis)	**Y**	**Y**	**NEF**	**Y**	Often found in the intestinal tracts of healthy birds. The detection of *C. perfringens* in faeces from wild birds near broiler chicken houses suggests that wild birds that gain entry to poultry houses have the potential to transmit the pathogen to poultry.	(Benskin *et al.*, 2009)
						Enterotoxaemia from *Clostridium* in captive shorebird species, e.g. E. curlews and more commonly wild geese and swan population in the UK.	(O'Brien *et al*., 2018); (WWT E. Curlew Health Report, 2023 – *internal report*)
14	*Escherichia coli* (colibacillosis, colisepticaemia) - and other enteric bacteria	**Y**	**Y**	**Y**	**Y**	Commensal bacterium in wildfowl with potential to cause disease.	(Friend and Franson 1999); (Cromie *et al.,* 2012)
15	*Mycobacterium avium* complex (MAC) (mycobacteriosis, avian tuberculosis, aTB)	**Y**	**Y**	**Y**	**Y**	All avian species potentially susceptible to disease. Mention of Charadriiformes though less common in these species.	(Witte *et al*., 2008); (Friend and Franson, 1999)
						Susceptibility in waders: Lapwings (*Vanellus vanellus*), Curlews, Black-tailed godwits, among others. Wild birds in proximity to captive collections.	(Lopez Colom, 2023)
16	*Chlamydia sp., especially C. psittaci* (avian chlamydiosis)	**Y**	**Y**	**Y**	**Y**	Contamination of the nesting site with infective exudates or faeces may be important in shorebirds.	(Brand, 1989)
						Infections by inhalation can be caused by generation of contaminated aerosols by waterfowl flocks landing or taking flight (e.g., NDV or chlamydiosis).	(Hubálek, 2004)

						Clinically apparent outbreaks have been seen occasionally in wild birds, including shorebirds and wildfowl.	(Spickler, 2017)
17	*Mycoplasma sp.* including *M. gallisepticum, M. meleagridis* and *M. synovia* (mycoplasmosis)	**N**	**Y**	**Y**	**Y**	Poultry and other captive-reared birds.	(Friend and Franson, 1999)
						Study on commercial chickens and turkeys with a history of respiratory disease established *Mycoplasma gallisepticum* infection rates on 164 poultry farms of the Russian Federation. Consideration should be given to the possibility of *M. gallisepticum* transmission by wild birds.	(Sprygin *et al.*, 2011)
						Wild geese can act as potential vectors of *Mycoplasma* strains that may pose a health risk to commercial waterfowl. *Mycoplasma* species could be a part of the normal microflora of gulls.	(Sawicka-Durkalec *et al.*, 2021)
18	*Pseudomonas spp.*	**Y**	**Y**	**Y**	**Y**	Ubiquitous environmental and commensal organism with potential to cause opportunistic infection.	(Walker *et al.* 2002); (Benskin *et al.* 2009)
						Pseudomonas spp. are among the bacteria capable of developing antimicrobial resistance. Shorebirds using the EAAF are especially vulnerable to disease transfer due to their gregarious flocking, shared foraging waters, and potential role as reservoirs for these bacteria.	(Smith, 2020)
19	*Staphylococcus aureus* (staphylococcosis)	**Y**	**Y**	**Y**	**N**	Ubiquitous commensal on skin and mucous membranes. Infection is frequently localised, but septicaemia is possible e.g. in immunocompromised birds.	(Friend and Franson, 1999)
						Infections with *Staphylococcus aureus* are frequently secondary to impairment of the host defence mechanisms, or are due to a compromised immune system.	(Benskin *et al.,* 2009)
						Staphylococcus spp. are often isolated from areas of pododermatitis (bumblefoot) in many avian species, as well as skin/feather infections.	(Lightfoot, 2020b)

						Prolonged heat waves in England led to wing oedema in captive waders (Curlews and Ringed plover (*Charadrius hiaticula*)) with significant presence of *Staphylococcus spp*. detected on infected skin.	(WWT, E. Curlew Health Report, 2023 – *internal report*); (WWT, Living Collection Health Report, 2023 - *internal report*)
	FUNGI						
20	*Aspergillus* spp. (especially *A. fumigatus*) (aspergillosis)	**Y**	**Y**	**Y**	**Y**	Avian aspergillosis is characteristically a disease of captivity and essentially one of recently captured water birds. Sporadic cases do occur in birds of all types and after long periods in captivity.	(Ainsworth and Rewell, 1949)
						Relatively common in captive waterfowl and in seabirds in captivity as well as domestic avian species.	(Beernaert *et al* 2010)
						Can cause serious and often fatal infections in a wide variety of captive and free-roaming wild birds. Crucial to have adequate preventive measures in place.	(Arné *et al.*, 2021)
21	*Candida albicans* (candidiasis, candidosis)	**Y**	**Y**	**Y**	**Y**	Common in poultry; reports in free ranging birds.	(Friend and Franson 1999)
						Common in captive avian species, especially in young and immunocompromised birds.	(Hoppes, 2021)
						Present in captive SBS population (UK).	(WWT Captive SBS Health reports, 2018-2023 – internal reports)
						Extensive infection affecting digestive tract, in young captive *E. curlew* due to prolonged heatwaves.	(WWT E. Curlew Health Report, 2023 – internal report)
22	Other fungi/yeast e.g. *Rhinosporidium sp., Mucor*	**Worldwide**	**Y**	**Y**	**Y**	Few reports of disease in free-ranging birds, mainly opportunistic infection.	(Wobeser, 1997)

	sp., Trichophyton sp., Microsporum sp., Cryptococcus sp., *Aspergillus niger*.					Ringworm (*Trichophyton sp.*) in birds is highly contagious, and it is transmitted by direct bird-to-bird contact or by contact with a contaminated environment. The added issues of mycotoxins (e.g. allergic responses), make fungi an important area for consideration in the management of free-ranging bird populations.	(Friend and Franson, 1999)
						Ecological importance of wild birds, e.g. Black-headed gulls, in the circulation of potentially pathogenic fungi in the biosphere.	(Dynowska, Indykiewicz and Ejdys, 2018)
	PARASITES						
	Blood-borne protozoa						
23	Haemosporidian parasites including *Plasmodium sp.* (*Haemoproteus sp*, haemosporidiosis or avian malaria) and *Leucocytozoon spp.*	**Y**	**Y**	**Y**	**Y** low prevalence	Anseriformes are commonly infected with species of *Haemoproteus* and Leucocytozoons. > 75 % of waterfowl species that were examined were hosts for one (1) or more of these parasites. Migratory shorebirds are less frequently parasitised.	(Friend and Franson, 1999)
						Parasite infection risk is higher for species wintering in freshwater areas. *Plasmodium* sp. infection was detected during the breeding season in pectoral sandpipers (*Calidris melanotos*), while semipalmated sandpipers (*Calidris pusilla*) were parasite-free. Overall, malaria prevalence in wild shorebirds is relatively low.	(Yohannes *et al.*, 2009)
						Leucocytozoon lineages were mostly found in thrushes (Turdidae) and usually limited to one host genus, while *Plasmodium* and *Haemoproteus* were found in multiple passeriform and non-passeriform hosts.	(Harl *et al.*, 2020)
	Other protozoa						
24	*Coccidia*, in most cases *Eimeria* sp. (coccidiosis)	**N**	**Y** Evidence in other avian sp.	**Y** Common disease of captive birds	**Y**	In birds, most pathogenic coccidia parasites are from the genus Eimeria. Habitat loss and the release of captive-reared birds into the wild increase coccidiosis risks. Eimeria infections have been recorded in wild gulls and shorebirds.	(Friend and Franson, 1999)

25	*Toxoplasma gondii*	**Y**	**Y**	**NEF**	**Y**	A serological survey suggests that wildfowl in Hokkaido, Chukotka, and Kamchatka may be exposed to *Toxoplasma gondii.*	(Murao *et al.*, 2008)
26	*Sarcocystis sp.* (sarcocystosis)	**N**	**Y**	**Y**	**Y?** limited evidence	DNA analysis confirmed *Sarcocystis rileyi* in all tested birds from the eastern Baltic region. Infection rates varied significantly by year and were higher in November-December than in September-October. Increased awareness of *S. rileyi* infection is needed.	(Prakas *et al.,* 2023)
	Metazoan endoparasites						
	Nematodes						
27	Tracheal worms: *Cyathostoma spp.* (especially *C. bronchialis*) and *Syngamus trachea* (gape worm, gapes)	**N**	**Y**	**Y**	**Y**	Young birds are mostly affected. Findings from captive bird collections have led to the conclusion that almost any species of cage or aviary bird is susceptible to infection.	(Friend and Franson 1999)
28	*Eustrongylides spp.* (eustrongylidosis, verminous peritonitis)	**Y**	**Y** Europe, mostly in fish, rarely in birds	**Y**	**Y**	Can cause large die-offs of nestlings in coastal rookeries, especially of egrets and other wading birds.	(Friend and Franson, 1999)
						Waterfowl identified as definitive hosts are Great cormorant (*Phalacrocorax carbo sinensis*) and wild ducks (Anseriformes: Anatidae).	(Honcharov *et al*., 2022)
29	*Echinuria uncinata* (acuariasis, echinuriasis)	**Y** (ingestion or intake of contaminated water)	**Y**	**Y**	**Y?** limited evidence	Common proventricular nematode of wildfowl. Disease most associated with drought, overcrowding and high levels of zooplankton (especially *Daphnia* spp.).	(Friend and Franson 1999
						For the first time in Uzbekistan, it was noted that the intermediate host of *E. uncinata* nematode is *Daphnia magna*. Along with wildfowl, there is also evidence of transmission to farm birds.	(Madumarov *et al*., 2021)
	Trematodes						
30	E.g. *Sphaeridiotrema globulus, Cyathocotyle bushiensis, Leyogonimus polyoon*	**Y**	**Y**	**Y**	**Y**	Occasional disease in wild wildfowl. Molluscs are the first intermediate host; therefore, aquatic environments bring potential hosts and these parasites into proximity.	(Friend and Franson, 1999)
31		**Y**	**Y**	**Y**	**Y**	Disease rare in birds.	(Cromie *et al.,* 2012)

	Blood flukes – e.g. *Schistosomatinae* (*Schistosoma and Trichobilharzia spp.* (schistosomiasis, Bilharzia)					Many of the migratory bird host species used by schistosomes, particularly *Trichobilharzia*, are in the family Anatidae.	(Lashaki *et al.,* 2020)
	Cestodes						
32	E.g. *Gastrotaenia* sp. & *Cloacotaenia* sp.	**Y**	**Y**	**Y**	**Y**	*Gastrotaenia sp*. inhabit the gizzard and penetrate the keratohyalin and glandular layers causing inflammation and tissue necrosis. Considered pathogenic.	(Wobeser, 1997)
						Common infections of wild birds but rarely fatal in isolation.	(Friend and Franson, 1999)
	Acanthocephalans						
33	E.g. *Fillicolis anatis* & *Polymorphus* spp. (*acanthocephaliasis*)	**Y**	**Y**	**Y**	**Y**	Worldwide distribution. Common infection of wildfowl.	(Wobeser 1997); (Friend and Franson, 1999)
	Ectoparasites						
34	Nasal leeches - *Theromyzon* spp.	**N**	**Y**	**Y**	**Y**	More common in colder climes.	(Wobeser 1997); (Friend and Franson, 1999)
						T. maculosum: Palaearctic species present in warmed shallow bays of Lake Baikal.	(Kaygorodova, 2013)
35	Other ectoparasites: ticks e.g. *Argas* spp. & *Ixodes* spp., lice, mites especially *Knemidocoptes*, fleas, flies, other biting insects	**Y**	**Y**	**Y**	**Y**	Heavy infestations may cause death in wild birds, especially in nestlings.	(Wobeser 1997); (Friend and Franson, 1999)

Table 3 – List of non-infectious health hazards, classified as: toxins, nutritional related disorders, trauma, management-related hazards and other

Index	**Non-infectious hazards** (*associated disease, agent or substance*)	**Species affected**	**Epidemiological comments**	**Primary references**
	TOXINS			
	Biotoxins			
36	Cyanobacteria and other toxins derived from algae blooms: Brevetoxicosis, saxitoxicosis, domoic acid (DA)	Wildlife	"Red tide" was again observed in Olyutorsky Gulf, July 2017. Dinoflagellate dominated blooms.	(Lepskaya *et al.*, 2018)
		Wildlife	Algae bloom distribution: higher in areas with colder climate and lower population density (Far Eastern Federal Districts 12%).	(Namsaraev *et al.*, 2020)
		Seabirds, fish and marine mammals	Food chain transfer of DA and other toxins can cause morbidity and mortality in seabirds.	(Karlson *et al.*, 2021)
37	Avian botulism (*Clostridium botulinum)*	Wildfowl and shorebirds	A notorious source of mass mortality among migrant waterbirds is botulism.	(Kirby *et al.*, 2008)
		Wildlife	Increased incidence of diseases in marine mammals, birds, fish, and molluscs (including botulism).	(Revich and Chashchin, 2008)
		Seabirds, e.g. Pelicans, cormorants, grebes, and occasionally northern fulmar and Laysan albatross have contracted type C botulism	Climate change is a direct and indirect factor involved in epizootics outbreaks (botulism and H5N1 mainly) and mass mortality caused by cyanotoxins.	(Catsadorakis and Portolou, 2017); (Stidworthy and Denk, 2018)
38	Plants	Captive avian species	E.g. Actively toxic plants such as Yew *(Taxus baccata), Laburnum*, Lilac (*Syringa vulgaris*), Lilies (*Lilium*), Foxglove (*Digitalis*), *Rhododendron* sp. and *Nerium oleander* sp. should be avoided.	(Chitty and Monks, 2018); (Richardson and Means, 2001)
	Chemical/heavy metal toxins			
39	Elements and metals (e.g. Copper, lead, mercury, cadmium, etc.)	Seabirds/shorebirds	Exposure can be through diet (wild collected): Cadmium levels found in sediments, sediment-dwelling invertebrates, and in wild dunlins that fed on these.	(Ferns and Anderson, 1994)

			Concentrations of iron, manganese and copper, as well as two toxic metals (cadmium and mercury) were detected in 11 seabird species collected in Chaun, northeast Siberia.	(Kim *et al.,* 1996)
			Intoxication occurs mainly by ingestion of fishing tackle and ammunition.	(Friend and Franson, 1999); (Stidworthy and Denk, 2018)
40	Pesticides and insecticides: Polychlorinated biphenyls (PCBs), organophosphates (OPs) and organochlorines, OCs	Birds appear to be more sensitive than other vertebrates to the toxic effects of OP and carbamate pesticides.	Bird species can become victims of secondary poisoning when they feed on live invertebrates covered with pesticide.	(Friend and Franson, 1999)
		Wide range of avian species	In general, birds that are higher in the food chain are more likely to be affected by OCs present in the environment than birds that are lower in the food chain.	(Friend and Franson, 1999)
		Avian species	Insecticides or weed killers sprayed too close to the aviaries are also dangerous to avian species.	(Chitty and Monks, 2018)
41	Solvents	Avian species	Glue and paint fumes for example can cause respiratory tract irritation, dyspnoea (laboured breathing), death.	(Richardson and Means, 2001)
42	Poison baits	Migratory waterbirds (The Yellow Sea region)	Mortality of waterbirds from poisoning at migratory stop over sites may influence breeding birds' survivability and egg quality at the breeding grounds.	(Peng *et al.*, 2017)
43	Pharmaceuticals	Seabirds	Seabirds are susceptible to fenbendazole toxicity. Intoxication can occur when fish feeding doses.	(Stidworthy and Denk, 2018)
		Avian species	Antiparasitic drug overdose can lead to neurological symptoms, organ dysfunctions and death.	(Chitty and Monks, 2018)
		Wildlife (domestic-human-wildlife interface)	Pharmaceuticals are considered emerging contaminants in terms of impacts on wildlife (e.g. barbiturates, antiparasitic).	(Herrero-Villar *et al*., 2021)
44	Nicotine (e.g. Tobacco, cigarettes, cigars)	Avian species	Ingestion can cause tachypnoea, emesis, neurological signs, excitation, collapse, coma and death.	(Chitty and Monks, 2018)
	NUTRITIONAL			

45	Malnutrition	Avian species in captivity	Protein, fat, carotenoids, minerals, and vitamins are an important part of nutrition in Charadriiformes, including embryonic development, neonates (chicks), juveniles and adults.	(McWilliams, 2008)
		Avian species in captivity	Malnutrition is responsible for up to 90% of captive bird disease.	(Chitty and Monks, 2018)
46	Vitamin deficiency	Avian species	Vitamin A is the vitamin that is more likely to be deficient in both captive and wild birds. Vitamin A deficiency leads to signs of hyperkeratinisation of mucous membranes, anorexia, poor conditioning, and increased susceptibility to infection.	(Orosz, 2007)
		Avian species	Deficiencies of vitamin E can cause encephalomalacia (e.g. chicks with abnormal tilted head and neck), exudative diathesis (fluid build-up and oedema), muscular dystrophy, and increased fragility of red blood cells.	(Orosz, 2007)
47	Dietary calcium, vitamin D3, phosphorus imbalance	Avian species in captivity	Insufficient dietary calcium, vitamin D3, or phosphorus and excess phosphorus or calcium can cause curving deformities of long bones and folding fractures.	(Schmidt, Reavill and Phalen, 2015)
			Dietary supplementation protocol and UV light provision to address metabolic bone disease detected in captive SBS.	(WWT Captive SBS Health reports, 2014-2023 – *internal reports*)
			Vitamin D toxicosis. Care with supplements since excessive vitamin D can lead to deposit of calcium in organs (e.g. kidneys).	(Lightfoot, 2020a)
	TRAUMA			
48	Collision/Trauma	Avian species	Bruising of the myocardium is very common in birds that have had blunt force trauma.	(Schmidt, Reavill and Phalen, 2015)
		Free-ranging and captive avian species	Frequent cause of morbidity in wild long-legged waders admitted for veterinary care and rehabilitation.	(Pizzi and Seddon, 2016)
		Captive SBS	Collision and blunt trauma reported within captive SBS population.	(WWT Captive SBS Health reports, 2014-2021 – *internal reports*)

49	Ringing or tagging related	Free-ranging and captive avian species	Inadequate ring size, type and placement method can lead to severe cutaneous lesions with secondary issues.	(Griesser *et al.*, 2012)
		Free-ranging and captive avian species	Ringing accidents in waders are rare; however, can occur. Development of intolerance to rings or flags with self-resolving leg flicking is also a possibility.	(Hiscock and Costa, 2023); (Loktionov *et al.*, 2023)
50	Predation	Arctic shorebirds	Potential reason for increased predation could be due to shift in the diet of predators towards eating more eggs/chicks instead of other food sources or perhaps change in predator species composition.	(Kubelka *et al.*, 2018)
		Free-ranging and captive wader species (Chukotka).	Recorded predators (Chukotka): Microtine rodents, Brown bear (*Ursus arctos),* Red fox (*Vulpes vulpes),* Artic fox (*Vulpes lagopus*), Wolf (*Canis lupus*), Wolverine (*Gulo gulo)* and Stoat (*Mustela erminea*).	(Tomkovich *et al*., 2022)
		Free-ranging waders (Chukotka).	SBS: High incidence of egg or chick loss at nests due to predation.	(Loktionov *et al.*, 2023)
	MANAGEMENT RELATED			
51	Foreign body *(ingestion or entanglement)*	All bird species	Waterfowl susceptible to ingestion of plastic debris.	(Friend and Franson, 1999)
		Captive waders	Hair nets required for wader rearing to avoid entanglement with long hair, same justification for the removal of any material (towels, cloths) which easily de-thread with wear and tear.	(WWT Captive SBS Health reports, 2014-2023 – internal reports)
		Migratory waterbirds (EAAF)	By-catch in nets along the flyway. Entrapment can lead to mortality and health status of birds arriving to breeding sites.	(Peng *et al.*, 2017)
52	Pododermatitis (bumblefoot)	Any bird species. Predominantly a disease of captive birds.	Bumblefoot in waterbirds held in captivity is a common health problem. Special care should be given to promote wading in clean water as much as possible.	(Friend and Franson, 1999)
		Captive avian species	Predisposing factors in captive avian species: sedentary behaviour and prolonged standing on abrasive, hard, moist, or faecally contaminated flooring.	(Stidworthy and Denk, 2018)

53	Incubation	Avian species	Alterations in temperature and humidity can lead to a long list of embryonic development issues (e.g. malposition, wry-neck, yolk retention, ataxia, malformations, etc.).	(Pollock, 2014)
		Avian species	Increased risk of embryo damage during transportation leading to unsuccessful hatching or egg survivability (e.g. trauma, acute changes to humidity and temperature values).	(Loktionov *et al.*, 2023)
54	Capture myopathy	Waders	Trapping and handling operations involving drop nets and rocket nets; drive-trapping, handling, and translocation of flightless birds; and handling birds to place marking devices (e.g. radio transmitters) on them have induced capture myopathy.	(Friend and Franson, 1999)
			Shorebirds held during banding activities can develop muscle cramps, especially when temperatures are high. Records of rehabilitated Great knot (*Calidris tenuirostris*), Red knot (*C. canutus*), Bar-tailed godwit (*Limosa lapponica*) and Red-necked stint (*C. ruficollis*).	(Rogers *et al.*, 2004)
			Can arise from the inflicted stress and physical exertion that typically occur with prolonged or short intense pursuit, capture, restraint or transportation of wild animals.	(Breed *et al.*, 2019)
	OTHER			
55	Inbreeding depression	Isolated populations (wild and captive)	Disregarding the influence of inbreeding depression on extinction risk will lead to serious overestimates of the survival prospects of threatened mammalian and avian taxa.	(O'Grady *et al.,* 2006)
		Dunlins	Rare but evidence of observed low heterozygosity and positive internal relatedness values in southern Baltic dunlins.	(Rönkä *et al.*, 2021)
		Isolated populations (wild and captive)	Low heterozygosity and genetic diversity. Reduced fertility rate and survival rate within a population.	(Zhengqiang, Ying and Zhibing, 2022)
56	Amyloidosis	Marine and coastal birds in captivity	Report of wild herring gulls (*Larus argentatus*) developing systemic amyloidosis upon capture within eight days. Multifactorial stressors.	(Hoffman and Leighton, 1985); (Jansson *et al.*, 2018)
			Charadriiformes seem to be particularly prone to develop amyloidosis when in captivity.	(Jansson *et al.*, 2018)

		SBS	Detected in captive SBS in combination with other diseases (e.g. pododermatitis, gut infections, etc.).	(WWT Captive SBS Health reports, 2012-2023 – *internal reports)*
57	Acute meteorological and environmental conditions (e.g. heat, cold, floods, etc.)	Captive shorebirds (waders)	Shorebirds may suffer if allowed to remain on frozen ground for prolonged periods. Heat sources are recommended when temperatures fall below 4.5–7 °C, particularly if a collection consists of small species sensitive to low temperatures.	(AZA Charadriiformes Taxon Advisory Group, 2014)
		Captive avian species	Sudden bad weather can affect aviary set-up i.e. pest-deterrent electric fence along the aviary (e.g., fallen trees, floods, etc.). Care should be taken to shield electrical appliances or cables to reduce the risk of electrocution.	(Chitty and Monks, 2018)
58	Climate change	All bird species	Increased nest predation causing decline in shorebirds especially in the Arctic, linked to climate-induced shifts in predator-prey relationships.	(Kubelka *et al*., 2018)
		Artic insectivorous birds	Food source availability: Climate change in the Arctic is leading to ‘earlier’ summers, creating a phenological mismatch between the hatching of insectivorous birds and the availability of their invertebrate prey.	(Saalfeld *et al*., 2019)
		All wildlife and human population	Emergence of potential pathogens along a permafrost thaw gradient. E.g. *Bacillus anthracis, Variola* virus*, Influenza* virus.	(Wu *et al*., 2022)
		Ground nesting waders	Flooding of breeding site (flood plains) can reduce the quality of eggs and number of eggs collected.	(Loktionov *et al*., 2023)

3. Hazard Prioritisation

Once infectious and non-infectious diseases have been identified, actions to prevent those most relevant to the HS programme need to be established. For this, a method of prioritisation based on scoring systems used in other WWT's HRAs (Beckmann *et al.*, 2017) is followed. Risk is quantified by the likelihood of the hazards developing and the severity of consequences to the programme if they occur (Table 4).

3.1 Likelihood and consequences

Likelihood is described as the probability or chance of the hazard occurring throughout the progression of the HS programme, with a score of 4 being highly likely or 'almost certain' to occur and 0 indicating minimal chance of developing. In parallel, the severity of the impact of the hazard, should it occur, is assessed. This also considers the programmes capacity to address or respond to each potential hazard effectively.

Table 4 – Quantitative scoring of 'Risk' based on the likelihood (0 – 4) and associated severity of the consequence (0 – 5) of a hazard

Likelihood of a given risk was scored from 0 to 4 using these criteria:	
4	**Almost certain** (>90% chance) to occur during the life of the project
3	**Likely** (50–90% chance) to occur during the life of the project
2	**Possible** (10–50% chance) occurrence during the life of the project
1	**Unlikely** (<10% chance) to occur during the life of the project
0	**Will not occur** (0% chance) during the life of the project

Severity of a given risk was scored from 0 to 5 using these criteria:	
5	**Catastrophic** – severe and irreversible damage to at-risk group
4	**Major** – severe damage to at-risk group, damage reversible but at high cost, violation of law/regulation
3	**Moderate** – significant disruption to at-risk group, reversible damage
2	**Minor** – some disruption to at-risk group, minor and reversible damage
1	**Minimal** – trivial problem easily handled; no lasting damage caused
0	**Zero** – no damage caused

3.2 Risk scores

The numerical criteria designated to create 'risk likelihood' and 'severity scores' were then used to produce an overall risk score for the main hazards of concern. 'Risk scores' are categorised qualitatively as 'Very High', 'High', 'Medium', 'Low', 'Negligible' or 'Uncertain' according to certain thresholds (Table 5). To obtain an overall risk score, 'likelihood' and 'severity' scores are multiplied (Table 6).

Table 5 – Risk scores

0	**Negligible risk**
1-4	**Low risk** – no mitigation strategy required
5-9	**Medium risk** – there should be a clearly defined mitigation strategy
10-14	**High risk** – there should be a detailed mitigation strategy and consider modifying project plan
15-20	**Very high risk** – serious consideration should be given to discontinuing the project.

Table 6 – Risk scores: Likelihood and severity scores are multiplied

	SEVERITY OF CONSEQUENCES					
LIKELIHOOD	**0 Zero**	**1 Minimal**	**2 Minor**	**3 Moderate**	**4 Major**	**5 Catastrophic**
4 Almost certain	0	4	8	12	16	20
3 Likely	0	3	6	9	12	15
2 Possible	0	2	4	6	8	10
1 Unlikely	0	1	2	3	4	5
0 Will not occur	0	0	0	0	0	0

Risk scores are assigned based on the ecological epidemiology of infectious diseases, known susceptibilities of Charadriiformes to various pathogens, including prevalence, incidence rates, ongoing outbreaks, environmental conditions, and expert experience.

Potential hazards of concern for the SBS HS programme are selected from the hazard's identification Tables 2 and 3 and scored to address those with the most significant potential impact on the HS project (Table 7). Main relevant diseases chosen for risk prioritisation are presented below:

Infectious:

- HPAIV
- Enterobacteriaceae infection (e.g., *E. coli, Campylobacter* spp., *Salmonella* spp.)
- Candidiasis (*Candida albicans)*

Non-infectious:

- Trauma
- Pododermatitis
- Foreign body entanglement
- Environmental conditions
- Predation

Other:

- Amyloidosis

Table 7 – Risk prioritisation matrix for HS SBS

Main hazards	Likelihood score		Severity of consequences score	Risk score		Risk category	
HPAIV*	2	3	5	10	15	High risk	V. high risk
Enterobacteriaceae	2		3	6		Medium risk	
Candidiasis**	1	2	3	3	6	Low risk	Medium risk
Trauma	2		4	8		Medium risk	
Pododermatitis	3		2	6		Medium risk	
Foreign body entanglement	2		2	4		Low risk	
Environmental	2		2	4		Low risk	
Predation	2		4	10		Medium risk	
Amyloidosis**	1	2	3	3	6	Low risk	Medium risk

Notes:
* Risk fluctuation due to uncertain pandemic dynamics and location
** Risk varies on exposure and type of captivity

In reference to the 'Sources of Uncertainty' section and the use of captive bird data, hazards associated with captive SBS at WWT have been considered; however, the risk scoring will differ for the HS group. Although the same species is being analysed, the environment is just as influential a factor as the host and agent in the context of infectious disease (Jakob-Hoff *et al.,* 2014). The differing environmental conditions between long-term captivity in the UK and short-term captivity in northeast Russia can significantly alter disease transmission dynamics and prevalence. Therefore, risk assessments must account for these environmental variations when assigning risk categories.

Primary health concerns in the SBS conservation breeding programme in the UK included amyloidosis, pododermatitis, candidiasis, and trauma. All these health issues can be linked to varying degrees of physiological and pathological stress issues or an inevitable mishap (e.g. minor injury from fright-flight). Although these diseases are more common in birds kept in long-term captivity, they add to the health management knowledge of the species, from a veterinary perspective.

Once the main health hazards of concern are identified and their mechanisms of development understood, knowing how these hazards may occur, to what extent, and which activities favour their appearance will lead to a better understanding of potential impacts and the best preventative management. This will contribute to the overall project's outcome (Beckmann *et al.*, 2022).

3.2.1 Amyloidosis

Low risk	Moderate risk

Characterised by the deposition of protein in tissues, primarily in the renal and hepatic systems. While the direct mechanism behind this condition is still somewhat uncertain, inflammatory processes, such as pododermatitis or enteric lesions resulting from gut infections that chronically activate the immune system, are likely aetiologies that promote the onset and progression of this disease (Landman, Gruys and Gielkens, 1998; Chitty and Monks, 2018). Other reports suggest physiological stressors from being kept in captivity, high density flocks and parasitic or ingestion induced emergence as contributors (Murakami, Ishiguro and Higuchi, 2013). With the SBS HS programme, the short time birds spend time in captivity and at a young age, makes this health hazard of reduced relevance.

3.2.2 Candidiasis

Low risk	Moderate risk

Fungal infection caused by *Candida albicans*, a ubiquitous yeast of opportunistic nature found in the environment and commonly associated with poor hygiene and stress conditions. It is frequently found in young birds, making it a prevalent issue in captive collections (Hoppes, 2021). The captive SBS in the UK have experienced recurring flare-ups of candidiasis (WWT Captive SBS Health reports, 2018-2023 – *internal reports*) and although sensitivity to disease is evident, exposure to this pathogen will depend on location (geographic prevalence), hygienic conditions within incubation and rearing facilities and immunological status of the individuals. Within the context of the HS programme at Meinypil'gyno, the short-term captivity and outdoor rearing stages means the likelihood of exposure and morbidity is considered low.

3.2.3 Pododermatitis

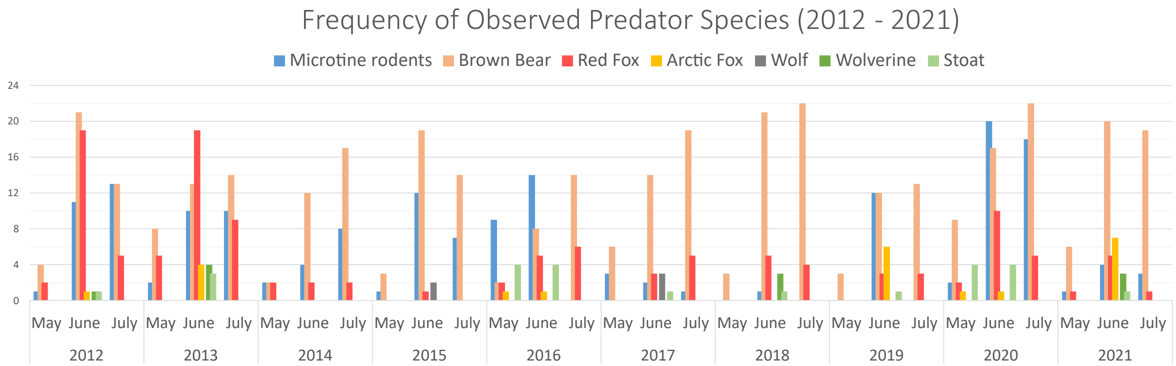
Moderate risk

Commonly known as 'bumblefoot', has been frequently and intermittently observed within the SBS captive collection at WWT and in the HS SBS. It is a multifactorial cutaneous condition of the feet and can present with varying degrees of severity depending on its chronicity and cause. Within the captive SBS at WWT, it has sometimes self-resolved with minor husbandry changes, while in other cases, it has required a short course of topical treatment, anti-inflammatories, and/or antibiotics administered orally in insects e.g. Mealworm larva (*Tenebrio molitor*). Left untreated other issues can develop from secondary infection, e.g. non-weight bearing lameness, infection, tenosynovitis (inflammation and infection of tendons and synovial sheath) and osteomyelitis (inflammation and infection of the bone and bone marrow) in foot and limb joints. Other shorebirds from WWT-led HS projects (e.g. HS E. curlew and HS Black-tailed godwits) housed in short-term captivity (but longer than HS SBS) have also presented pododermatitis that either self-resolved or required single-application of topical treatment (Hiscock *et al.*, 2021). Although the development is likely, the impact is minor due to the short time spent in captivity.

3.2.4 Predation

Moderate risk

Predation pressures at the breeding grounds presents an additional threat to those encountered along the SBS's migratory flyway. In combination with weather conditions, this can influence the year's proportion of failed nests and relay of second clutches (Zöckler *et al*., 2010). Nest predation, by terrestrial predators (Figure 4) and avian predators such as ravens (*Corvus)*, skuas (*Stercorarius*), and herring gulls, can result in SBS egg loss. Reproductive disruption due to nest predation in wild ground-nesting Arctic wader populations is common and increasing (Kubelka *et al.*, 2018; Léandri-Breton and Bêty, 2020). Loss of eggs from first clutches before they are fully completed reduces the number of viable eggs available in each nest; thereby reducing total clutch size and growth rate for that population, where second clutches or replacement clutches aren't stimulated. This can be mitigated by prioritising the collection of first clutches (Loktionov *et al.*, 2023). The likelihood of predation can also vary with the presence of alternative prey species, such as voles (Arvicolinae), and environmental conditions, including climate factors (Kubelka *et al.*, 2018). Year-round monitoring of these prey populations could provide valuable data for estimating the number of SBS eggs needed to reach the target number of released HS birds (e.g., increasing collection if predation risk rises due to scarce alternative prey). Predation is considered a moderate risk; while measures can buffer its effects during nesting, it may still affect the survival of released HS SBS. Raptors preying on released HS chicks could compromise the overall success of the HS programme. Predator aversion techniques may also be employed to reduce the risk to HS SBS.



(Data taken from Bird Russia's HS expedition reports; Tomkovich *et al*., 2022)

Note: Field observations suggest that, among the species recorded, foxes, stoats, and ground squirrels are likely to pose a significant threat to SBS, particularly to eggs and chicks. Falcons may threaten adults and fledged birds, while skuas are reported to pose a risk across all life stages.

Figure 4 – Frequency of terrestrial predator species observed within the surrounding areas of Meinypil'gyno.

3.2.5 HPAIV

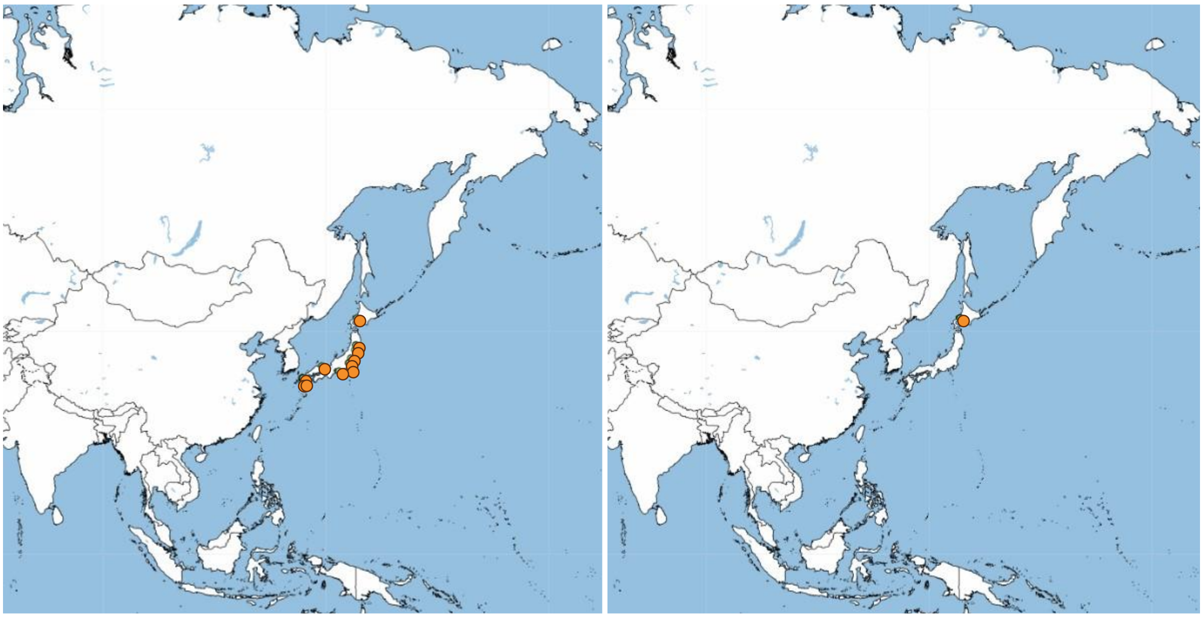
High risk	V. High risk

The status of HPAIV is constantly evolving. Recent shifts have been observed in gull species in Europe, with novel persistent Eurasian strains undergoing further reassortment and mutations within the American continent. There has been confirmed transmission to a broader range of non-avian species, including marine mammals, ground predators such as foxes and mustelids, and even domestic cats and humans (Freath *et al.,* 2023; Alexakis *et al.,* 2024).

Although Chukotka is remote, northeast Russia hosts avian species that use multiple migratory flyways extending across the eastern and western Palearctic regions. These flyways include inland and coastal corridors spanning the Russian and Asian continents. Notable species using these routes include Bewick's swans (Cygnus bewickii) (Wei *et al.,* 2023), Dunlins (Lagassé *et al.,* 2020 and IUCN Peatland Programme, 2024), Red knots (*Calidris canutus*) and Bar-tailed godwits (Piersma *et al.,* 2016).

Limited access to regions may reduce the number of reported cases; however, field expeditions conducted prior to the HS project can help mitigate this limitation and offer valuable insight for assessing the risk levels of wild bird populations potentially affected by HPAIV in the area. Reported H5 HPAIV cases outside the breeding season, the tracked spread along different flyways (Figure 5) and species affected has led to the classification of 'High risk' and 'Very High risk' especially due to the impact HPAIV can have within a flock of birds once it is present (Hall *et al*., 2011). However, no cases have been reported at Meinypil'gyno.

Vertical transmission (maternal transmission of infection into the egg) of LPAIV/HPAIV is unlikely, with no evidence of natural occurrence. Inoculation experiments in chickens have assessed the viral load required for the virus to pass to the oviduct at the right moment when eggs are formed (note that chickens have much higher egg production and are therefore not entirely comparable to wild avian species) (Stephens, Spackman, and Pantin-Jackwood, 2020). These experiments indicate that vertical transmission is rare. However, contamination of HPAIV may occur from the parents' faeces within the nests, which can stain the eggs or expose the hatchlings to the virus. Consequently, dipping eggs in a licensed disinfectant, could be implemented if the risk is deemed very high. It is also advised not to collect from nests abnormal-looking eggs (e.g., thin-shelled or partially predated eggs).



Sept 2022 – March 2023 April 2023 – Sept 2023

Figure 5 – Confirmed positive H5 HPAIV cases in domestic avian species, wild avian species and environmental samples taken along the EAA Flyway (EMPRES-i, 2024)

3.2.6 Trauma

Moderate risk

Trauma is a leading cause of morbidity and mortality among waders requiring veterinary care in captivity (Pizzi and Seddon, 2016). Trauma accounted for approximately 10% of mortality of the captive SBS population at WWT, often resulting from fright-flights (WWT Captive SBS Health reports, 2014 - 2023 – internal reports). Trauma can present acutely, but if the internal damage is not severe, it may lead to debilitation first which can then increase risk of further injury or susceptibility to disease. Detecting blunt force trauma can be challenging without a postmortem examination, potentially delaying the implementation of a response plan and necessary changes to husbandry practices.

The HS project involves obligatory handling for certain activities which increases the likelihood of occurrence. Capture is required to transfer birds from indoor to outdoor rearing aviaries and for ringing or tagging to ensure chicks are identifiable post release. Handling of small avian species has an attributive risk of trauma and stress (Pollock, 2010) that can be reduced using experienced personnel and short restraint times.

Trauma, however, can act not only as an indicator of inadequate rearing infrastructure and set-up but also a suboptimal nutritional plan. Suboptimal diet or deficiencies can be evidenced with the presentation of weakness or fractures (metabolic bone disease) in reared birds. Easily traumatised eggs (thin eggshells) and/or hatchlings with fragile bones may indicate a larger problem affecting the wild parents' health condition (e.g. through nutritional deficiencies, environmental contaminants, toxicosis, etc.) (Miljeteig *et al.,* 2012).

3.2.7 Bacterial infections

Moderate risk

Enterobacteriaceae, such as *Campylobacter* spp. *Escherichia coli*, and *Staphylococcus aureus,* are carried by most mammals and birds and are commonly found in water sources. These bacteria are considered commensal in waterbirds. However, when an individual experiences discomfort or is subjected to stress factors resilience to bacterial infection reduces. This can lead to gut and skin disease such as progressive ulcerative pododermatitis which can progress into articular swelling, and consequent secondary lameness. These conditions exacerbate discomfort and stress, further affecting their immune status and resilience to disease.

Yolk infections, or omphalitis, have also been reported in hatchlings of the captive SBS population in the UK and within the HS project (Clements *et al.*, 2021; Loktionov *et al.*, 2023). Parental incubation is thought to reduce the prevalence or development of bacterial and fungal presence on eggshells compared to eggs that are not parentally incubated (Assersohn *et al*., 2021). If a chick hatches with yolk protrusion or retention, the risk of infection is very high if left unaddressed, particularly as it might lead to other developmental disorders. Given this context, although the likelihood of infection can be reduced with good husbandry and medical practices, the impact on the health of an individual, particularly during the early rearing stages, can be significant and may extend to brood level therefore there is moderate risk.

4. Translocation Route

4.1 Translocation pathway

The relationship between agent, host, and environment along the translocation pathway from egg collection to the release of HS SBS is reviewed. This allows the analysis of where and how each component of this epidemiological triad overlaps (Figure 6).

Step 1: Incubation set-up and rearing facility

A building (house) in Meinypil'gyno was rented during the summer months to function as the artificial egg incubation and early stage rearing facility. It was cleaned and disinfected. Separate rooms were set up for incubation, for rearing purposes, and cleaning routines. One room was used as a bedroom for aviculturists to remain present 24/7 to attend eggs and young birds in case power shortages affect the equipment.

Step 2: Disinfection and calibration of equipment

Specialist personnel, including arctic wader fieldworkers and aviculturists experienced in egg incubation and chick raising methods for wader species, retrieved equipment from storage and set up, test, and repair accordingly. All equipment was disinfected ready for use.

Step 3: Nest search

SBS nests were located by experienced arctic wader field workers who had access to off-road vehicles and motorised boats. Nests were only approached by foot. Nests were visited every 24-48 hours until the clutch was complete. Where possible, parental incubation was allowed to commence before egg collection.

Step 4: Egg collection

Given the terrain and distance of the nests from the artificial incubation/rearing facility, an off-road vehicle was used to get within a few kilometres of a nest. A 12v battery-powered portable incubator operating at 36°C was then carried by hand to the nest and the eggs carefully placed inside. Over very rough terrain, eggs were placed in an insulated box and walked back to the portable incubator waiting at the vehicle, to avoid carrying and potentially dropping heavy equipment. Once back to the vehicle the eggs were driven cautiously to the facility.

Step 5: Egg processing

The incubation stage of each clutch was assessed using each egg's mass and linear measurements to estimate fresh egg mass. Eggs were also candled to assess for damage and to ascertain embryo development. The shell of each egg was uniquely marked with permanent ink to enable individual identification of eggs before being placed into a stationary incubator at the incubation/rearing facility.

Step 6: Egg incubation to point-of-hatch

The stationary incubator was set at 37.5°C and 50% relative humidity (RH). Eggs were turned automatically and manually through 180° 24-36 times throughout each day. Eggs were weighed at least every other day to track the weight loss trend, aiming for a 15% 'loss' of estimated fresh mass over the incubation period to the point of hatch. Eggs with a mass loss projection that deviated from the optimum 15% or expected trend were moved to an incubator with more appropriate RH with daily monitoring until 'back on track'. Those eggs that were suspected to contain dead embryos or had artificially repaired damaged (e.g. cracked) shells were placed in a separate incubator to avoid any possible cross-contamination to healthy embryos.

Step 7: Hatching and drying

Once the chick had entered the airspace of the egg ('internally pipped') to begin the hatching process the egg was moved to a 'hatcher' incubator. This incubator operated at approximately 37.2^{o}C and 70% RH. The eggs were no longer turned. 'Internal pipping' to 'external pipping' (i.e. when the chick begins to break its shell) 1-2 days. It took another 2-3 days for the chick to emerge completely. Once hatched chicks were left for a short period to rest, then transferred to a 'drier' incubator operating at 37^{o}C and ambient RH (approximately 40-50%). Upon handling at transfer from 'hatcher' to 'drier', chicks were visually inspected, and their navels disinfected with iodine solution. At this point, chick mass was recorded and an identifying colour ring placed on the left or right tibiotarsus. Chicks remain in the drier for 24-36 hours.

Step 8: Indoor rearing

Once the chicks are dry and active they are moved in groups of 3 or 4 to 1 m x 0.5 m brooders. In transit they are given a unique leg flag on the right tibia and metal rings on the left tibia. The brooders have a thermostatically controlled 'hotspot' at one end of the brooder, initially set to 36^{o}C (decreased by 0.5-1°C daily). The 'hotspot' has a soft blanket substrate. The substrate elsewhere in the brooder is a variety of non-slip materials. Multiple food and water dishes (age-appropriate sizes) with a mixture of artificial and natural food depending on chick age were available ad lib. UV lighting was provided above food and water dishes. The chick diet comprises an artificial wader pellet diet, insectivorous enriched soft food, mineral and vitamin supplements, and wild caught aquatic and flying invertebrates. The food and water were refreshed every 3 hours. Grit and opportunities to forage on pieces of tundra 'turf' was provided to chicks aged 3-4 days. At around 5-6 days, broods of chicks were put together in larger corrals on the floor of the rearing room with the same provisions as brooders. At around 7-8 days old, when chicks reach approximately 13 g, they were transported to the outdoor rearing aviary which was also the release aviary. They were transported in fleece lined cardboard boxes driven slowly in an off-road vehicle.

Step 9: Outdoor rearing

The 20 m x 3 m aviary was located 3 km outside of the village on the shore of a brackish lake in known breeding habitat of wild SBS. The aviary had a metal polytunnel structure with the lower portion covered in a small gauge wire mesh buried partially to exclude ground/digging predators. The upper portion was covered in nylon netting to exclude avian predators. An inner layer of soft netting was used to prevent collision injuries with the metal frame.

The aviary was surrounded by a battery-powered electric fence to deter large ground predators. The aviary perimeter being monitored by fieldworkers 24/7 to ensure large predators and avian predators are deterred.

Once the chicks arrived at the aviary, they were initially housed in small, heated shelters matching the temperature of the rearing facility. The heat was reduced over several days. Chicks were kept in this enclosure for 24-36 hours before given access to a small portion of the aviary along with the shelters. The space was gradually increased until they had full access to the aviary. Artificial diet provision continued with an increased proportion of naturally occurring live food. Food and water were refreshed every 4 hours.

Step 10: Release

The birds were soft released from the outdoor rearing aviary at the release site. The food and water dishes were removed from inside and placed outside near the door. The electric fence and the door were then removed to enable fledglings to walk out in their own time. This usually took between 1-2 hours. Once all the birds had left, the door was replaced. Once all HS SBS had dispersed from the release site the aviary was dismantled and food and water dishes removed.

Step 11: Post release monitoring

This was usually performed twice a day for one-hour intervals (weather depending) at times of high activity. The shoreline area 100 m north and 100 m south of the release pen was checked. Monitoring took place until no birds were observed within the immediate area or until surveyors left Meinypil'gyno.

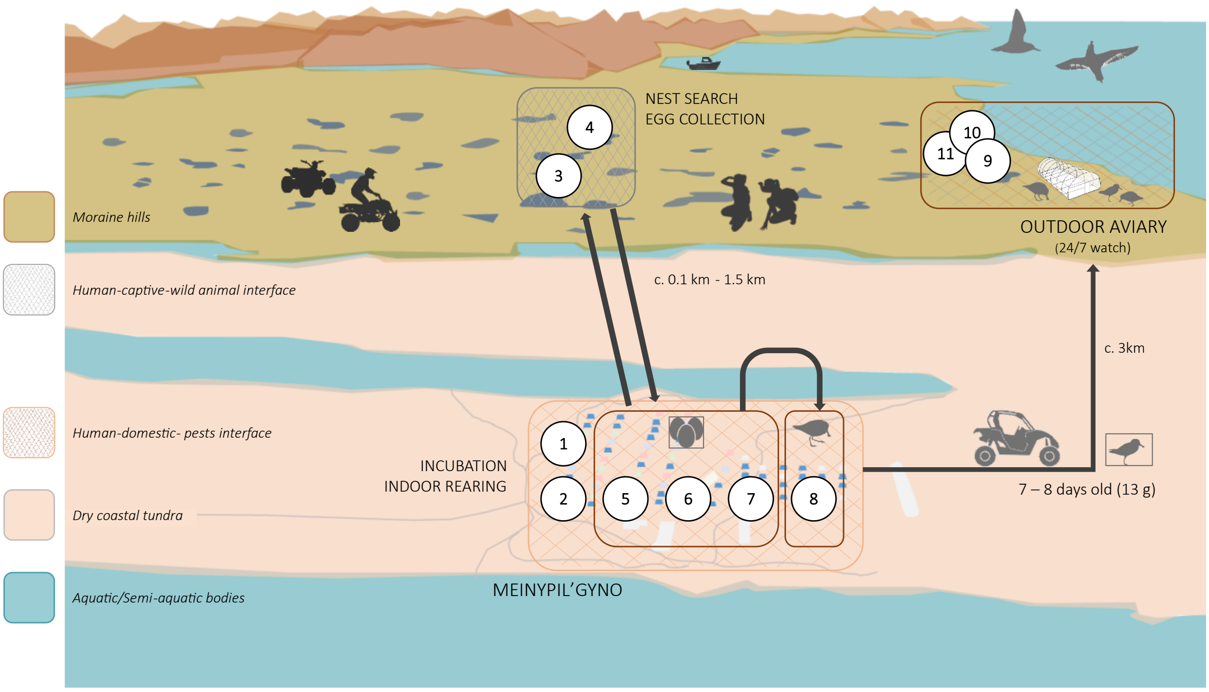


Figure 6 – Along the translocation pathway, the agent-host-environment interface will vary at each stage since exposure to hazards will also vary depending on controllable and uncontrollable variables

5. Hazard Transmission Routes and Critical Control Points (CCPs)

5.1 Identification of hazard transmission routes

Based on the translocation pathway, hazard types (see Tables 8, 9, 10 and 11) can be used to identify risks to target hosts or risk groups, as well as critical control points (CCP) (Table 12) where measures to reduce pathogen exposure and contamination have a higher and more important impact than at the rest of the translocation pathway. This will enable a better use of resources and create awareness of more relevant focal points (Figure 7).

Risk groups are those potential hosts or environments including vectors that may have exposure to or presence of pathogens of concern within a specific phase and/or holding.

Table 8 – Hazards type/name as determined by the origin, extent and means of transmission, novelty of emergence within the different stages of the programme, environment and corresponding harm to the HS SBS population

Hazard type		**Definition**
No.	**Name**	
1	SOURCE	Infectious agents, or strains of these agents, from the source population, which are novel to and could cause harm in: a. species in the release region b. species in direct or indirect contact with the translocated/HS population during its transport/ captivity
2	CONTAINMENT	Harmful, possibly novel, infectious agents, or strains of these agents, which translocated/HS animals may encounter during transport or captivity and potentially transmit to other species on release: a. from species in direct or indirect contact with the captive, translocation/HS population b. present in areas in which translocated individuals are held during transport and captivity
3	DESTINATION	Infectious agents in the release region which are harmful and potentially novel to the released population
4	CARRIER	Infectious, including commensal, agents in the source population, which have potential to cause disease in translocated individuals under certain conditions e.g. stress, and which could potentially cause disease in species at the destination under similar conditions (but which are not novel to these species)
5	ZOONOTIC	Zoonotic infectious agents present in: a. translocated individuals, or b. project sites that may harm project human beings (personnel or visitors)
6	ANTHROPONOTIC	Infectious agents, other than Containment Hazards, that humans (programme personnel or the visitors) could: a. carry on their footwear, clothes or equipment, b. or are infected with, which could harm the translocated population, or species at the source or release sites
7	RESERVOIR	Infectious agents found in the release environment for which the risk to local species could be intensified through addition of the new hosts to the region
8	AT-SOURCE	Infectious agents in the source environment posing a population-level threat to the source population

Note: The hazard types were initially adapted from those advocated by Sainsbury and Vaughan-Higgins, 2012; Bobadilla Suarez *et al.,* 2015 and then further fitted from other WWT species recovery HS health risk assessments (Beckmann, K. *et al.,* 2017)

Table 9 – **SOURCE ENVIRONMENT:** Early project stages (e.g. egg collection and transport)

Risk group	**Hazard type**			
	8	1	6	5
Environment at source *Including other free-living wildlife, domestic animals (e.g. cats, dogs), vectors or environmental reservoirs of infectious agents*	What risk do infectious agents pose to the SBS source population? *(incl. agents encountered along the flyway)*		What infection risk do project personnel pose to the source SBS population and other species at the nesting sites?	
Captive environment *Transport vehicle and portable incubators*		What risk do infectious agents from the source SBS population pose to other species on route during transport?		What risk do zoonotic agents in the source SBS population (incl. eggs) and within the environment travelled pose to project personnel?
Project personnel *Field staff and captive rearing*				What risk do zoonotic agents the source SBS population/environment (incl. eggs) pose to field staff on handling?

Table 10 – **CAPTIVE ENVIRONMENT:** Early to mid-rearing stages include an overlap with 'late' collected eggs, incubation and indoor rearing in brooders at Meinypil'gyno, as well as movements between these stages

Risk group	**Hazard type**			
	2	1	6	5
Captive environment *Incubators and brooders*	What risk do infectious agents present at Meinypil'gyno pose to the HS eggs and chicks?	What risk do infectious agents carried by the HS eggs (surface) or chicks (vertical transmission) pose to the environment at Meinypil'gyno or within their captive environment?	What infection risk do project personnel pose to the HS eggs/chicks?	
Project personnel *Field staff and captive rearing*				What risk do zoonotic agents in the HS eggs or chicks pose to the avicultural team?

Table 11 – **RELEASE ENVIRONMENT:** Mid-end rearing stages of SBS chicks involve transporting SBS chicks weighing at least 13 g (7–8 days old) to outdoor aviaries at the release site, approximately 3 km from the indoor facility

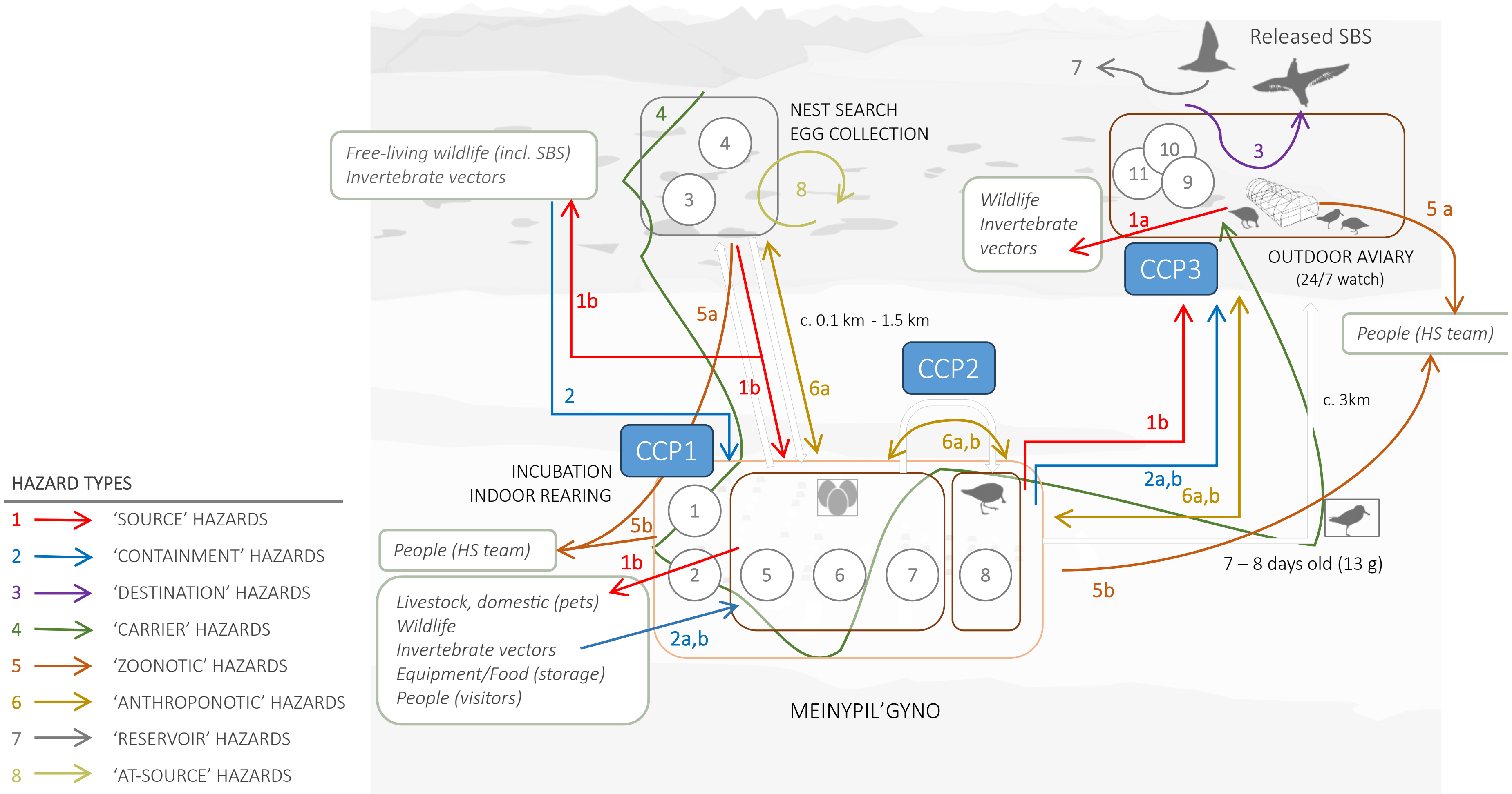
Risk group	**Hazard type**						
	2	1	6	5	4	7	3
Captive environment *Release aviary and transport*	What risk do infectious agents in environment along the transport route and the release aviary pose to the HS SBS?	What risk do infectious agents carried by the HS SBS pose to other species along the transport route?	What infection risk do project personnel pose to the HS chicks during transport to the release aviary and then on their return to the indoor HS SBS?		What risk do infectious (incl. commensal) agents in the source population pose to translocated SBS' health after transport/handling stress?		
Project personnel				What risk do zoonotic agents in the HS chicks, release environment and during capture for assessment pose to the avicultural team, vet team and field team?			
Release environment (*Including other free-living wildlife, domestic animals, vectors or environmental reservoirs of infectious agents)*	What risk do infectious agents at the release aviary pose to the captive HS SBS and other species on release?	What risk do infectious agents from the source population carried by the HS SBS pose to other species at the release aviary?	What infection risk do project personnel pose to the environment and HS SBS at the release site?		What risk do infectious, (incl. commensal), agents in the source population pose to translocated SBS' health post-release stress and other species under similar conditions at the release site?	What is the risk that the translocation could lead to intensification of infection already present in the release environment?	What risk do infectious agents at the release sites pose to the translocated SBS post-release?

5.2 Critical control points (CCPs)

Critical control points are designated based on areas where hygiene and biosecurity measures have the greatest impact of reducing or eliminating an infectious agent or its consequences if present. These points tend to be where breaches are of higher risk.

Table 12 – CCPs and the type of transmission any action taken intends to target

CCP#	CCP target	Description
CCP1 (Between Source and containment)	a. Contact between wild species and eggs collected b. Contact between environment and eggs. c. Infected wild birds d. Human and vehicle movement, fomites e. Incubators	Contamination of infectious agent at the nest from either: - Faeces of infected parents - Faeces of other wild species - Residues from predated or damage egg of the same clutch Contamination from personnel in charge of field monitoring, nest finding and egg collection who have been in contact with: - Other infected SBS nests - Infected domestic species - Infected wild species - Contamination via other personnel (e.g. shared gloves, vehicle, handshakes, etc.) Contamination of eggs from incubators - Damaged eggs - Build-up of environmental residue (e.g. nest material, feathers dust)
CCP 2 Containment (incubation or indoor rearing)	a. Contact between eggs b. Contact between eggs and hatchling c. Incubators d. Brooders/Indoor rearing unit e. Human movement between incubators and brooders – e.g. handling	Vertical and horizontal bacterial transmission of eggs: - Damaged eggs within incubators will act as a source of bacterial contamination to other eggs and hatchlings. - Hatchlings of ill-health may contaminate the incubator and promote transmission of infectious agents to other clutches as well as introduce disease into the chick rearing facility (e.g. brooders) - Infectious agent build-up within incubators becoming a source of infection to personnel. - Personnel can transmit disease to the brooders when moving hatchlings or when checking eggs and hatchlings when these start to co-exist as the project progresses (Overlapping rearing stages). This risk may be heightened when personnel are housed within the same building.
CCP 3 Containment and release site	a. Contact between wild birds and HS SBS b. Human and vehicle movement, fomites returning to base camp. c. Infected wild birds d. SBS infecting wildlife	Exposure to wild birds once transferred to the outdoor aviary. Transmission of any infectious agent to HS SBS chicks in the outdoor/release aviary by personnel in charge of health care of 'sick' chicks indoors. Transmission of any infectious agent by personnel in charge of health care of sick HS SBS chicks onto the release site. Zoonotic agents' transmission between personnel if tasks shared during transport to, and subsequent management of chicks, at the release site. Or during release site monitoring handover.



Note: These are areas where breeches in biosecurity or exposure to pathogens can easily happen, as well as, where hygiene and biosecurity measures have the greatest impact

Figure 7 – Hazard types along the translocation pathway with Critical Control Points (CCP) indicated

6. Risk Assessment and Management

6.1 Risk management for priority hazards

An analysis of the priority hazards facilitates the determination of risk levels for each hazard type at each stage of HS activities. Mitigation actions to reduce risk, if feasible, can then be implemented (Tables 13 and 14).

Table 13 – Mitigation actions for infectious hazards with their associated risk level based on hazard types and HS project stage

<table>
<tr><th>Infectious hazard</th><th>Risk level</th><th>Additional mitigation measures feasible and advised?</th><th>Mitigation action/s</th></tr>
<tr><td colspan="4">1. Highly pathogenic avian influenza (HPAI)
Transmission pathways of concern:</td></tr>
<tr><td>a. At-Source</td><td>Uncertain and temporally variable; potentially V. high (emergence of novel Eurasian HPAIV strains together with known HPAIV strains along the EAAF)</td><td>N</td><td>• Monitoring and field survey to record and ascertain causes of mortality in wild SBS, other avian species and marine mammals.
• Produce contingency plan for HPAIV: If risk is considered High in any given year, translocation may not be justifiable.
• SBS Task Force - to discuss the national AI situation and its relevance to SBS work.
• Risk to be reviewed before, and during, each rearing season, as the national HPAIV outbreak picture can change rapidly and unpredictably.</td></tr>
<tr><td>b. Containment hazard
i.e., exposure may be encountered at nests, HS SBS during rearing, travel and at release sites. Potentially be transmitted from HS SBS to other birds on release.</td><td rowspan="2">Uncertain and temporally variable; considered Medium (Impact high but likelihood low. No known cases reported at Meinypil'gyno)</td><td>Y</td><td rowspan="3">• Entrance portals to facilities to ensure that 'dirty' and 'clean' spaces are established at the incubation and rearing facilities.
• Handling of eggs on collection, when processing, weighing or candling to be done with disposable gloves and/or hands washed thoroughly in between any egg handling if gloves not available.
• An additional team member, not part of the egg collection or nest-finding team, based at the incubation facility, prepared for the arrival of SBS eggs. This minimises introduction of viral agents from the field into the incubation facility.
• Alternatively, mitigation measures could include putting solid plastic over the release-rearing aviary/ies or alternative roofs to avoid wild bird droppings entering the aviary/ies. Added spikes on potential perching surfaces to deter wild birds from resting on the aviary/ies.
• During each rearing season, project staff will not handle other wild birds or their carcasses.</td></tr>
<tr><td>c. Destination hazard
i.e., may be encountered by HS SBS once they've been released – at the release site or further afield.</td><td>Y</td></tr>
<tr><td>d. Zoonotic hazard
i.e., present in HS SBS, or at the collection and release sites, and may harm project personnel or visitors. HPAIV could be present in wild birds or their carcasses.</td><td>Uncertain and temporally variable; considered Medium; may increase with wider dispersal of infected migratory species or with the incursion of a more zoonotic strain</td><td>Y</td></tr>
</table>

			• Biosecurity measures and strict hygiene standards in place PPE (gloves, goggles, mask), disinfection of portable incubators prior and after use, disinfection of vehicle before and after use.
2. Other infectious agents: e.g., coccidial parasites, helminths (nematodes, cestodes, acanthocephalans), ectoparasites or commensal bacteria e.g., *Campylobacter* spp.; *Candida* spp., and unknown infectious agents			
Transmission pathways of concern:			
a. Carrier hazards i.e., infectious, including commensal, agents in the source population, which have potential to cause disease in HS SBS under certain conditions.	Low (collection of eggs)	N	• Keep veterinary team updated with incubation stage and predicted hatch timeframe. • Ensure any potentially infected eggs/chicks are kept separate from others and "barrier nursed" (isolating the infected chicks, with each chick having their own designated PPE, disinfected equipment, and minimising contact with other animals or staff). . • Ill-health chicks and healthy chicks to be handled by different team members or by the same team member wearing different PPE. • Clean and disinfect brooders before and after use. Any brooders that have contained chicks with 'ill-health' not be used for healthy broods. • Postmortem examinations to be performed in separate location from incubation and rearing facilities, and at the end of a working shift. • The risk these pathogens pose will escalate as aviaries are re-used year-on-year - consider using a different location each year. • Faecal pathogen surveillance to be conducted during HS, and management of these pathogens to be reviewed annually based on surveillance results. • Recommended management options include pre-season re-turfing of aviaries (if allowed by local authorities), and, if these agents start to be detected, prophylactic treatment. Alternatively, relocate. • Fluid communication between aviculturists and veterinary team.
b. Containment hazard Exposure to infectious agents within captive facilities/indoor rearing stages.	Medium	Y	
c. Zoonotic hazard i.e., present in HS SBS, or at the collection and release sites, and may harm project personnel or visitors.	Low (Hygiene protocols in place)	N	

Table 14 – Mitigation actions for non-infectious hazards with their associated risk level based on hazard types and HS project stage

Non-infectious hazard of concern	Risk level	Additional mitigation measures feasible and advised?	Actions
Project stage and specific concern:			
1. PREDATION			
a. Source population Breeding ground (nest sites).	V. high	N	• If losses are substantial in any given year, procedures and mitigation measures should be reviewed. • Field surveys and monitoring. • Predator control and surveillance at release aviary. • Predator aversion training.
b. Captive environment Rearing and release aviaries.	Low	N	
c. Post release Release site.	High	N	
2. ENVIRONMENTAL			
a. Source population i. Flooding – rapid snow melt ii. Unseasonable weather – storms, ice, etc.	Medium	N	• Close collaboration with expedition team to actively monitor snow, flood risks to breeding grounds. • Expand area of nest search to accessible breeding areas.
b. Handling or transport of eggs or chicks Adverse weather during egg transport or chick handling events.	Low	Y	• Where possible, chick-handling events to be timed to coincide with relatively stable weather conditions. • Note that a maximum of 45 mins without controlled heat (eggs) has been deemed acceptable by fieldworkers studying wild SBS breeding pairs; however, should be kept to the minimum possible.
c. Captive environment i. Power outage: Loss of controlled temperature and humidity levels: incubators, brooders, indoor rearing units ii. Storms, flooding or other adverse weather, affecting the rearing/ release aviary/ies.	Medium	Y	• Back-up energy source for power outages. Record of when this occurs. • Eggs and chicks within the indoor facilities to be monitored for impact (developmental and health). • Minimal handling recommended to reduce development of secondary ailments. • Monitor outdoor/release aviary to quickly amend any damage to infrastructure. • SBS to acclimatise to outdoor rearing via gradual change in heat source.
d. Post release Storms, flooding or other adverse weather.	Medium	Y	• Avoid release in inclement weather. • GPS tracking, tag or ring monitoring to track or ID released SBS and to retrieve carcasses for postmortem examination.
3. (ANTHROPOGENIC) TRAUMA			
a. Source population Accidental nest destruction or disturbance, e.g. “domestic” reindeers, vehicles, other field researchers, etc.	Medium	N	• Establish good open lines of communication with field scientists and locals to monitor and manage increased disturbance at breeding areas.

b. Handling or transport of eggs or chicks i. Egg collection. ii. Chick handling. iii. Fitting of monitoring devices to chicks.	Low (Led by experienced team)	Y	• Involvement of at least 3 individuals, (i.e. 2 aviculturists and 1 driver): 1 aviculturist for the collection of eggs and 1 aviculturist to receive eggs at the artificial incubation facility. • Conduct and record initial assessments of eggs upon collection, prior to travel. Mark areas of concern on eggshells with indelible ink. Lesions will create internal exposure to environmental pathogens, as well as reduce the probability of hatch. Minimise damage to eggshell integrity by using appropriate-sized trays in portable incubators. • During egg translocation, where there is 'rough terrain', the aviculturist should t disembark from the (quad bike) vehicle and carry the incubator around these areas, to prevent damage to the eggs. • Handling times will be kept to the minimum necessary to fit monitoring devices and for health checks – aim for 5 minutes from beginning to end. • If traumatic injuries occur, the approach to catches will be reviewed. • Where appropriate and feasible, an experienced wildlife vet will be present at bird catches. • In case of any injuries: medication and essential supplies like splints, dressings, bandages, wound disinfectants, and other materials designed for handling trauma in birds, to be on hand for administration or application under direct/ remote vet supervision. • Once monitoring equipment is fitted, birds will be observed closely and remain in rearing/ release aviaries for a 3-7 days prior to release: adverse reactions to be investigated and dealt with promptly.
c. Captive environment i. Incidental trauma, e.g., collision or entanglement, in rearing or release aviaries.	Medium	Y	• Assessment of enclosure/brooder 'furniture, to remove/exclude potential hazards. • Written handling instructions, induction of new staff and initial supervision of new staff. • As above re. medication available for administration under veterinary guidance, and local emergency veterinary support available. • Unnecessary human presence to be limited to husbandry delivery.
ii. Anthropogenic disturbance.	Low	N	
d. Post release i. Incidental trauma e.g., collision injury. ii. Persecution. iii. Anthropogenic disturbance.	Medium	N	• Post-release monitoring will help determine extent of disturbances and causes of morbidity/mortalities • Non practicable, beyond existing control measures.

			• The extent of losses post migration is likely to be unknown.
4. NUTRITIONAL DISORDER			
a. Captive environment i. Malnutrition. ii. Deficiencies (developmental limb disorders, wing abnormalities, etc.). iii. Wild sourced food: (bio)toxin/heavy metal/chemical exposure.	Medium	Y	• Diet formulated with these issues in mind • If nutritional disease arises, diet to be reviewed carefully. • If collecting wild invertebrates as added nutritional supplement, ensure habitat is clear from any potential anthropogenic contamination (e.g. chemicals, waste), domestic animal presence, algae overgrowth, carcasses, or similar. Record sources and invertebrate species offered.
5. MANAGEMENT RELATED DISEASE			
a. Handling or transport of chicks i. Myopathy.	Medium	Y	• If capture myopathy occurs, the approach to catches should be reviewed, and oral prophylactic treatment to be considered ahead of catches • Assessment of travel conditions to address any potential stressor hazards beforehand • Monitor birds during and after travel (within release pen
b. Captive environment i. Foreign body ingestion. ii. linear object (entanglement) .	Low	Y	• Consider use of hair nets as part of PPE and review all materials (e.g. substrate) that 'unthreads' easily. • Assessment of enclosures/brooders to remove/exclude potential hazards. • Health check protocol in place to address any observed sedentary behaviour. • Review and change any surface that is observed to be abrasive, hard, moist, especially for chicks with ailment. • Ensure clean and minimal faecal contaminated flooring. • Daily updated health care, husbandry and observation records. Routine health checks (physical examinations with body score/weight checks, leg scores (photographic monitoring) and basic health parameters). • Fluid (i.e. regular) communication between aviculturists and veterinary team members.
iii. Bumblefoot.	Medium	Y	
6. BEHAVIOURAL DISORDER			
a. Post release Tameness and/or poor predator avoidance.	Low	N	• Post-release monitoring HS SBS.
7. REPRODUCTIVE/ GENETIC DISORDER			
a. Post release i. Genetic disorder. ii. Reproductive disorder.	Low	N	• To consider: Genetic structure and productivity monitored as part of current and future projects. • Field laboratory: DNA extraction for wider research purposes.

Note: As HS SBS are sourced and then released into the source population the exposure to novel pathogens on release is likely to be minimal. Implementation of biosecurity and healthcare protocols during HS activities should reduce the risk of pathogen build-up and disease throughout the overlapping stages of HS activities.

7. Health Risk Communication Plan

Coordination of preparation activities:

Purpose:

- To ensure everyone is on the same page regarding timelines, responsibilities, and requirements leading up to egg collection and incubation activities.

Actions:

- Regular meetings or briefings to discuss project milestones, roles, and resource needs.
- Documenting and sharing project timelines, goals, objectives and progress with all team members e.g., through email and project management tools.

Egg collection coordination:

Purpose:

- To ensure timely and organised egg collection and translocation activities.

Actions:

- Setting up a communication system to receive information about nest locations and egg collection opportunities. Clarifying roles and responsibilities during the collection phase to avoid misunderstandings.
- Providing regular updates on weather conditions or other factors that might affect nest search locations and egg collection timings.

Involvement of health care team for SBS:

Purpose:

- To facilitate smooth coordination and support between the avian health experts and other project members.

Actions:

- Arranging regular meetings or updates between aviculturists and the health care team members to discuss bird health and care protocols.
- Ensuring timely updates on bird health status and veterinary interventions required.
- Creation of Standard Operating Procedures (SOPs) for treatment plans or postmortem examinations.

Contingency planning and emergency response:

Purpose:

- To prepare for unforeseen circumstances e.g. non-arrival of key team members due to travel difficulties, flooding of surveyed areas, emergency collection of abandoned eggs or bird health issues.

Actions:

- Developing clear protocols for handling emergency situations, such as emergency egg collection or bird health emergencies.
- Establishing a rapid communication network (e.g., phone tree, emergency contact list) to implement immediate responses.

Communication with field trackers and nest locators:

Purpose:

- To maintain effective coordination with field personnel tracking wild SBS and monitoring egg laying and incubation activity at wild nests.

Actions:

- Field teams regular updating the project manager and lead aviculturist and other team members on nests' status and SBS movements.

- Providing field personnel with project timelines and any changes in collection plans promptly.
- Facilitating two-way communication for reporting field observations and sharing important updates with the central project team.

Project sponsor and manager involvement:

Purpose:

- To ensure overall project alignment and support.

Actions:

- Scheduled updates or progress reports to project sponsors and managers.
- Providing a platform for sponsors and managers to address concerns and/or to provide guidance, based on developments.
- Aligning all communication efforts with project objectives and budget.

The communication plan should focus on establishing transparent and efficient channels of communication among all stakeholders involved in the SBS HS project. This includes regular updates, clear delineation of responsibilities, and proactive measures to address any unexpected events or emergencies that may arise.

Recommended allocation of responsibilities for communication actions relevant to the HRA and frequency are shown in Table 15.

Table 15 – Communication plan

	Communication action	Primary responsibility	Others to keep in loop as required	Frequency
1.	Consultation on the HRA and HS plan; review of and updates	Programme Manager/ sponsor	TBD BirdsRussia SBS Taskforce	As required. At least twice yearly, pre & postseason
2.	Consultation on status of nests that are available for collection	Lead aviculturist Assistant aviculturist I Assistant aviculturist II	Meinypil'gyno based support team	On-going during project season
3	Consultation with Birds Russia's field workers on abandoned nests available for collection	Lead aviculturist	Meinypil'gyno based support team	On-going during project season
2.	Regular communication about disease issues and day-to-day health management of birds	Lead aviculturist	SBS health team Programme Manager Aviculturist team	On-going during project season
3.	Notification of novel/ potentially high-risk threats that may have significant implications for the translocation, requiring urgent discussion	Lead aviculturist	SBS health team Meinypil'gyno based team Programme Manager aviculturist team	On-going during project season
4.	Scheduled health checks/ veterinary interventions	Lead aviculturist Assistant aviculturist I Assistant aviculturist II	SBS health team Meinypil'gyno based support team	Before SBS moves
6.	Responsibility for updating HRA/ Health care plan	Veterinary Health care team	As per 1.	Annually
7.	Peer review of the HRA	Veterinary Health care team involved Lead aviculturist Programme manager/ sponsor	Avicultural team and relevant stakeholders	Annually
8.	Other groups may also be consulted as appropriate/ indicated	Programme manager/ sponsor	Stakeholders and other experts	Ad hoc

8. Implementation and Review

The HRA will require annual review to adapt to the epidemiological status of the geographic area as well as whenever there is a change in the HS plan and delivery team's composition. This is to ensure that clear delivery roles are assigned to personnel and that epidemiological, environmental or public health regulations changes and responsibilities are understood by all stakeholders

8.1 Risk management action plan

Table 16 – Management targets and review plan

Management target	Goals	Actions	Obstacles	Responsibility (Individual & organisation)	Means of review
Manage the logistical challenges of transporting people and equipment to Meinypil'gyno	Full team at Meinypil'gyno Arrival of equipment	Good lines of communication Ensure correct paperwork prior to travel	Time (BirdsRussia's invitation to fieldworkers from overseas, visa application, documentation, etc.) Weather (unpredictable) Socio-political (international relations)	BirdsRussia Collaborators	Ad hoc meetings pre/post travel Annual report
Minimal to no egg or chick losses due to predation	Reduce likelihood of predation risks	Expedition Rescue clutches Pest control Field surveys Monitored aviaries	Avian predators Post release limitations Nest site accessibility Disturbance	Field team SBS healthcare team	Annual report (field predator surveys, egg numbers collected, number of chicks released)
Awareness of samples required for investigation.	Early detection of novel health hazards Updated risk estimations HRA changes for the following season	Record keeping of SBS health Sample collection (ensure adequate kit ahead of the project) Storage until able to send to designated lab	Remote location (limited resources, limited delivery options) Time (limited sample storage, reception of results)	SBS healthcare team Lead aviculturist Field team Laboratory team	Annual report (Results from samples sent) Decision making based on results
No biosecurity breach	No cross-contamination No introduction of pathogens into HS indoor facilities	Hygiene and biosecurity protocols followed Barrier nurse and separation	Time (overlapping timings of egg collection, chick hatching and raising and rearing) Short staffed (limited if travel is postponed,	Lead aviculturist SBS health care team	Annual report (No infectious outbreaks)

Management target	**Goals**	**Actions**	**Obstacles**	**Responsibility** (Individual & organisation)	**Means of review**
	No exposure to harmful pathogens within SBS broods	of chicks of ill-health	international conflict)		
Updated HRA	Ensure health hazards assessed are current and relevant to the SBS HS timeline	Infectious disease monitoring (national and global disease surveillance platforms) Communication during the project with SBS health care team	Remote location Accessibility to data	SBS health care team Programme manager Lead aviculturist	Annual report (All health hazards accounted for) HRA review
HS project	Continuity	Assessment of results, population dynamics and future feasibility	Lack of funding	Birds Russia Programme manager SBS task force Expedition team Lead aviculturist	Biannual or quarterly meetings Ad hoc meetings

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