Bird Study

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/tbis20

Mortality among scarce breeding gulls and terns during a highly pathogenic avian influenza (HPAI) H5N1 virus outbreak in Poland during 2023

Marcin Przymencki, Szymon Beuch, Piotr Indykiewicz, Klaudia Litwiniak, Dariusz Bukaciński, Monika Bukacińska, Piotr Zieliński, Jacek Betleja, Dominik Marchowski, Mateusz Ledwoń, Szymon Bzoma, Arkadiusz Buczyński, Łukasz Wardecki, Łukasz Bednarz, Adam Flis, Halszka Łożyńska, Bartłomiej Kusal & Tomasz Chodkiewicz

To cite this article: Marcin Przymencki, Szymon Beuch, Piotr Indykiewicz, Klaudia Litwiniak, Dariusz Bukaciński, Monika Bukacińska, Piotr Zieliński, Jacek Betleja, Dominik Marchowski, Mateusz Ledwoń, Szymon Bzoma, Arkadiusz Buczyński, Łukasz Wardecki, Łukasz Bednarz, Adam Flis, Halszka Łożyńska, Bartłomiej Kusal & Tomasz Chodkiewicz (02 Jan 2025): Mortality among scarce breeding gulls and terns during a highly pathogenic avian influenza (HPAI) H5N1 virus outbreak in Poland during 2023, Bird Study, DOI: 10.1080/00063657.2024.2439131

To link to this article: https://doi.org/10.1080/00063657.2024.2439131

BIRD STUDY
https://doi.org/10.1080/00063657.2024.2439131

Mortality among scarce breeding gulls and terns during a highly pathogenic avian influenza (HPAI) H5N1 virus outbreak in Poland during 2023

Marcin Przymencki [a], Szymon Beuch [b], Piotr Indykiewicz [c], Klaudia Litwiniak [d], Dariusz Bukaciński [e], Monika Bukacińska [e], Piotr Zieliński [f], Jacek Betleja [g], Dominik Marchowski [f], Mateusz Ledwoń [h], Szymon Bzoma [i], Arkadiusz Buczyński [e], Łukasz Wardecki [a], Łukasz Bednarz [j], Adam Flis [k], Halszka Łożyńska [h], Bartłomiej Kusal [h] and Tomasz Chodkiewicz [b]

[a]The Polish Society for the Protection of Birds (OTOP), Warsaw, Poland; [b]Ornithological Research Laboratory, Museum and Institute of Zoology, Polish Academy of Sciences, Warsaw, Poland; [c]Faculty of Animal Breeding and Biology, Department of Biology and Animal Environment, Bydgoszcz University of Science and Technology, Bydgoszcz, Poland; [d]Ornithological Society of Silesia, Wrocław, Poland; [e]Institute of Biological Sciences, Cardinal Stefan Wyszynski University in Warsaw, Warsaw, Poland; [f]Ornithological Station, Museum and Institute of Zoology, Polish Academy of Sciences, Gdańsk, Poland; [g]Department of Natural History, Upper Silesian Museum, Bytom, Poland; [h]Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Kraków, Poland; [i]Waterbird Research Group KULING, Gdańsk, Poland; [j]Bird Horizons Foundation, Niedrzwica Duża, Poland; [k]Institute of Nature Conservation, Polish Academy of Sciences, Kraków, Poland

ABSTRACT

Capsule: During spring and summer 2023, the highly pathogenic avian influenza (HPAI) H5N1 virus caused mass mortality among colony-breeding gulls and terns in Poland.

Aims: To document the national impact of the 2023 HPAI outbreak on scarcer species of gulls and terns in breeding colonies across Poland.

Methods: Surveys were primarily focused within breeding colonies of Black-headed Gulls *Chroicocephalus ridibundus*, an 'umbrella species' whose breeding colonies serve as nesting sites for other scarce gull and tern species.

Results: In total, during the survey period we recorded the deaths of at least 46 Common Gulls *Larus canus*, 21 Mediterranean Gulls *Ichthyaetus melanocephalus*, nine Caspian Gulls *Larus cachinnans*, two Herring Gulls *Larus argentatus*, 1,369 Common Terns *Sterna hirundo*, 42 Little Terns *Sternula albifrons*, three Black Terns *Chlidonias niger*, two Whiskered Terns *Chlidonias hybrida* and 35 Sandwich Terns *Thalasseus sandvicensis*. The most affected populations were those of Mediterranean Gulls (12% of the Polish breeding population) and Common Terns (16% of the Polish breeding population).

Conclusions: Common Terns and Common Gulls were considered the most vulnerable species to longer-term negative population impacts. It is strongly recommended to monitor mortality and productivity of all gull and tern species during future breeding seasons, to determine the ongoing impact of HPAI.

ARTICLE HISTORY
Received 30 April 2024
Accepted 30 October 2024

Prior to 2021, highly pathogenic avian influenza (HPAI) viruses were seasonally present in Europe. The majority of infections were reported between autumn and spring, with no disease observed during the summer months (Pohlmann *et al.* 2022). However, the situation began to change in the winter of 2020/21. Initially, the disease was caused by the HPAI H5N8 virus, leading to high mortality rates among White-fronted Geese *Anser albifrons* and Greylag Geese *A. anser* in Western Europe (EFSA *et al.* 2020, 2021). From late spring 2021, the HPAI H5N1 subtype started to dominate among wild birds throughout Europe. Infections were sporadically detected during the summer and early autumn, causing, for instance, mass mortalities among Great Cormorants *Phalacrocorax carbo* in Estonia and Great Skuas *Stercocarius skua* in the United Kingdom (Banyard *et al.* 2022, Knief *et al.* 2024).

Nevertheless, in the autumn and winter of 2021/22, Europe witnessed an unprecedented outbreak of HPAI H5N1 (clade 2.3.4.4b) (e.g. Knief *et al.* 2024). This virus triggered the largest and most severe global epizootic incident among wild birds (as well as poultry and captive birds) observed so far (Pohlmann *et al.* 2022). By spring 2022, this clade had become enzootic, meaning that after causing the initial mass wave of infections it did not disappear during the summer months, and was also responsible for mortality among breeding birds. Between March and September of 2022

CONTACT Marcin Przymencki marcin.przymencki@otop.org.pl

the virus was detected in 80 species of wild bird (EFSA *et al.* 2022), with coastal colonial waterbirds being most affected, including the Northern Gannet *Morus bassanus*, Common Tern *Sterna hirundo* and Sandwich Tern *Thalasseus sandvicensis*. The virus caused the death of 16.3% of the latter species' population throughout north-western Europe in 2022 (Knief *et al.* 2024). Despite the high mortality rates among these species in many European countries, the epidemic did not significantly affect colonies in Poland.

In the winter of 2022/23 a novel genotype of the virus appeared, showing a strong affinity for gulls (EFSA *et al.* 2023). In Western Europe, it began causing disease and mortality mainly among overwintering Black-headed Gulls *Chroicocephalus ridibundus*, but also among Herring Gulls *Larus argentatus* and other gull species. The virus probably began to spread in parallel with the return of individuals to their breeding grounds.

In the latter half of April 2023, numerous dead birds were found in several breeding colonies of Black-headed Gulls in Poland. Research conducted by the National Veterinary Research Institute in Puławy, Poland, revealed that the cause of death for these individuals was the H5N1 subtype of avian influenza virus (GIW 2024). It quickly became apparent that the epidemic had spread throughout the country. During the breeding season, subsequent outbreaks of avian influenza were observed in many Black-headed Gull colonies (e.g. Marchowski *et al.* 2024). Due to the high densities of nests in colonies of this species, the virus rapidly spread to other nesting individuals, resulting in mortality rates reaching several thousand individuals in some locations. As the Black-headed Gull is considered an 'umbrella species', due to its breeding colonies serving as nesting sites also for other gull and tern species (Šálek *et al.* 2022), the HPAI outbreak caused numerous deaths within the Black-headed Gull population, as well as in the co-occurring scarce species, many of which are considered threatened or vulnerable and require special attention, especially in the long term. Avian influenza outbreaks may be one of the factors impacting on population trends; thus, collecting reliable and comprehensive data on mortality among those species is essential to understand the impact of H5N1 on Poland's breeding gulls and associated species.

This paper documents the impact of the HPAI outbreak in 2023 on scarce breeding populations of gulls and terns in Poland, especially the Common Gull *Larus canus*, Mediterranean Gull *Ichthyaetus melanocephalus*, Common Tern, Little Tern *Sternula albifrons* and Sandwich Tern.

Methods

Data sources and analysis

We analysed a comprehensive dataset of the mortality among scarce (up to 30,000 breeding pairs; Sikora *et al.* 2007) gull and tern species in the whole of Poland from 1 April to 31 July 2023. The data included wild bird mortality observations from 101 breeding colonies. We focused only on these sites to provide an insight into how HPAI-affected breeding populations of the focal species. Most of the data on the described species came from four annual programmes of Monitoring of Birds of Poland (MPB; Chodkiewicz & Przymencki 2023), which are: (1) the Coast and River Species Census that collected data for deaths of Common Gulls, Little Terns, Common Terns and Black Terns; (2) the Marsh Terns Census that collected data for deaths of Black Terns and Whiskered Terns; (3) the Mediterranean Gull Census that collected data for deaths of Mediterranean Gulls and Common Terns and (4) the Sandwich Tern Census that collected data for deaths of Sandwich Terns and Common Terns.

All colonies surveyed by MBP were visited at least twice during the breeding season. In the Upper Vistula Valley, target colonies of the Whiskered Tern were inspected twice per week, but exact data regarding the frequency of visits are not available for the others. Additionally, precise data were provided from the middle Vistula riverbed by researchers from the Cardinal Stefan Wyszyński University of Warsaw, as well as the Bird Horizons Foundation. As only part of Poland's large gulls population is monitored by MBP programmes, most data for the species' mortality came from observers involved in volunteer groups, such as the Caspian Gull Research Group, which monitors all Polish breeding sites annually. For Herring Gulls, all mortality data came from the General Veterinary Inspectorate (https://www.wetgiw.gov.pl/nadzor-weterynaryjny/grypa-ptakow); dead birds were not observed at breeding sites, but nearby during the breeding season (May and June) within the species range in the country. Some additional data for marsh tern populations came from research groups studying Black Terns at Szczecin Lagoon and in the Lower Odra River Valley (northern Poland; D. Marchowski) and Whiskered Terns at fishponds in southern Poland (M. Ledwoń). A few examples of Common Tern mortalities were provided by co-authors individually.

In 2023, in response to the widespread occurrence of avian influenza among colonial waterbirds, observers were specifically instructed to document any dead

birds found within colonies. The consortium of the Polish Society for the Protection of Birds (OTOP) and the Museum and Institute of Zoology of the Polish Academy of Sciences, which manage the MBP, provided collaborators with guidelines for how to protect themselves and prevent virus transmission during the work. The data provided by collaborators included the results of MBP programmes, complete with data from regions not otherwise covered by MBP. To obtain this information, we contacted observers via social media, e-mail and telephone. The dataset also included dead birds tested for HPAI by the National Veterinary Research Institute in Puławy, as well as those not tested but recorded at colonies where a HPAI outbreak was confirmed in Black-headed Gulls or other species.

The mortality rate was calculated for each species using the formula: number of deaths/(number of breeding pairs * 2).

Studied species

Although the species studied usually nest among Black-headed Gulls in Poland, which could have been the main vector of HPAI, we decided not to include the Black-headed Gull in this study due to large differences in abundance between the species, and thus the characteristics of their populations.

The Common Gull is declining dramatically in Poland; in the early 1990s there were around 3,500 nesting pairs, mostly in the middle Vistula riverbed (Bukaciński *et al.* 2007). Since the late 1990s, however, Common Gulls have undergone a consistently strong population decline (Bukaciński *et al.* 2017, 2018), with a 79% loss during 2008–20, and joining a group of species facing the highest risk of extinction in Poland in the near future (Chylarecki *et al.* 2018, Wardecki *et al.* 2021). By 2023, numbers of Common Gulls were estimated at only 475 breeding pairs, of which only half bred in the middle Vistula riverbed, and the rest on urban infrastructure (Przymencki *et al.* 2024b) or a few pairs at waterbodies elsewhere. The Common Gull's original habitats within the middle Vistula riverbed have been monitored and actively protected by the group of researchers annually for almost 40 years (Bukaciński & Bukacińska 2008, Bukaciński *et al.* 1994, 2000, 2017, 2018, 2021). Consequently, all deaths of adults and chicks on the breeding grounds were recorded.

The abundance and distribution of Poland's breeding population of Mediterranean Gulls have been monitored since 2007. Despite a significant number of suitable breeding habitats of both natural and anthropogenic origin, the species is not as abundant in Poland as in north-western Europe and Ukraine (Zieliński *et al.* 2022). Between 2006 and 2020, the population of Mediterranean Gulls fluctuated between 50 and 100 pairs, and over a similar period (2007–20) the species had a moderately declining trend that averaged 6.4% per annum (Zieliński *et al.* 2022). Polish Mediterranean Gulls commonly breed singly or in small colonies of up to 42 pairs (Beuch & Gwóźdź 2018).

The four species of large gull *Larus spp*. that we considered are the Caspian Gull *Larus cachinnans*, Herring Gull *Larus argentatus*, Yellow-legged Gull *Larus michahellis* and Lesser Black-backed Gull *Larus fuscus*. All breed in Poland, with Caspian Gulls and Herring Gulls being the most abundant, while Yellow-legged Gulls and Lesser Black-backed Gulls nest ephemerally. The Caspian Gull population is estimated to be at least at 5,700 pairs (Przymencki *et al.* 2024a), although the number of pairs reached 6,027 in 2023 (unpubl. data from M. Przymencki, K. Litwiniak), indicating a continued increase (Litwiniak *et al.* 2021, Przymencki *et al.* 2022). Herring Gull numbers and distribution are rather less known, as the species nests mainly in urban environments (Litwiniak & Przymencki 2022); however, the total population is estimated between 2,700 and 3,000 pairs (Chodkiewicz *et al.* 2015). Yellow-legged Gulls and Lesser Black-backed Gulls are both rare, with a respective 0–4 and 0–2 pairs annually (Chodkiewicz *et al.* 2019, Przymencki *et al.* 2023).

The Common Tern is the most abundant tern species in Poland, with a total population estimated at 6,000–8,000 pairs (Chodkiewicz *et al.* 2019). A comprehensive national census of the breeding population is not carried out, although as part of annual monitoring some counts are made at sites of other species in the surveys mentioned above. In 2023, at least 4,377 pairs of Common Terns nested in 135 colonies. Of the total population, 57% or 2,479 pairs were breeding on the Vistula River, 21% or 932 pairs nested on inland standing waters, 18% or 780 pairs bred on the coast and 4% or 186 pairs nested on the Bug River.

Unlike the Common Tern, the total Polish population of Little Terns has been counted by MBP since 2020. Although it was previously estimated at 700–1,100 pairs (Chodkiewicz *et al.* 2019), the most recent results revealed 1,151 pairs in 2023 (Beuch, Sikora *et al.* 2023). The main breeding sites are at the Vistula and Bug rivers, but a few pairs also nest on large waterbodies elsewhere in the country.

We included the three *Chlidonias* species of Black Tern *Chlidonias niger*, Whiskered Tern *Chlidonias hybrida* and White-winged Black Tern *Chlidonias leucopterus*. Since 2021 the majority of their important breeding sites, and approximately 70% of the national population of these species, has been monitored by MBP. During the 2023 counts, there were 2,885 pairs of Black Terns, 2,889 pairs of Whiskered Terns and 89 pairs of White-winged Black Terns observed (Beuch, Ledwoń *et al.* 2023). The Whiskered Tern population in Poland has rapidly increased over the past 30 years, with the largest local population in the Upper Vistula River Valley (Ledwoń *et al.* 2014). The number of all the species is strongly dependent on the fishery management of ponds and the water levels (Goławski *et al.* 2015).

Sandwich Terns breed only in the Gulf of Gdańsk in northern Poland, at just one colony, which shifts in location between years. Since 2022 the colony has been established on the breakwater in the Port of Gdańsk, reaching 355 pairs in that year and 450 pairs in 2023, the latter being the first successful breeding season in several years (Bzoma 2023). This colony also includes Black-headed Gulls and Common Terns.

Results

Common Gull

In 2023, six adults were found dead in four breeding colonies in the middle Vistula riverbed: three in the first half of May and three in June (4.5% of all natural nesting sites). The presence of H5N1 virus was confirmed in each carcass. This mortality of adult Common Gulls concerned less than 1% of birds in the Polish breeding population (Table 1). In the Vistula riverbed, Common Gulls nested with Black-headed Gulls in two colonies, as well as with Common Terns in another two sites. Although adult mortality from H5N1 was rather low compared to other species, it increased the overall average mortality rate for this species. In 2018–22, there were 0–3 dead adults recorded on the same section of the river. No deaths due to HPAI within urban populations were recorded.

In 2023, the mortality rate of Common Gull chicks in colonies in the middle Vistula riverbed was also monitored. In the second half of June, in the largest colony, HPAI caused the death of 34 chicks out of 114 that hatched (29.8% of hatchlings). In a small breeding aggregation (six nests), chick mortality was observed among 37.5% of hatched individuals (six out of 16). In both cases the chicks were older than 14 days.

Table 1. Mortality of scarce species of gulls and terns in Poland during HPAI outbreak in 2023, and mortality rates as a percentage of the Polish national population size.

Species	Population size (pairs)	Mortality		
		Adults	% of population	Chicks
Common Gull	475	6	0.6	40
Mediterranean Gull	71	17	12.0	4
Caspian Gull	6,027	6	0.1	3
Herring Gull	2,700–3,000	2	0.1	0
Yellow-legged Gull	0–4	0	0.0	0
Lesser Black-backed Gull	0–2	0	0.0	0
Common Tern	4,377	1,381	16.0[a]	0
Little Tern	1,151	42	1.8	0
Black Tern	2,885	3	0.1[a]	0
Whiskered Tern	2,889	2	0.1[a]	0
White-winged Black Tern	89	0	0[a]	0
Sandwich Tern	450	35	4.0	0

[a]Percentages refer to population counts from 2023 (see Methods).

Mediterranean Gull

In 2023, 71 pairs of Mediterranean Gulls were breeding in Poland (Zielińska & Zieliński 2023). During that season, 21 dead individuals were found, including 17 adults and four chicks. The dead gulls were discovered in five different colonies throughout Poland (20% of the species' breeding sites). Although none of the Mediterranean Gulls were tested for HPAI, all dead individuals were reported from Black-headed Gull colonies where laboratory tests confirmed the presence of avian influenza. The majority of deaths occurred in the first half of May. However, dead individuals were also found throughout May and early June.

The mortality of adults amounted to 12% of the national population (Table 1). In all cases the death of one or both partners resulted in the loss of the brood. In the colony at Mietków Reservoir, which held 21 pairs in 2023, the adult mortality rate was 21.4% (nine adults). The total number of dead chicks was unknown, due to dense vegetation in the colonies during the chick-rearing period. Only at two colonies were dead chicks found, with three at Mietków Reservoir and one at Goczałkowice Reservoir (both in south Poland).

Large gulls

No mass mortality event among large gull species was recorded in 2023 in Poland. However, there were some cases of Caspian Gulls being found dead in three breeding colonies: four dead adults and a chick all tested positive for HPAI on the Vistula River, and, in southern Poland, two dead chicks in the Januszkowice colony were not tested but found in a Black-headed Gull colony where HPAI was confirmed, and two dying adults were found in the Jankowice colony

showing symptoms of HPAI. Two Herring Gull carcasses were also recorded in northern Poland in May and June, which tested positive for HPAI. No dead Yellow-legged Gulls or Lesser Black-backed Gulls were recorded.

Common Tern

A minimum of 1,381 dead adult Common Terns were recorded from the 39 colonies supplying data, but there were other colonies from which no information was received. This indicates that at least 16% of the breeding population counted in 2023 perished due to HPAI (Table 1). The highest mortality rate (72.5%) was found in Zakroczym at the Vistula River, followed by the Mietków Reservoir (58.0%) and Goczałkowice Reservoir (50.0%). However, the greatest number of deaths was recorded at Rudy Pond in the Barycz valley, involving 150 individuals from one colony, representing 70.8% of the birds present.

The virus was detected in at least 29% of the Common Tern breeding colonies surveyed in 2023. Deceased birds were observed mostly (94%) at colonies where Black-headed Gulls occurred. The peak of observed mortality was in the second half of May. No information on chick mortality was available.

Little Tern

In total, 42 dead adult Little Terns were reported in the 2023 breeding season on islands in the Vistula and Bug riverbeds, at 12.6% of their Polish breeding colonies, and representing 1.8% of the national population (Table 1). None were tested for HPAI, but most were found in breeding colonies where HPAI was confirmed in other species and where mass mortality occurred. Almost all of the dead individuals were found in June and July, later than the peak mortality among Common Terns.

Marsh Terns

Notably, reports documented only two dead adult Black Terns in north-western Poland at two locations, and one adult in eastern Poland from the Bug River (Marchowski *et al.* 2024, Ł. Wardecki pers. comm.). Over the last two decades (2004–23), between two and 12 colonies in the Upper Vistula Valley have been inspected annually to study the breeding biology of Whiskered Terns, with 11 colonies (encompassing 700 nests) inspected in 2023. Two or three dead adults were typically discovered at these colonies each year, with two adults noted in 2023 and no increase in chick mortality relative to preceding years (M. Ledwoń pers. obs.). It is important to note that the dead birds in 2023 were not tested for HPAI. Nevertheless, the impact of the HPAI epidemic on marsh tern populations in Poland in 2023 appears to have been minimal.

Sandwich Tern

In total, 35 dead individuals were found at the colony in the Gulf of Gdańsk and on the nearby beach, which represented 4% of the breeding population (Table 1). The dead birds were not tested for HPAI, but Black-headed Gulls and Common Terns were tested at the colony and HPAI was confirmed.

Discussion

The mass mortality among gulls and terns in Poland, triggered by the H5N1 HPAI virus in the breeding season of 2023, is unprecedented, but only a few species were seriously impacted. From April to July, at least 1,535 scarce breeding gulls and terns were reported dead in the whole country, and all were found in their colonies. Most casualties nested alongside the most abundant gull species in Poland, the Black-headed Gull, which had the highest mortality from HPAI (P. Indykiewicz, M. Przymencki et al. unpubl. data).

Very few cases of HPAI mortality involved places where Black-headed Gulls were not breeding. For example, Black-headed Gulls were absent from just five colonies of Common Terns where mortality was noted, and where Black-headed Gulls were absent then Common Gull, marsh terns and large gulls mortality was zero or very low. This indicated that Black-headed Gulls might be the main vector of HPAI and, therefore, have a great impact on coinhabiting but scarcer gulls and terns.

It is worth noting that in a mixed colony of Black-crowned Night-herons *Nycticorax nycticorax* and Black-headed Gulls in southern Poland, where the former nested on low trees and the latter on the ground, no mortality of Black-crowned Night-herons was recorded, even when dead Black-headed Gulls were found there (J. Betleja pers. obs.). In the Upper Vistula Valley, in the Whiskered Tern colonies with and without nesting Black-headed Gulls, mortality among the terns was also very low (M. Ledwoń pers. obs.). Furthermore, no evidence of higher than normal mortality was found in other colonially breeding waterbirds, like Great Cormorants, Grey Herons *Ardea cinerea* and Pied Avocets *Recurvirostra avosetta*,

where mortality was no different to other years (Marchowski *et al.* 2024).

The highest mortalities among adults were recorded in two species: Mediterranean Gull and Common Tern (Table 1). The former breeds only within Black-headed Gull colonies; in the largest concentration in 2023, at Mietków Reservoir, the mortality rate among adults was 21.4%. The Mediterranean Gull is listed in Annex I of the EU Birds Directive and classified as Least Concern (LC) in the IUCN Red List for Europe. However, in the Red List of Birds of Poland (Wilk *et al.* 2020) and HELCOM Red List Category (HELCOM 2023), the species is classified as endangered (EN). After increasing its range and numbers between 1998 and 2005 (Zielińska *et al.* 2007), the species started to decline (Zieliński *et al.* 2022). The mortality due to avian influenza may now be the key threat for Mediterranean Gulls in Poland, and could have a negative impact on the population in the short- and longer term.

Given the generally low survival rate of chicks during outbreaks of avian influenza in Black-headed Gull colonies (P. Indykiewicz, M. Przymencki et al. unpubl. data), low chick survival can also be expected in Mediterranean Gulls. However, breeding dispersal of Mediterranean Gulls nesting in Poland is high (P. Zieliński, M. Przymencki et al. unpubl. data), and the Polish breeding population is supplemented with individuals from Germany and other neighbouring countries.

Over 4,000 Common Tern pairs breed in Poland, and relatively large numbers of dead birds were recorded, as well as a high adult mortality rate (Table 1). Similar to Mediterranean Gull, the Common Tern is listed on Annex I of the EU Birds Directive and classified as Least Concern (LC) according to the IUCN Red List for Europe. Also, in Poland, the species is not of special conservation concern, but the total number of breeding pairs is relatively low compared to other counties (e.g. The Netherlands, Sovon 2024), and HPAI should be considered a major threat due to the high mortality in 2023. This situation is more serious because Common Terns have high breeding site fidelity (Palestis 2014), thus immigration from locations not affected by avian influenza is not expected, unlike in Mediterranean Gulls.

Common Terns, like other species considered here, are long-lived birds and their average annual breeding success is quite low (0.12–1.57 fledglings per brood; Vedder & Bouwhuis 2018). However, breeding success increases with age (Zhang *et al.* 2015), and so the loss of older, more experienced breeders is especially harmful. Ring recoveries from dead individuals confirmed many of them were at an advanced age. For example, three out of five ringed dead birds found at Mietków Reservoir were older than 20 years. Thus, it can be assumed that the loss of a large number of adult birds is likely to have a negative long-term impact on population development. The complete impact of the HPAI epizootic in 2023 on long-term population patterns will not be known until repeat censuses are undertaken. Although MBP covers more than half of the Common Tern breeding population, it is also crucial to monitor future mortality, in adults as well as in chicks and fledglings, to better understand the changing demographics of the species.

Mortality in Common Terns was high in Germany in 2022 (Polhmann *et al.* 2023), both in adults and in chicks. The mortality rate of adults was between 0.3% and 46.3%, and this variation probably resulted from different nest densities in the colonies (Polhmann *et al.* 2023). During the breeding season, gull and tern colonies usually have high population densities, and the close proximity of the birds is likely to greatly increase HPAI transmission rates. In colonies, where distances between nests are large, the mortality may be very low due to limited transmission of H5N1, although this requires more investigation.

However, very low mortality among adults was observed among large gulls, and adults of Common Gulls and Little Terns in our study. As Common Gulls and Little Terns nest at rather lower densities than other species, the interesting finding was that for large gulls, especially Caspian Gulls. This species' population is strongly increasing in Poland (Przymencki *et al.* 2022), and some colonies holding hundreds of pairs have reached their apparent capacity and not risen for several years (Przymencki *et al.* 2024a). This suggests that Caspian Gulls are breeding in high densities in some places, but no increased mortality from HPAI was observed during 2023. That could be due to a high resistance to the H5N1 virus in the population. Low adult mortality was also recorded in Herring Gulls, and this may also be due to the low nest densities observed in the species at urban breeding sites (Litwiniak & Przymencki 2022).

Despite the relatively low number of dead adult Common Gulls in 2023, high mortality among chicks due to HPAI H5N1 may become another significant factor contributing to the extinction of this species in the middle Vistula riverbed. The recorded mortality of 30–38% of hatched chicks in the Common Gull colonies on the Vistula River, due to HPAI, will undoubtedly and significantly affect the demography of this species, but with a lag of two to three years until the time of sexual maturation for this species,

when these individuals would have joined the Vistula breeding population (Bukaciński & Bukacińska 2003).

Such high mortality rates of Common Gull chicks of this age were not recorded in Poland since 1988. In recent decades, including years of very strong predation pressure from the American Mink *Neogale vison*, mortality of chicks older than 14 days has never exceeded 15% of hatched individuals, and most often concerned 8–10% of hatchlings (D. Bukaciński pers. obs.). Furthermore, this species shows a high breeding site fidelity (Rattiste 2006, Bukaciński *et al.* unpubl. data), and its increasingly urban populations in Poland are unlikely to be a source of individuals to replenish the original population inhabiting the Vistula Valley almost exclusively (Bukaciński *et al.* 1994, Przymencki *et al.* 2024b). As with Common Terns, we recommend that monitoring of chick mortality should be conducted in the most important breeding sites for Common Gulls, including the urban populations.

The relatively low mortality among Sandwich Terns was also notable. This species suffered high mortality from HPAI in 2022 in north-western Europe, involving more than 17% of the regional breeding population (Knief *et al.* 2024). In Poland, only nine dead Sandwich Terns were found in 2022 (1% of national population), and in 2023 there were 35 dead individuals, but this mortality would not necessarily have a long-term impact on the population. However, as previously recommended, it is important to continue monitoring this species because of its susceptibility to HPAI.

Aside from gulls and terns, there were confirmed cases of HPAI in other waterbird species in Poland during this study period, for example a single Eurasian Oystercatcher *Haematopus ostralegus* reported from the Vistula River (GIW 2024). As mentioned above, the risk of epizootic infections did not appear to be distributed evenly, as differences in mortality rates were observed between different HPAI-affected colonies of the same species, such as the Mediterranean Gull. A varying incursion time of HPAI into the colonies might explain these differences; for example, most dead Little Terns were found rather late in the spring/summer (June/July), compared to other species.

It is important to note that the mortality rates provided in this study are a minimum calculated only from the number of dead birds discovered, and the estimated number of breeding pairs for each species and colony. Some dead birds were certainly not found during the breeding season, especially for marsh terns – given their nesting preferences in aquatic vegetation where current monitoring methods may be inadequate. Direct, regular and frequent colony inspections are essential for detecting dead birds.

Some of the estimated HPAI mortality rates were very low and, therefore, indistinguishable from the presumed background mortality. For Herring Gulls, the mortality rate of 0.1% of the population may be an underestimate; however, nearly the entire Polish population of this species breeds in urban environments (Litwiniak & Przymencki 2022), so dead birds are easily noticeable by the public and likely reported to veterinary authorities, as happened in a few cases (GIW 2024). Furthermore, all dead Herring Gulls tested positive for HPAI. Therefore, it appears that virus transmission in the urban environment may be limited by relatively low densities of breeding pairs, similar to the urban Common Gulls, with individual pairs typically occupying single buildings.

Underestimation of the mortality of Caspian Gulls seems unlikely. Almost all Polish breeding sites are surveyed every year, many involving ringing, which means colonies were visited at least once. If a greater number of dead birds were to be found in 2023, observers would have reported this to those responsible for collecting species occurrence data. Nevertheless, there was one case where dead Caspian Gulls tested positive for HPAI, but the mortality rate of 0.1% of the total population might not have exceeded background mortality. Similar mortality rates were found in marsh terns, where it might have been underestimated. Marsh terns nest on patches of floating vegetation, and, consequently, dead birds may fall into the water and remain unnoticed by observers. On the other hand, studies of Black Terns and Whiskered Terns (see Methods) did not detect increased mortality, so the situation remains ambiguous.

There were some limitations to this study, including a low survey effort that meant any estimates of chick mortality were largely missing, and also no data on the background adult mortality, data lacking from some known colonies of Common Terns and marsh terns, and some estimates based on casual observations rather than precise counts (Herring Gull). Considering all these factors, accurately quantifying the full impact of the HPAI outbreak on the Polish populations of the studied species proved challenging, and will inevitably result in underestimations. Nevertheless, this study serves as the first detailed information for the severity of avian influenza among colonially breeding scarce gulls and terns throughout Poland.

Acknowledgements

We thank all collaborators of Monitoring of Birds of Poland who helped collect data for gull and tern mortality. We

particularly thank Michał Baran, Damian Celiński, Darek Czernek, Przemysław Doboszewski, Anna Floryszek, Stanisław Gacek, Marta Gołek, Wiktoria Gutowska, Tomasz Iciek, Dariusz Jakubas, Tomasz Janiszewski, Wiesław Lenkiewicz, Adam Lendvai, Piotr Minias, Beata Orłowska, Marek Sawicki, Marcin Sidelnik, Bartosz Smyk, Jerzy Stasiak, Tadeusz Stawarczyk, Paweł Szewczyk, Jakub Szymczak, Radosław Włodarczyk and Liwia Zemla. MBP is conducted on behalf of the Chief Inspectorate for Environmental Protection thanks to funding from the National Fund for Environmental Protection and Water Management.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Marcin Przymencki 0000-0002-7554-6070
Szymon Beuch 0000-0001-5454-8280
Piotr Indykiewicz 0000-0003-1254-2424
Klaudia Litwiniak 0000-0002-6077-8792
Dariusz Bukaciński 0000-0003-0163-2950
Monika Bukacińska 0000-0002-4526-3141
Jacek Betleja 0000-0001-8186-3411
Dominik Marchowski 0000-0001-7508-9466
Mateusz Ledwoń 0000-0003-3017-6376
Arkadiusz Buczyński 0000-0002-7577-4663
Adam Flis 0000-0003-4707-2629
Bartłomiej Kusal 0000-0001-9242-7391
Tomasz Chodkiewicz 0000-0002-9342-2370

References

Banyard, A.C., Lean, F.Z.X., Robinson, C., Howie, F., Tyler, G., Nisbet, C., Seeking, J., Meyer, S., Whittard, E., Ashpitel, H.F., Bas, M., Byrne, A.M.P., Lewis, T., James, J., Stephan, L., Lewis, N.S., Brown, I.H., Hansen, R.D.E. & Reid, S.M. 2022. Detection of highly pathogenic avian influenza virus H5N1 clade2.3.4.4b in Great Skuas: a species of conservation concern in Great Britain. *Viruses* **14:** e212.

Beuch, S. & Gwóźdź, R. 2018. The largest breeding colony of Mediterranean Gulls *Ichthyaetus melanocephalus* in a gravel-pit in Bieńkowice, upper Odra Valley, in 2018. *Ptaki Śląska* **25:** 133–138. (in Polish).

Beuch, S., Ledwoń, M., Goławski, A. & Marchowski, D. 2023. Marsh Terns Census. In Chodkiewicz, T. & Przymencki, M. (eds) *Sprawozdanie z prac terenowych i opracowanie wyników uzyskanych w sezonie lęgowym w 2023 roku. Zadanie 1. Monitoring ptaków - prace terenowe i opracowanie wyników. Monitoring ptaków z uwzględnieniem obszarów specjalnej ochrony ptaków Natura 2000, lata 2023–2025*, 127–141. GIOŚ, Warszawa. (in Polish).

Beuch, S., Sikora, A. & Ławicki, Ł. 2023. Coast and River Species Census. In Chodkiewicz, T. & Przymencki, M. (eds) *Sprawozdanie z prac terenowych i opracowanie wyników uzyskanych w sezonie lęgowym w 2023 roku. Zadanie 1. Monitoring ptaków - prace terenowe i opracowanie wyników. Monitoring ptaków z uwzględnieniem obszarów specjalnej ochrony ptaków Natura 2000, lata 2023–2025*, 101–116. GIOŚ, Warszawa. (in Polish).

Bukaciński, D. & Bukacińska, M. 2003. *Larus canus* Common Gull. *BWP Update* **5:** 63–97.

Bukaciński, D. & Bukacińska, M. 2007. Common Gull *Larus canus*. In Sikora, A., Rohde, Z., Gromadzki, M., Neubauer, G. & Chylarecki, P. (eds) *The Atlas of Breeding Birds in Poland 1985–2004*, 230–231. Bogucki Wyd. Nauk., Poznań.

Bukaciński, D. & Bukacińska, M. 2008. Threatened bird species of the middle Vistula River islands: status, necessity for protection and proposed activities. In Uchmański, J. (ed) *Theoretical and Applied Aspects of Modern Ecology*, 219–239. UKSW, Warsaw.

Bukaciński, D., Bukacińska, M. & Buczyński, A. 2018. Threats and the active protection of birds in a riverbed: postulates for the strategy of the preservation of the middle Vistula River avifauna. *Stud. Ecol. Bioethic.* **16:** 5–23.

Bukaciński, D., Bukacińska, M. & Chylarecki, P. 2021. Manipulating parental condition affects brood sex ratio, immunocompetence and early chick mortality in two gull species differing in sexual size dimorphism. *Ornithology* **138:** ukab007.

Bukaciński, D., Bukacińska, M. & Lubjuhn, T. 2000. Adoption of chicks and the level of relatedness in Common Gull, *Larus canus* colonies: DNA fingerprinting analyses. *Anim. Behav.* **59:** 289–299.

Bukaciński, D., Cygan, J., Keller, M., Piotrowska, M. & Wójciak, J. 1994. The number and distribution of waterbirds nesting on the Middle Vistula – changes in 1973–93. *Not. Orn.* **35:** 5–47. (in Polish).

Bukaciński, D., Keller, M., Buczyński, A. & Bukacińska, M. 2017. Breeding avifauna of the middle Vistula riverbed in 2009 – changes in abundance and distribution over the last 36 years. In Keller, M., Kot, H., Dombrowski, A., Rowiński, P., Chmielewski, S. & Bukaciński, D. (eds) *Ptaki środkowej Wisły*, 97–127. M-STO, Pionki. (in Polish).

Bzoma, S. 2023. Sandwich Tern Census. In Chodkiewicz, T. & Przymencki, M. (eds) *Sprawozdanie z prac terenowych i opracowanie wyników uzyskanych w sezonie lęgowym w 2023 roku. Zadanie 1. Monitoring ptaków - prace terenowe i opracowanie wyników. Monitoring ptaków z uwzględnieniem obszarów specjalnej ochrony ptaków Natura 2000, lata 2023–2025*, 197–202. GIOŚ, Warszawa. (in Polish).

Chodkiewicz, T., Chylarecki, P., Sikora, A., Wardecki, Ł, Bobrek, R., Neubauer, G., Marchowski, D., Dmoch, A. & Kuczyński, L. 2019. Report on the implementation of Art. 12 of the Birds Directive in Poland in 2013–2018: status, changes, threats. *Biul. Monitor. Przyr.* **20:** 1–80. (in Polish).

Chodkiewicz, T., Kuczyński, L., Sikora, A., Chylarecki, P., Neubauer, G., Ławicki, Ł & Stawarczyk, T. 2015. Population estimates of breeding birds in Poland in 2008–2012. *Ornis Pol.* **56:** 149–189. (in Polish).

Chodkiewicz, T. & Przymencki, M. (eds). 2023. Report on field work and analysis of the results obtained in the 2023 breeding season. Task 1. Bird monitoring – field work and preparation of results. Bird monitoring, including Natura 2000 Special Bird Protection Areas, 2023–2025. GIOŚ, Warszawa. (in Polish).

Chylarecki, P., Chodkiewicz, T., Neubauer, G., Sikora, A., Meissner, W., Woźniak, B., Wylegała, P., Ławicki, Ł, Marchowski, D., Betleja, J., Bzoma, S., Cenian, Z., Górski, A., Korniluk, M., Moczarska, J., Ochocińska, D., Rubacha, S., Wieloch, M., Zielińska, M., Zieliński, P. & Kuczyński, L. 2018. *Bird Abundance Trends in Poland*. GIOŚ, Warszawa. (in Polish).

EFSA (European Food Safety Authority), ECDC (European Centre for Disease Prevention and Control), EURL (European Union Reference Laboratory for Avian Influenza), Adlhoch, C., Fusaro, A., Gonzales, J.L., Kuiken, T., Marangon, S., Mirinaviciute, G., Niqueux, E., Stahl, K., Staubach, C., Terregino, C., Brogliaand, A. & Baldinelli, F. 2021. Avian influenza overview February – May 2021. *EFSA J.* **19:** e06951.

EFSA (European Food Safety Authority), ECDC (European Centre for Disease Prevention and Control), EURL (European Union Reference Laboratory for Avian Influenza), Adlhoch, C., Fusaro, A., Gonzales, J.L., Kuiken, T., Marangon, S., Mirinaviciute, G., Niqueux, E., Stahl, K., Staubach, C., Terregino, C., Brogliaand, A. & Baldinelli, F. 2022. Avian influenza overview March – June 2022. *EFSA J.* **20:** e07415.

EFSA (European Food Safety Authority), ECDC (European Centre for Disease Prevention and Control), EURL (European Union Reference Laboratory for Avian Influenza), Adlhoch, C., Fusaro, A., Gonzales, J.L., Kuiken, T., Marangon, S., Mirinaviciute, G., Niqueux, E., Stahl, K., Staubach, C., Terregino, C., Brogliaand, A. & Baldinelli, F. 2023. Avian influenza overview December 2022 – March 2023. *EFSA J.* **20:** e07415.

EFSA (European Food Safety Authority), ECDC (European Centre for DiseasePrevention and Control), EURL (European Union Reference Laboratory for Avian Influenza), Adlhoch, C., Fusaro, A., Gonzales, J.L., Kuiken, T., Marangon, S., Mirinaviciute, G., Niqueux, E., Stahl, K., Staubach, C., Terregino, C., Brogliaand, A. & Baldinelli, F. 2020. Avian influenza overview August – December 2020. *EFSA J.* **18:** e06379.

GIW (General Veterinary Inspectorate). 2024. Avian influenza outbreaks in wild birds in Poland in the year: 2023. https://www.wetgiw.gov.pl/nadzor-weterynaryjny/hpai. Accessed 10.04.2024. (in Polish).

Goławski, A., Kasprzykowski, Z., Mróz, E., Rzępała, M. & Chmielewski, S. 2015. The differences in habitat selection in two sympatric species of eastern Poland: the White-winged Black Tern (*Chlidonias leucopterus*) and the Black Tern (*Chlidonias niger*). *Wilson J. Ornithol.* **127:** 52–58.

HELCOM. 2023. Mediterranean Gull. Red List Bird Expert Group.

Knief, U., Bregnballe, T., Alfarwi, I., Ballmann, M.Z., Brenninkmeijer, A., Bzoma, S., Chabrolle, A., Dimmlich, J., Engel, E., Fijn, R., Fischer, K., Hälterlein, B., Haupt, M., Hennig, V., Herrmann, C., in 't Veld, R., Kirchhoff, E., Kristersson, M., Kühn, S., Larsson, K., Larsson, R., Lawton, N., Leopold, M., Lilipaly, S., Lock, L., Marty, R., Matheve, H., Meissner, W., Morrison, P., Newton, S., Olofsson, P., Packmor, F., Pedersen, K.T., Redfern, C., Scarton, F., Schenk, F., Scher, O., Serra, L., Sibille, A., Smith, J., Smith, W., Sterup, J., Stienen, E., Strassner, V., Valle, R.G., van Bemmelen, R.S.A., Veen, J., Vervaeke, M., Weston, E., Wojcieszek, M. & Courtens, W. 2024. Highly pathogenic avian influenza causes mass mortality in Sandwich-Tern *Thalasseus sandvicensis* breeding colonies across north-western Europe. *Bird Conserv. Int.* **34:** 1–11.

Ledwoń, M., Betleja, J., Stawarczyk, T. & Neubauer, G. 2014. The Whiskered Tern *Chlidonias hybrida* expansion in Poland: the role of immigration. *J. Ornithol.* **155:** 459–470.

Litwiniak, K. & Przymencki, M. 2022. Density and aspects of breeding ecology of the Herring Gull *Larus argentatus* in the Żabianka estate in Gdańsk. *Ornis Pol.* **63:** 169–176. (in Polish).

Litwiniak, K., Przymencki, M. & de Jong, A. 2021. Breeding-range expansion of the Caspian Gull in Europe. *Brit. Birds* **114:** 331–340.

Marchowski, D., Chara, P., Borek, Ł, Kajzer, Z. & Bzoma, S. 2024. Effects of highly pathogenic avian influenza among colonial waterbirds in the lower Odra valley. *Acta Ornithologica* **59:** 23–33.

Palestis, B.G. 2014. How philopatric are common terns? *Wader Study Group Bull.* **121:** 43.

Pohlmann, A., King, J., Fusaro, A., Zecchin, B., Banyard, A.C., Brown, I.H., Byrne, A.M.P., Beerens, N., Liang, Y., Heutink, R., Harders, F., James, J., Reid, S.M., Hansen, R.D.E., Lewis, N.S., Hjulsager, C., Larsen, L.E., Zohari, S., Anderson, K., Bröjer, C., Nagy, A., Savič, V., van Borm, S., Steensels, M., Briand, F., Swieton, E., Smietanka, K., Grund, C., Beer, M. & Harder, T. 2022. Has epizootic become enzootic? Evidence for a fundamental change in the infection dynamics of highly pathogenic avian influenza in Europe, 2021. *mBio* **13:** e0060922.

Pohlmann, A., Stejskal, O., King, J., Bouwhuis, S., Packmor, F., Ballstaedt, E., Hälterlein, B., Hennig, V., Stacker, L., Graaf, A., Hennig, C., Günther, A., Liang, Y., Hjulsager, C., Beer, M. & Harder, T. 2023. Mass mortality among colony-breeding seabirds in the German Wadden Sea in 2022 due to distinct genotypes of HPAIV H5N1 clade 2.3.4.4b. *J. Gen. Virol.* **104**: 001834.

Przymencki, M., Litwiniak, K., Adriaens, P., Atamas, N., Bertalan, L., Betleja, J., Čerkauskas, A., Dubois, P.J., Horst, T., Jelínek, M., de Jong, A., Karaska, D., Klein, R., Muusse, M., Peev, S., Pyshko, A., Samusenko, I., Smislovs, E., Trapp, H. & Vratny, J. 2024a. Breeding-range expansion of the Caspian Gull in Europe: 2021–22 update. *Brit. Birds* **117:** 26–35.

Przymencki, M., Litwiniak, K., Betleja, J., Neubauer, G., Ledwoń, M., Bednarz, Ł, Szymczak, J., Sidelnik, M., Grochowski, P., Pomorska-Grochowska, J., Kołodziejczyk, P., Pietrasik, J. & Stawarczyk, T. 2022. Current distribution, abundance and trends of the Caspian Gull *Larus cachinnans* in Poland. *Ornis Pol.* **63:** 1–11.

Przymencki, M., Litwiniak, K., Beuch, S., Rapczyński, J., Wardecki, Ł, Bednarz, Ł, Włodarczak-Komosińska, A., Doboszewski, P., Borek, Ł, Rębiś, M., Dolata, P.T., Zieliński, P., Bilecki, K., Węcławek, D., Bukacińska, M. & Bukaciński, D. 2024b. Abundance and distribution of the Common Gulls *Larus canus* nesting on the components of urban infrastructure in Poland in 2023. *Ornis Pol.* **65:** 30–41. (in Polish).

Przymencki, M., Litwiniak, K., Grochowski, P. & Pomorska-Grochowska, J. 2023. First breeding record of a Lesser Black-backed Gull *Larus fuscus* pair in Silesia. *Ptaki Śląska* **28:** 65–70. (in Polish).

Rattiste, K. 2006. Life History of the Common Gull (*Larus canus*). A Long-Term Individual-Based Study. *Acta Universitatis Upsaliensis. Digital Comprehensive Summaries of Uppsala Dissertations from the Faculty of Science and Technology* **224**: 38. (Uppsala).

Sikora, A., Rohde, Z., Gromadzki, M., Neubauer, G. & Chylarecki, P. (eds). 2007. *The Atlas of Breeding Birds in Poland 1985–2004*. Bogucki Wyd. Nauk., Poznań. (in Polish).

Sovon. 2024. Common Tern *Sterna hirundo*. https://stats.sovon.nl/stats/soort/6150. Accessed: 29.04.2024.

Šálek, M., Sládeček, M., Kubelka, V., Mlíkovský, J., Storch, D. & Šmilauer, P. 2022. Beyond habitat: effects of conspecific and heterospecific aggregation on the spatial structure of a wetland nesting bird community. *J. Avian Biol.*, **2022** (2)**:** e02928.

Vedder, O. & Bouwhuis, S. 2018. Heterogeneity in individual quality in birds: overall patterns and insights from a study on common terns. *Oikos* **127:** 719–727.

Wardecki, Ł, Chodkiewicz, T., Beuch, S., Smyk, B., Sikora, A., Neubauer, G., Meissner, W., Marchowski, D., Wylegała, P. & Chylarecki, P. 2021. Monitoring of Birds of Poland in the years 2018–2021. *Biuletyn Monitoringu Przyrody* **22:** 1–80. (in Polish).

Wilk, T., Chodkiewicz, T., Sikora, A., Chylarecki, P. & Kuczyński, L. 2020. *Red List of Birds of Poland*. OTOP, Marki. (in Polish).

Zhang, H., Rebke, M., Becker, P.H. & Bouwhuis, S. 2015. Fitness prospects: effects of age, sex and recruitment age on reproductive value in a long-lived seabird. *J. Anim. Ecol.* **84:** 199–207.

Zielińska, M. & Zieliński, P. 2023. Mediterranean Gull Census. In Chodkiewicz, T. & Przymencki, M. (eds) *Sprawozdanie z prac terenowych i opracowanie wyników uzyskanych w sezonie lęgowym w 2023 roku. Zadanie 1. Monitoring ptaków - prace terenowe i opracowanie wyników. Monitoring ptaków z uwzględnieniem obszarów specjalnej ochrony ptaków Natura 2000, lata 2023–2025*, 191–196. GIOŚ, Warszawa. (in Polish).

Zielińska, M., Zieliński, P., Kołodziejczyk, P., Szewczyk, P. & Betleja, J. 2007. Expansion of the Mediterranean Gull *Larus melanocephalus* in Poland. *J. Ornithol.* **148:** 543–548.

Zieliński, P., Chodkiewicz, T., Zielińska, M., Iciek, T., Sidelnik, M., Szymczak, J., Bukaciński, D., Bukacińska, M., Rudenko, A., Neubauer, G. & Sikora, A. 2022. Breeding of the Mediterranean Gull *Ichthyaetus melanocephalus* in Poland in 2006–2020 in relation to species status in Europe. *Ornis Pol.* **63:** 83–99. (in Polish).