

**AVIAN INFLUENZA AND DALMATIAN PELICANS AT LESSER PRESPA LAKE
AND SOUTHEASTERN EUROPE IN 2022: EVENTS, LESSONS LEARNED
AND FUTURE CHALLENGES**



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Report writing

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Cover photo: View of the pelican colony at Lake Lesser Prespa in early March 2022 with dead Dalmatian pelicans on one of the breeding islets. G. Catsadorakis/*SPP photo archive*.

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SUMMARY

The avian influenza wave of 2022 affected the Near Threatened Dalmatian pelican *Pelecanus crispus* in most of its European range, but the effect on the Lesser (Mikri) Prespa Lake colony, in north-west Greece, the largest colony of the species, was devastating. The first deaths were recorded by the Society for the Protection of Prespa (SPP) in mid-February, a week after the first Dalmatian pelicans had arrived at Prespa. In the following weeks, the mortality rate peaked, then slowed down after mid-March and had ceased by the end of April. All dead pelicans were adults in breeding plumage. Laboratory results indicated the highly pathogenic H5N1 strain. By the end of April, 1,734 Dalmatian pelicans had died, c. 60% of the colony. In addition, three other colonies in the eastern part of the country were affected: Cheimaditida Lake with 181 deaths, Karla Reservoir with 103 and Kerkini Lake with 90. The two colonies on the west coast remained untouched by the virus. Overall, 2,286 Dalmatian pelican deaths were recorded in 13 wetlands. The H5N1 strain was also confirmed in the two Albanian and Montenegrin colonies, Karavasta Lagoon and Skadar Lake, and in three of the Romanian colonies in the Danube Delta, with a total of 189 deaths. No deaths were recorded in Bulgaria or Turkey. In total, >40% of the south-east European population was lost, c.10% of the global Dalmatian pelican population.

Other species were affected, but in small numbers, which implies that Dalmatian pelicans are particularly susceptible to H5N1. Prior to 2015 this species had not been infected by the avian influenza virus, and all previous events had resulted in minor losses. Several factors may have contributed to high infection rates and the high vulnerability of Dalmatian pelicans, especially in the Prespa colony: an early start to breeding combined with low temperatures, high pelican densities and contamination of colony substrates by droppings of migratory ducks and resident greylag geese, which roost on pelican islets in winter. Documentation of mortality, removal of carcasses and the mobilisation of authorities was challenging because of the large number of carcasses, difficult access, risks of personnel exposure, and the need to minimise disturbance to nesting pelicans. It took 7 days to remove 82% of the carcasses, almost 15 t, from the Lesser Prespa Lake colony. Approximately 190 pairs managed to nest successfully and raised 110 young in total.

It will take decades for the population to recover, provided that no other incidents occur. Considering that the highly pathogenic avian influenza virus is a serious global threat to wildlife, vigilance, increased protection measures at colonies and focused research is essential throughout the Dalmatian pelican range. Armed with the lessons learnt from the 2022 disaster, there is an urgent need to prepare for the future as efficiently as possible. At the same time, the effective protection of all important sites for pelicans and the mitigation of other threats to them are critical measures to minimise the impacts of avian influenza.

About bird flu

Avian influenza is a highly contagious disease of poultry and wild birds that first appeared around a century ago. It is caused by viruses with little tolerance for high atmospheric temperatures and therefore usually occurs during the winter months and vanishes in spring and summer. It can spread to entire flocks of domestic birds within a few days, through their excreta and saliva or through contaminated food and water.

In 1961, the first outbreak in wild birds was recorded, which caused massive deaths in common terns *Sterna hirundo* in North Africa. Deaths occurred from the highly pathogenic (HPAI) H5N3 strain. Since then, expert surveillance of the disease, with sampling of various species of wild birds, has shown that the viruses that cause avian influenza are mainly of low pathogenicity (LPAI), and the bird carriers of the virus are typically asymptomatic. The H5N1 strain of avian flu, which is the most widespread today, was first reported in China in 1996.

Incidents of mass deaths of pelicans due to avian influenza prior to 2022 and preventive actions taken by the Society for the Protection of Prespa

According to our knowledge, there was no evidence that the Dalmatian pelican or any other pelican species could be affected by the avian influenza prior to 2015. In the early spring of 2015, the virus (H5N1 strain) killed 167 adult Dalmatian pelicans in Danube Delta (Romania), Lake Srebarna (Bulgaria) (Photo 1) and at the Volga Delta (Russia), without affecting the Greek colonies.



Photo 1. Dead Dalmatian pelicans being removed from the colony at Lake Srebarna in Bulgaria on 16-3-2015. Their deaths were detected by cameras installed on the wooden platform where they had recently begun to nest.

These events alarmed and mobilised the SPP, as the nightmare scenario of mass deaths in the world's largest colony of the species began to appear possible. Therefore, before such an

emergency might occur, the SPP aiming for an effective contribution to the management of such incidents, together with the local authorities and the assistance of the local veterinary authorities, designed and published relevant material in 2018, with the title [Contribution to the management of incidences of disease outbreaks in waterbirds in the Prespa National Park](#) in print and electronic form. This material was created in the framework of the European [LIFE Prespa Waterbirds](#) project. To check and comment on the written material, a pro bono Ornithological/Veterinary Expert Panel (*OEP*) was formed, composed of bird and wildlife pathology researchers, bird veterinarians and ornithologists, significantly contributing to the outcome.

Three years later, avian influenza infected Dalmatian pelicans in Greece as well. During the winter and spring of 2021 mass deaths of Dalmatian pelicans were recorded in many wetlands in northern Greece and the H5N8 subtype was detected in the samples. This phenomenon started in mid-February in Lake Kerkini and in early March dead pelicans started to be detected in both Lesser Prespa and the neighboring lakes of Kastoria and Cheimaditida. By early April a total of 183 dead Dalmatian pelicans were detected, with the highest number (73) in Lesser Prespa, 53 in Lake Kerkini, 29 in Lake Kastoria and 28 in Lake Cheimaditida. It is important to also note that, in these instances, all the dead birds were adults in breeding plumage.

The SPP's [Plan for co-ordinated action](#) (Photo 2), and its increased knowledge and expertise in these issues, were valuable allies in dealing with both the 2021 epizootic and the much larger one in 2022.



Photo 2. Folder containing material proactively prepared by the SPP in 2018 for the management of mass deaths of waterbirds in Prespa: the main text “Plan for Co-ordinated Action”, a supplementary leaflet on “General information and answers to Frequently Asked Questions” and a tri-fold leaflet “What to do in cases of mass mortality of wild birds in Prespa”.

Regarding the great white pelican *Pelecanus onocrotalus*, the first recorded deaths from avian flu were more recent and occurred in late January of 2021 in the National Bird Sanctuary in Djoudj in Senegal ¹. Djoudj is a migratory stopping point for 350 bird species, yet only great white pelican casualties were recorded. Of these, 740 were juvenile birds and only 10 were adults. This incident was followed by the death of 1,642 juvenile and 24 adult great white pelicans in Diawling National Park in Mauritania, which borders Djoudj, as both are located in

¹ <https://www.birdlife.org/news/2021/03/04/response-to-the-bird-flu-outbreak-in-senegal-and-mauritania/>

the Senegal River delta, which is the natural border between the two countries. On both occasions H5N1 was responsible. In late January of 2022, mass deaths of great white pelicans reoccurred in the same areas, and again H5N1 was detected. In Djoudj, 833 great white pelicans were infected, of which 758 died, most of which were juveniles. In early February of 2022 mass bird mortality was recorded in neighboring Diawling, with mainly juvenile great white pelicans were affected once again². During the same period (late 2021-early 2022) in Israel, in addition to cranes, 500 great white pelicans died from H5N1, but this time the mortality was amongst adult birds, during their migration to sub-Saharan East Africa.

Chronicle of the infection of Dalmatian pelicans at Lesser Prespa Lake

During 2022, the first Dalmatian pelicans arrived in Prespa on February 9th, according to SPP's monitoring programme. About a week later, the first mass deaths began to occur. Specifically, on February 17th, from a vantage point on Mount Devas, 11 dead Dalmatian pelicans were recorded on their nesting islets. A few days later, on February 21st, an increase in the number of dead birds was detected. The SPP in collaboration with the Prespa National Park Authority (now the Management Unit of Prespa National Park and Protected Areas of Western Macedonia – hereinafter referred to as PAMU/N.E.C.C.A.), continued recording the phenomenon in Prespa. As the number of dead pelicans increased, it became difficult to count them from vantage points using conventional methods (telescopes and binoculars), so it was decided to conduct a detailed drone survey of all the breeding islets in the colony. The first attempt, on February 25th, revealed 209 dead pelicans. Subsequently, the SPP carried out weekly drone flights, recording the development of the phenomenon in detail (Figure 1).

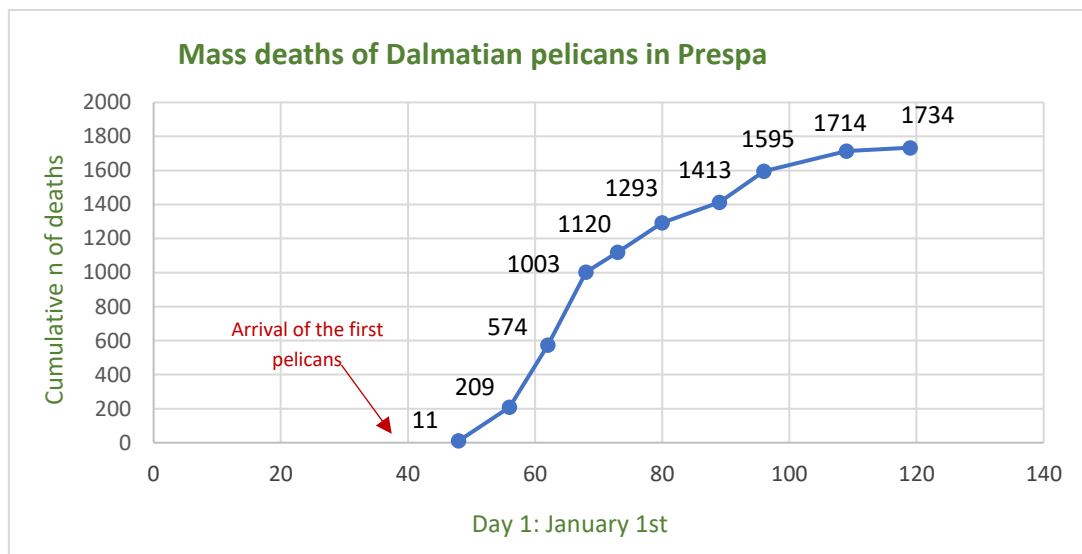


Figure 1. Cumulative number of deaths of Dalmatian pelicans during their breeding period in 2022 in the colony of Lesser Prespa Lake. Arrival of the first Dalmatian pelicans on February 9th (Day 40: Julian date – number of days from the beginning of the year), onset of the phenomenon on day 48 (February 17th), development of the phenomenon and its end at the end of April-early May.

On March 3rd, the veterinary authorities (Department of Veterinary Medicine at the regional unit of Florina) announced the results of the sampling of two dead Dalmatian pelicans: avian

² <https://www.cms.int/en/news/alert-increased-risk-highly-pathogenic-avian-influenza-outbreaks-wild-bird-populations-africa>

influenza had been detected, specifically the subtype H5N1 which is highly pathogenic (HPAI). A related announcement highlighted the increased risk of infection for farmed poultry and called for the implementation of biosecurity measures. The SPP was informed by the National Reference Laboratory for avian influenza that some of the virus strains that were detected were further analysed by the European Reference Laboratory and it was found that they belonged to clade 2.3.4.4b, which, according to experts, has been responsible for most epizootics of the highly pathogenic avian influenza since 2000.

In the first weeks the increase in deaths was dramatic, with the number reaching 1,003 by March 9th, when the main peak of the mortality rate was observed, with 60-70 deaths/day (Figure 2). It seems that the first wave of arrivals, that is the pelicans that arrived in Prespa from 9/2 to 25/2, was literally vanished during this peak. In the following weeks, the mortality rate slowed down but remained high, with an average of 20 deaths/day over the ensuing month. By the end of April, the epidemic had practically ended, leaving a total of 1,734 dead Dalmatian pelicans in Prespa. This number corresponds to approximately 60% of the breeding population of Lesser Prespa's colony (1,300-1,500 pairs in recent years), as all the dead pelicans were adult birds in breeding plumage.

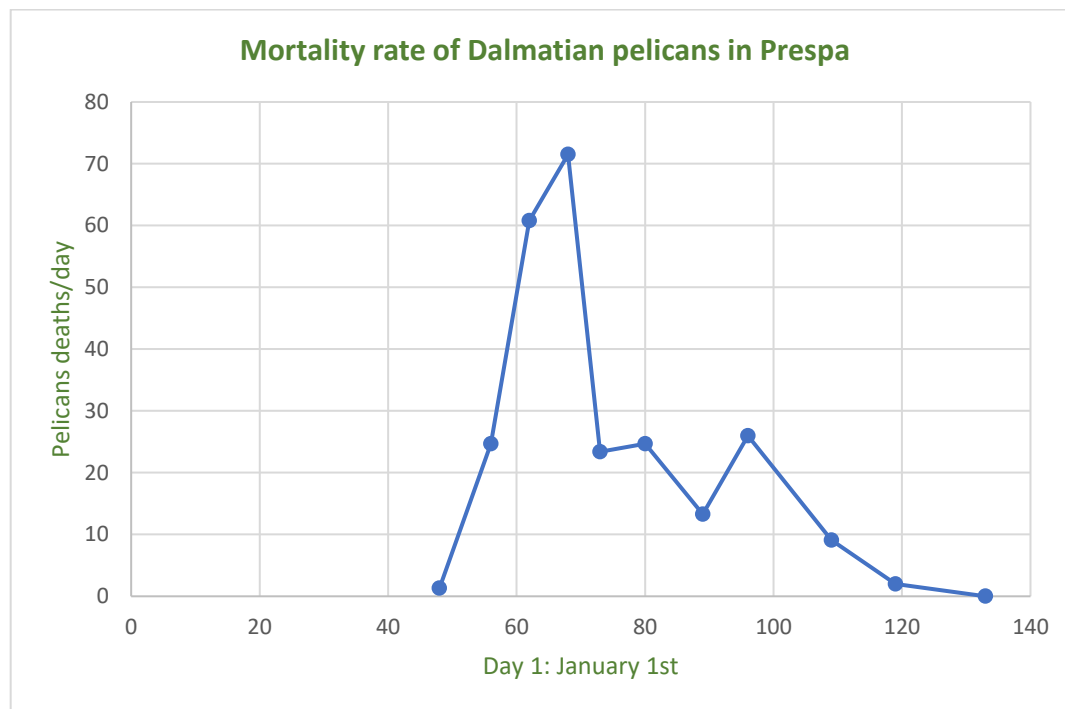


Figure 2. Change in the mortality rate (deaths/day) of Dalmatian pelicans in the colony of Lesser Prespa, from day 40 to day 133 (Julian day).



Photos 3 & 4. The largest nesting islet of Dalmatian pelicans in the Lesser Prespa Lake colony, which has hosted up to 300 nests in recent years. In the left image the islet is almost empty in late March 2022, with few living birds following the removal of 250 carcasses from this particular islet in the preceding days. In the right image the same island in March 2019 is full of life. SPP photo archive.

Geographical spread of the disease, collaboration with management units and scientists to monitor and keep on track with the epizootic in Greece and worldwide

Following the Plan for Co-ordinated Action for the management of incidences of disease outbreaks in waterbirds in the Prespa National Park, the SPP informed the relevant authorities (PAMU/ N.E.C.C.A, Ministry of Environment, Ministry of Rural Development and Food, Region of Western Macedonia, veterinary authorities, local and regional authorities), as well as environmental organisations, when the number of dead pelicans exceeded 10 individuals (17/2).

At the same time, the SPP notified collaborating authorities in Albania and North Macedonia regarding the transboundary Prespa, as well as corresponding environmental agencies and Management Units/N.E.C.C.A in other wetlands of Greece. In addition, immediate communication was established with the international *PELECANUS GROUP*³ network and the OEP, with the aim of providing guidelines to address the phenomenon with the utmost safety for both pelicans, other birds, humans and wetlands. Special emphasis was given to the co-ordination for the dissemination of information about the outbreak to the public, ensuring sufficient and well documented information without causing panic in wetlands where the phenomenon occurred.

Throughout the development of the epizootic, the SPP gathered information about dead pelicans in other wetlands in the country. This data came from the network of volunteers of the Hellenic Ornithological Society (HOS), as well as from the management units for protected areas in the country and other local authorities (e.g. Municipality of Amyndaio), and it showed the gradual spread of this phenomenon to various wetlands.

The first reports of dead pelicans outside Prespa came from the neighboring lakes of Kastoria and Cheimaditida in early March. However, it should be noted that the SPP was informed at a later stage by volunteers of HOS that on 9th January dead pelicans had already been found at

³ A network of researchers and other people engaged with the protection and conservation of Old World Pelicans. It includes 73 members from 23 countries, and they constitute the Pelican Specialist Group of the International Union for Conservation of Nature/Pelican Specialist Group (Old World)/WI - IUCN SSC.

Lake Kastoria, about a month before the first mass deaths in Prespa. According to the same volunteers, the local veterinary authorities were notified, but it is not known if samples were taken. After the first reports of dead pelicans at lake Cheimaditida in late February, the SPP began monitoring the development of the phenomenon with regular visits and drone flights to this colony – which is the newest Dalmatian pelican colony in the country, that was discovered by SPP in 2017 – as well as at the neighboring Lake Zazari.

At the same time, the disease was spreading in Greece, both to other breeding sites of the species and to other wetlands where pelicans feed during the breeding period. It is known that throughout the breeding season Dalmatian pelicans nesting in Prespa often travel, especially before May, to wetlands located up to 200 km away from Prespa in order to fulfill their increased nutritional needs during this period (Figure 3). These movements may have contributed to the spread of the disease, facilitating or even accelerating it.

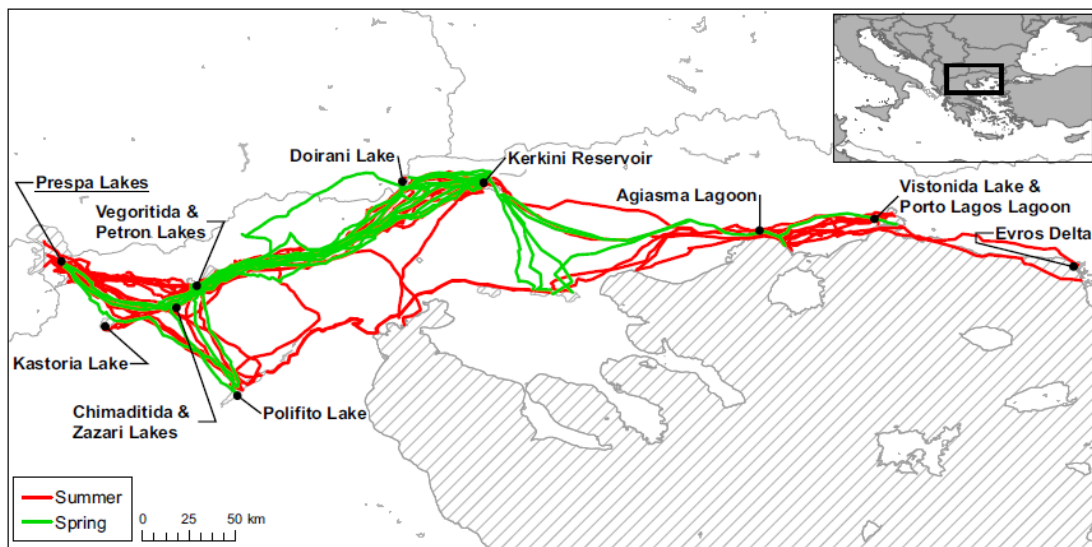


Figure 3. Spring (green line) and summer (red line) movements of Dalmatian pelicans between wetlands of N. Greece, as mapped from satellite transmitters in the framework of a telemetry project (from a scientific publication by the SPP, Efrat et al. 2018).

On March 8th, the first mass deaths at Lake Kerkini were recorded, and a few days later, on 13th March, at Karla Reservoir, and thus by the middle of March, all four colonies of the eastern sub-population of the country had been affected. Until the end of March, mass deaths of pelicans had been recorded in a total of 13 wetlands in Northern and Central Greece (Table 1 & Figure 4). Overall, in the spring of 2022, 2,286 deaths of Dalmatian pelicans were recorded in the country. The biggest losses were observed in the high-altitude colonies (Lesser Prespa Lake and Lake Cheimaditida) and 90% of total deaths were found in the lakes of Western Macedonia. Mortality was lower in low altitude colonies (Lake Kerkini and Karla Reservoir), probably because of higher air temperatures that do not favour the survival of the virus.

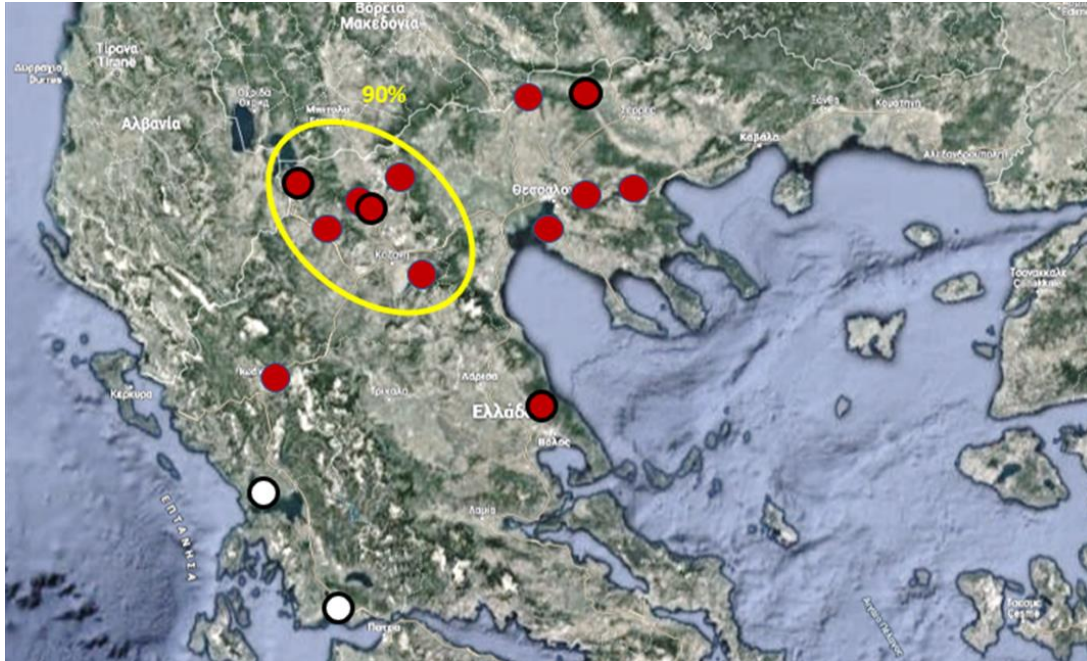


Figure 4. With a red dot the 13 Greek wetlands where mass deaths of Dalmatian pelicans occurred in the spring of 2022 - amongst them the 4 colonies of the eastern sub-population are marked with a black outline. The 2 colonies of the western sub-population, that were not affected, are marked with a white dot.

Table 1. Numbers of dead Dalmatian pelicans per wetland in Greece during the avian influenza epizootic in spring of 2022. The four breeding colonies are marked with an asterisk.

Wetland	N of dead pelicans
Lesser Prespa Lake *	1,734
Lake Cheimaditida *	181
Karla Reservoir *	103
Lake Kerkini *	90
Lake Kastoria	85
Lake Zazari	42
Lake Koroneia	23
Lake Doirani	15
Lake Pamvotida	4
Polifitou Reservoir	3
Lake Volvi	3
Lake Vegoritida	2
Aggelochori small coastal wetland	1
TOTAL NUMBER	2,286

It is important to note that at Karla Reservoir, dead chicks, 6 Dalmatian pelicans and 4 great white pelicans, were also recorded. Since no samples were taken from them for analysis, it is

not clear whether the chicks died from starvation due to abandonment by one or both parents, who had also died, or if they were infected by the virus and died.

Fortunately, in the two colonies of the species in Western Greece (Amvrakikos Gulf and Messolonghi Lagoon) there were no recorded incidents. It is known that the two populations, eastern and western, show very little gene exchange, which is attributed to minimal communication between them due to the barrier of the Pindos Mountain range. This fact possibly explains the absence of mortality in Western Greece to some extent.

Infection of other species in the country

No other species seems to have been affected in Greece during the 2022 avian flu epizootic. However, a few dozen dead wild birds from 11 additional species were recorded, mainly at wetlands where mass deaths of Dalmatian pelicans occurred, but also in other sites. It is not clear if all these deaths were connected with avian flu, because of the small sample size from other species, but it is quite possible due to the spatial and temporal coincidence. According to the information that the National Reference Laboratory gave to the SPP, the H5N1 subtype of avian flu was detected in 1 great white pelican and 2 mute swans *Cygnus olor* from Lake Kastoria, and in 1 yellow legged gull *Larus michahellis* from Lake Koroneia. A total of 6 dead great white pelicans were recorded in Kerkini (3), Karla (2) and Kastoria (1), however there were no great white pelican deaths in Lesser Prespa, even though it is the only major colony of the species in the country and the two species nest side by side on the same islet. It is almost certain that all dead great white pelican belonged to the small group of individuals that winter in Greece, and they probably died before the arrival of the large number of migrants from Africa. It is worth noting that, in Prespa, great white pelican breeding starts about two months after the start of the Dalmatian pelican breeding, so they began their breeding season in the spring of 2022 when the epizootic was coming to an end. In contrast, in Karla, where there have been a small number of great white pelican nests sporadically in recent years and these are chronologically closer to the nests of Dalmatian pelican, there were losses of great white pelicans, a few adults and more juveniles. Regarding other species: the biggest losses were recorded in Karla Reservoir (10 cormorants *Phalacrocorax carbo*, 1 mute swan, 1 grey heron *Ardea cinerea*, 1 yellow-legged gull, 1 black-headed gull *Larus ridibundus*, 1 ruff *Philomachus pugnax*), in Prespa (2 great egrets *Ardea alba*, 2 grey heron, 1 mute swan, 3 great crested grebes *Podiceps cristatus*, 1 pygmy cormorant *Microcarbo pygmaeus*), in Lake Agra (5 mute swans), in Koroneia (3 yellow-legged gulls, 1 common shelduck *Tadorna tadorna*), in Kastoria (2 mute swans) and in Cheimaditida (1 mute swan).

It is worth noting that although significant numbers of bird deaths from other species were not recorded, there are indications, at least in the colonies of large waterbirds at Lesser Prespa, that the breeding process was disrupted. According to the results of the SPP's scientific monitoring of heron and pygmy cormorant populations in Prespa in 2022, the following were recorded: 1. Mass abandonment of pygmy cormorant nests (estimated 50% of nests, an unprecedented percentage), primarily during the early stages of nesting, 2. Several abandonments of great white egret nests, 3. Low breeding success for the great white egret (which likely applies to other species as well). We speculate that the above are related to the avian influenza epizootic: it is possible that either some birds were infected and interrupted their reproduction yet did not die, or/and they were at some extent affected by the carcass

removal operations. It is also possible that inter-specific and intra-specific interactions, as well as other social mechanisms, that we do not sufficiently understand, informed the birds about the crisis taking place around the shared habitats and resources they use, negatively impacting the breeding process.

Impacts on other Dalmatian pelican populations in SE Europe

According to information gathered by the SPP through the *PELECANUS GROUP*, the presence of the H5N1 avian influenza strain was confirmed in 6 more Dalmatian pelican colonies in SE Europe. In the only colony of the species in Albania, at Karavasta lagoon, the losses were few with 3 dead pelicans, while the only colony in Montenegro, at Lake Skadar, had greater losses: 26 dead pelicans were recorded there, about 10-12% of the population⁴. Avian influenza was responsible for deaths in three more colonies of the species in the Danube Delta, Romania, with a total of 158 individuals, a number that corresponds to 20% of Romanian's breeding population⁵. As far as is known, there were no incidents in the remaining colonies of SE Europe, in Bulgaria and Turkey. Compounding the data from all the Dalmatian pelican colonies in SE Europe, the tragic outcome is 2,475 dead adult birds. Therefore, it is estimated that 40% of the breeding population of SE Europe has been lost, a percentage that corresponds to approximately 10% of the global breeding population of the species (estimated at about 24,000 individuals).

Global spread of avian influenza

According to estimations by the World Organisation for Animal Health (WOAH) more than 400,000 wild birds died from the H5N1 strain of avian flu between October 2021 and late 2022, with most of them located in Europe and the Americas. However, experts believe that the real number is much higher, as it is certain that many seabirds died on remote islands or at sea and therefore they were not recorded. The geographical spread of the virus in Europe was phenomenal: from the Svalbard islands in Norway in the Arctic Ocean to Italy and Greece, and from Portugal to Ukraine, the virus was detected in 37 countries, almost in the whole of Europe. At least 63 wild bird species were infected in Europe, with some of them suffering serious losses. Indicatively mentioned: 16,000 barnacle geese *Branta leucopsis* in Scotland (1/3 of the Svalbard-Scotland population was lost), >2,200 great skua *Catharacta skua* in Great Britain (7% of the global population), >8,000 northern gannet *Morus Bassanus* also in Great Britain⁶ (Photos 5 and 6), many thousands of sandwich terns *Sterna sandvicensis* in the Netherlands, Belgium and other countries along the North Sea: in many colonies of the species losses of up to 100%⁷ were recorded.

⁴ Vizi A. 2022. Outcome of avian flu outbreak in Dalmatian pelican population at Skadar Lake, Montenegro. *Natura Montenegrina Podgorica*, 2022, 14(3): 125-127.

⁵ <https://life-pelicans.com/news/the-avian-flu-strongly-affected-the-population-of-the-dalmatian-pelican-in-romania/>

⁶ <https://committees.parliament.uk/writtenevidence/113751/default/>

⁷ <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9707584/>



Photos 5 & 6. Removal of carcasses from a seabird colony in Great Britain (left) and dead northern gannet (right).
 Photo credits: Graham Hunt/BNPS. <https://www.dailymail.co.uk/health/article-11704597/Britains-biggest-avian-flu-outbreak-infects-mammals-including-otters-foxes.html>

The first worrying news had arrived from Israel in December 2021: >8,000 common cranes *Grus grus* died in the Hula Valley⁸, an important stopover for common cranes and other birds during their migration route to Africa. The Israeli authorities described the event as the biggest wildlife disaster in the history of the country. In the following period, until the end of 2022, similar disasters followed one another: from Europe to North America and then to South America, the H5N1 virus showed its aggression, attacking and indiscriminately killing many different species of birds, from waterfowl and seabirds to raptors and vultures. However, at the same time, Europe was at the centre of the virus's catastrophic action, as shown by the numbers (Figure 5). It is worth noting that mass deaths of wild birds were recorded on all continents except Australia and Antarctica in 2022. It should also be noted that in the same period more than 50,000,000 poultry had to be culled in Europe and many more in North America due to extensive bird flu outbreaks.

Among the species affected by the H5N1 strain around the world were all three American species of pelicans⁹, the near-threatened Peruvian pelican *Pelecanus thagus*, the brown pelican *Pelecanus occidentalis* and the American white pelican *Pelecanus erythrorhynchos*. The losses for the near-threatened Peruvian pelican were significant, with approximately 10,500 individuals affected¹⁰ (Photo 7).

⁸ <https://www.euronews.com/green/2021/12/28/most-serious-damage-to-wildlife-at-least-5-200-cranes-killed-by-bird-flu-in-israel>

⁹ <https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/animal-disease-information/avian/avian-influenza/hpai-2022/2022-hpai-wild-birds>

¹⁰ <https://phys.org/news/2022-11-bird-flu-pelicans-seabirds-peru.html>

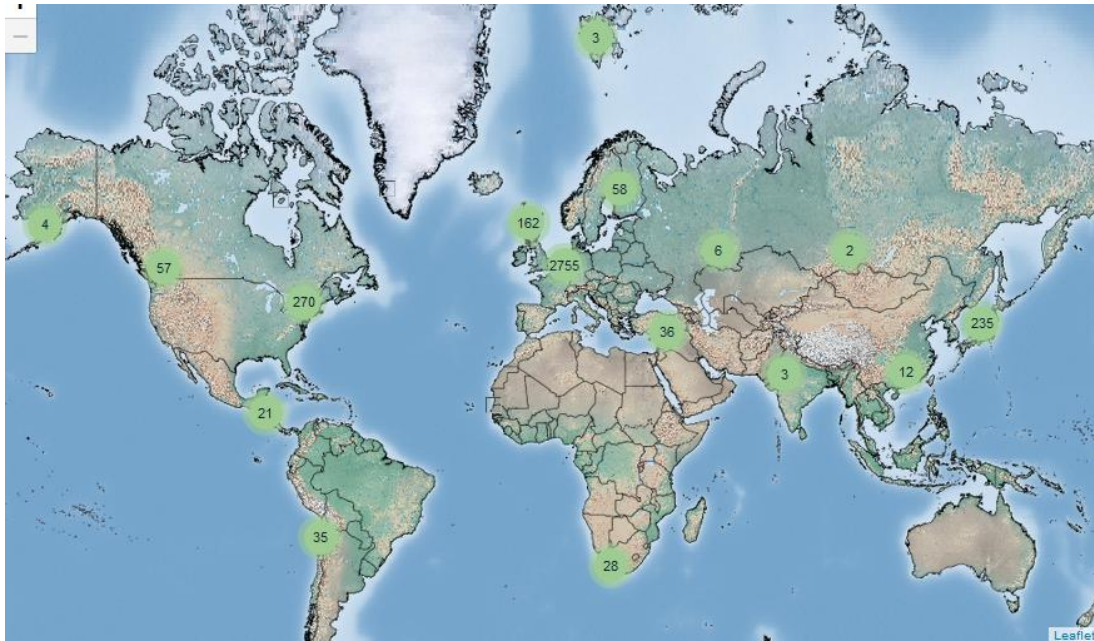


Figure 5. Geographical spread of avian influenza from October 2021 until the end of 2022, and the number of diagnosed wild birds per geographic unit. The map highlights the serious situation in Europe. (Source: EMPRES-i + Global Animal Disease Information System/FAO-UN).



Photo 7. Municipal employees disinfect the dead bodies of Peruvian pelicans on San Pedro in Lima, Peru, 1-12-2022. Photo credits: Associated Press <https://www.thehindu.com/sci-tech/energy-and-environment/pelicans-dying-as-bird-flu-outbreak-spreads-to-venezuela/article66229576.ece>

Activities and measures taken during the crisis

In 21/2/22, a few days after the first record of mass mortality of pelicans at the Lesser Prespa colony, and as the number of dead birds increased rapidly, the SPP activated the Plan for Co-ordinated Action. The Veterinary Department of Florina Regional Unit, the Management Body for the Prespa National Park (now PAMU/N.E.C.C.A) and the Municipality of Prespa were informed, while there were many verbal and written updates sent to all competent authorities (Ministry of Environment and Energy, Natural Environment and Climate Change Agency, Ministry of Agricultural Development and Food, Directorate for Forests of the Prefecture of Florina, Region of Western Macedonia), so that action would be co-ordinated.

The PAMU/N.E.C.C.A intensified its patrols around the wetland and assisted the veterinary authorities in taking samples (i.e., using the Management Unit's boat, rangers in proper protective gear went to the colonies and assisted the veterinarian in sampling, and in the second visit they collected two dead pelican carcasses, which were transported to the National reference Laboratory for Avian influenza. The SPP continued to monitor the colony intensively using conventional and aerial means (drone). Given the transboundary character of the area, the authorities of the neighboring countries were simultaneously notified of the need of vigilance, as well as the PrespaNet network of environmental NGOs. In addition, all the management bodies of the protected wetlands in the country, the *PELECANUS GROUP*, and the environmental organisations/members of the SPP were notified.

At the end of the first week (25/2) the rapid evolution of the phenomenon was obvious, as the number of dead pelicans had exceeded 200. By the end of the second week (3/3), and while 600 pelicans had already died, the veterinary authorities announced the detection of the highly pathogenic strain of avian influenza H5N1.

From the very beginning of the outbreak the SPP had called for guidance from the inter-scientific panel of experts/*OEP* (see above), and, through its extensive network of partners, had been in contact with specialised scientists from all over the world, who had recently faced similar crises (e.g. with collaborators from Israel). For the information and preparation of other bodies in transboundary Prespa and in the other wetlands in Greece, the SPP not only sent its own material, but also other useful documents (e.g. [Ramsar Wetland Disease Manual](#)), announcements of the CMS-FAO Scientific Task Force (Convention on Migratory Species- Food and Agricultural Organisation of the United Nations) on avian influenza and wild birds, and recordings from two useful webinars¹¹ that had occurred just a few days before, on the topic of managing incidents of mass mortality in wild birds due to avian influenza.

All the expert scientists agreed that there was not an effective way to treat the epizootic and they recommended the immediate, if possible, removal of dead pelicans to reduce the viral load and indirectly limit the spread of the disease and its catastrophic effects. At the same time, there was concern to ensure at least a minimum breeding success for living Dalmatian pelicans by the end of the season, while there was anxiety about the fate of great white pelicans, that were about to arrive in March-April, as losses had already been reported in Israel

¹¹ [Managing large-scale highly pathogenic avian influenza \(HPAI\) outbreaks in wild birds \[PART 1\] - YouTube](#), [Managing large-scale highly pathogenic avian influenza \(HPAI\) outbreaks in wild birds \[PART 2\] - YouTube](#)

two months earlier. However, despite the immediate and continuous interest of local and regional authorities, the immediate mobilisation of all the NGOs-members of the SPP (WWF Greece, Hellenic Ornithological Society, Hellenic Society for the Protection of Nature, Elliniki Etairia/Society for the Environment and Cultural Heritage, Arcturos, Friends of Prespa, MedINA, Greek Biotope/Wetland Centre) and extensive consultations that took place at Prespa, the removal of carcasses only started on March 17th, exactly one month after the start of the outbreak and after more than 1,000 Dalmatian pelican carcasses had already been amassed in Lesser Prespa.

At the same time, in order to ensure a detailed recording of the outbreak's progression in the country, and in the absence of a central archiving body, the SPP took on the task of gathering information about the whole of Greece. Through related announcements via email and social media platforms, the SPP undertook the collection of data on mass mortality of pelicans and other birds, both from the HOS volunteer network and from the management units of protected areas in the country and other local bodies.

Efforts were also made to continuously update the public, and national and international experts, through regular announcements on SPP's website, social media and the *PELECANUS GROUP*. Contributions were also made to relevant reports from international organisations¹². Given the intense interest and concern of the global community regarding the mass deaths of a vulnerable and iconic species, in close collaboration with HOS, the SPP was the only actual source of information regarding the devastating impacts of avian influenza in Prespa and the rest of the country.

At the same time, an effort was made to inform the general public about the development and impact of the outbreak both in Prespa and in other wetlands of the country, in order to produce unbiased information that would not cause panic or misunderstandings regarding the role of wetlands or waterbirds in the public health and the economy.

Operation for the removal and management of dead pelicans

To cope with this unprecedented crisis, many public and private, national, and international organisations, as well as scientists, were mobilised. Numerous coordination and decision-making meetings with local stakeholders were organised, and in these meetings the plan for addressing the crisis was gradually developed. With everyone's assistance, a special operational plan was formulated to remove dead birds from their nesting islets and the lake, which was particularly challenging in its implementation details and faced many challenges on various levels:

1. Safeguarding the breeding of living pelicans and other species nesting near the dead birds,
2. Obtaining the necessary permits and implementing proper procedures for taking action in Zone A (Strict Protection Zone),
3. Ensuring procedures for the health and safety of the operational team,

¹² <https://www.unep-aewa.org/en/news/avian-influenza-continues-impact-wild-migratory-birds-case-prespa-national-park>

4. Organising a specialised operational plan for the collection and incineration of the dead birds, and finally,
5. Organising targeted and calm communication in order to protect economic activities in the Prespa region, such as tourism and fishing.

In a wide meeting on 6/3/22 of all involved local bodies, with the participation amongst others of the Deputy Minister of Environment and Energy, the Regional and Deputy Regional Governor of Western Macedonia, the Lieutenant Colonel and Commander of the 9th Infantry Division, the Chairman of the Management Body for the Prespa National Park, the Mayor of Prespa and the SPP, it was decided that the Region of Central Macedonia and the Regional Administration of Florina undertake co-ordination of the operation for the removal and management of the carcasses, as well as the financial burden.

Before the interventions, the necessary licenses were obtained from the Department of Wildlife of the Ministry of Environment and Energy, as the operation would take place in Areas of Strict Nature Protection of the Prespa National Park. In these licenses the operational planning approach to ensure the protection of non-infected birds (e.g. intervention after implementing a monitoring programme, determining routes that would not disturb other species) and to prevent actions that would impact other values of the wetland (e.g. prohibiting widespread use of disinfectants) was described in detail. In addition, the permit included measures to be taken to ensure public health and the safety of the operational team from the infectious disease.

It should be noted that during co-ordination discussions between stakeholders it was decided to collect only the dead birds and not the sick/dying ones, as there was no clear directive on handling them after their removal from the colonies.

Numerous agencies contributed to the completion of the operation: local veterinary authorities; the Management Unit of Prespa National Park, with its personnel and its boat; the Municipality of Prespa, with its personnel and crane truck; the SPP with its personnel, its agricultural tractor, and the amphibious TRUXOR machine (which undertook the opening of access routes to the most inaccessible islets of the reedbed and the towing of the boat in shallow waters); the Army Guardhouse of Limos, which provided sturdy and suitable boats for sailing in shallow waters; the "Pelican" Agricultural Co-operative of Bean Producers, which provided its bridge scale for weighing the dead birds; and the Police Station of Agios Germanos, which contributed with the management of television crews, as there was increased interest from the country's media.



Photos 8, 9 & 10. On the top left the image shows the transfer of the dead birds from the boats to the Municipality of Prespa truck. On the top right, the amphibious vehicle of the SPP during the operations, while at the bottom, a photograph of loading the dead pelicans onto a specialised truck for transportation to an incinerator. SPP photo archive.



Figure 6. Operational map for the removal of dead pelicans from Lesser Prespa. In red the routes that the boats followed via Koula channel towards the nesting/roosting pelican sites and the shallow lake of Viro. The blue triangles depict the vantage points for the co-ordination of the operation and the safety of the boatmen, the green dashed line shows the pathway opened by the amphibious machine of SPP in the reedbed to ensure access to this inaccessible area.



Photo 11. The northern part of Lesser Prespa where the breeding and resting islets of pelicans are located. At the lower end of the image is the Koula channel, through which the transfer of dead birds occurred. With a red arrow is the swallow lake Viro. SPP photo archive.

Although the regional authorities made an effort to employ specialised workers to undertake the operations (collection, transportation and disposal of carcasses), this was not fruitful. Eventually, two local fishermen were employed (Photo 12), and it was them who carried out

the most demanding and dangerous part of the operations, namely the collection of hundreds of dead pelicans.

The local fishermen, knowing the area and its unique characteristics better than anyone, worked tirelessly in very difficult conditions, amidst the intense smell of hundreds of carcasses and in very low temperatures. It should be noted that waterbirds often nest in marshy areas that are difficult or impossible to approach, even for experienced personnel.

During their work, the local fishermen wore special personal protective equipment (single use suits, face masks, protective eye masks and reinforced gloves), although this did not make movement inside or out of the boat at all easy. In addition, to ensure their safety and the coordination of their work, they were monitored by the personnel of the RAMU/NECCA, from a boat which sailed at a close distance and was equipped with suitable rescue equipment. While the operation took place in dense reeds, making visual observation of the collection team difficult at times, members of the SPP observed the operation from vantage points and from the amphibious machine. This allowed them to relay messages via wireless communication to the team of the PAMU/NECCA, which was alongside.

The two fishermen used hay forks to place the carcasses in the boats, in specialised plastic boxes or durable bags for transporting heavy materials. Then the boats came out of the wetlands and the boxes/bags were loaded one by one in the municipality's crane truck or the SPP's tractor platform. Afterwards, they were transported in a refrigerated truck and finally transferred to a special unit for handling medical waste in Kozani.



Photo 12. The two local fishermen who undertook the difficult task of collecting the hundreds of dead birds at Lesser Prespa. Photo credit: Dimitris Vavilis/ SPP archive.

Seven working days were needed for the collection of carcasses, five days during March (17-19/3, 21/3, 24/3) and two days during April (11/4, 15/4). In April, some trips were repeated in

small islets where the mass deaths had continued, after the first carcass removal. A very difficult operation was also organised in the swallow lake Viro, which hosts almost the half population of pelicans in Prespa.

In April's operations, special care was taken to minimise the disturbance in the surviving Dalmatian pelicans, that had managed to build nests, as well as the great white pelicans that had recently arrived. Thus, weighing the risk of not removing all the carcasses and the benefits to the remaining pelicans from ceasing disturbance in the highly distressed colony, it was decided that the boats would not approach some of the islets, where there were nests at an advanced stage, and to leave some carcasses behind. In the middle of April, a drastic decrease in the viral load had been achieved: A total of 1,420 carcasses of Dalmatian pelicans had been removed from the lake (82% of the total), weighing 14.3 tons.



Photo 13. Collection of dead pelicans in the difficult-to-access colony of Viro, while the first great white pelicans had already arrived in Prespa. Photo credit: Dimitris Vavilis/ SPP archive.

Collection of dead pelicans in other wetlands

According to the information that SPP had from other wetlands, collection and management operations for dead pelicans were carried out in most wetlands with large numbers of carcasses, as at Lake Cheimaditida and Lake Zazari, Lake Kastoria, Karla Reservoir and Lake Koroneia. In Lake Kerkini the collections of carcasses were not possible because they were in shallow areas and there was no access.

It is important to note that there were different approaches in managing the incidents by local authorities, depending on the wetland, in many cases there was improvisation in their actions, highlighting the lack of central planning and the ambiguous framework for addressing incidents of mass wildlife mortality.



Photos 14 & 15. Sampling of dead pelicans at Lake Kastoria (Nikos Panagiotopoulos/ SPP archive) and collection of dead pelicans from Lake Cheimaditida by local fishermen (Eleni Gyriki/ SPP archive).

Breeding outcome of Dalmatian pelicans in Prespa in 2022

The tragic loss that marked the 2022 breeding season resulted in a dramatic reduction in the population and the loss of a large number of nests. Dalmatian pelicans arrived in waves and died in a few days, with some of them managing to build nests and to lay eggs before they died. Some others abandoned their nests because they lost their mate. New waves of arrivals were followed by new losses, a continuous flow of deaths. After the collection of carcasses in March, there was an explosion of new nest construction, in a few days there were 150 new nests, but birds continued to die, at a slower rate, until late April. The nests that were built in late April were not affected, their mortality was almost zero and these birds survived.

Approximately 190 pairs of Dalmatian pelicans managed to successfully nest, raising a total of 110 chicks. These numbers were the lowest recorded in Prespa since 1990s. It should be noted that the number of Dalmatian pelican nests in Lesser Prespa in the last years had been around 1,300 to 1,500 (Figure 7)

Meanwhile, great white pelicans in Prespa remained unaffected by the disaster in their relative species, even though a portion of the population built their nests during the epizootic and even close to Dalmatian pelican carcasses. The final assessment of the year was positive for them. Both their nest numbers and breeding success were stable at the same levels as in previous years.

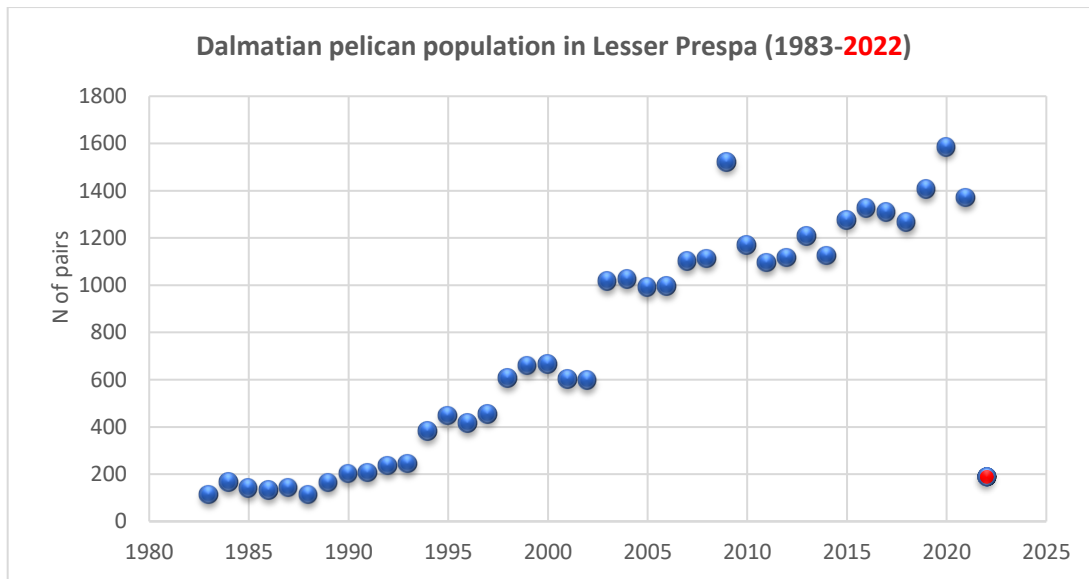


Figure 7. The development of the Dalmatian pelican breeding population in the Lesser Prespa colony, from 1983 until today.

Alarming questions and concerns

When and where did the Dalmatian pelicans that died in Prespa become infected with avian flu?

The Dalmatian pelicans of SE Europe winter in wetlands in N Greece (mainly Lake Kerkini), in NE Greece (mainly in Lake Vistonida, Porto Lagos Lagoon and the Evros Delta), as well as in E Turkey. During their migration route to Prespa they visit various wetlands in N Greece to feed and rest, staying in some of them for days or even weeks. Given that the first symptoms of avian flu may develop from a few hours to 3 days at a minimum, and until 14 days at a maximum, it can be expected that if the birds had been infected in their wintering grounds or at any of the intermediate stops, mass deaths would occur before the pelicans arrived in Prespa. However, this didn't happen, as was mentioned above in the description of the geographical spread of the disease in the country: The first mass deaths of pelicans were recorded in the Lesser Prespa colony, or most likely in the neighboring lake of Kastoria, while mass deaths of pelicans in eastern wetlands would follow later.

The hypothesis under examination is that the Dalmatian pelicans were affected upon reaching their breeding islets in Lesser Prespa. According to this scenario, the influenza virus was transmitted to the pelicans through their contact with the excreta of migratory waterbirds and/or the resident population of greylag geese (*Anser anser*). It is well known that waterbirds, such as geese, are often carriers of avian flu without getting sick. The evidence supporting this scenario is: a. the fact that the pelican islets are used by different species of waterbirds as roosts, before pelicans arrive in the area; b. the pelicans build their nests by carrying old reed canes, that are available on the islets, with their bills – in these reeds, it is certain that there are excreta from previous users; c. in the winter of 2021-2022 the number of wintering waterbirds in Lesser Prespa was the highest that has ever been observed and triple the average.

What is the cause of the great vulnerability of the Dalmatian pelican?

Various factors may have contributed to the high rates of infection and vulnerability of the Dalmatian pelicans, especially in the Prespa colony. The early onset of their breeding cycle in recent decades, in combination with the low temperatures in Prespa for this period (mean monthly temperatures for February, March and April 2022: 4°C, 5°C and 9°C respectively), seems to be a catalytic factor. According to current knowledge, avian influenza viruses remain infectious for 30-35 days at 4°C and for 7 days at 20°C. As previously mentioned, mortality was high in the colonies of Lesser Prespa and Cheimaditida, which are mountain wetlands with low temperatures during this period, while, on the contrary, in the colonies of Kerkini and Karla where the temperatures are higher, mortality was much lower.

Another factor that may have had a negative role is the high concentrations of pelicans on their breeding islets in Prespa. The mass gathering of hundreds of pelicans, high concentrations in limited space, mating displays, fights and pairings, all these favour the dispersion and exchange of droplets originating from the respiratory and digestive organs, thus creating ideal conditions for the rapid transmission of the virus. According to our observations, the small and isolated nesting islands suffered less than large and densely populated ones.

Finally, it is possible that unknown genetic factors may have contributed to the vulnerability of the Dalmatian pelican.

Which are the chances of the future re-emergence of avian influenza epidemics of similar severity?

According to recent scientific publications and reports from organisations, such as the European Centre for Disease Prevention and Control (ECDC), the avian influenza virus should no longer be considered as a bird disease, but as an emerging threat to wildlife worldwide. The latest ECDC¹³ report for the evolution of the avian flu epizootic in 2021-2022, highlights it as the longest-lasting and geographically most widespread epizootic of the disease that has ever been observed in Europe, while expressing concern about the high numbers of virus detections in wild birds in 2022, even during the summer months, when incidents typically do not exist. The same report notes as important the difference in the bird species that get affected, from migratory winter species to resident and/or breeding species, including colonial ones.

Experts are sounding the alarm for wildlife management agencies to get prepared for a disease that hasn't been a concern before. The preparation of responsible authorities for the future is an urgent need in particular. They emphasise the need for careful recording of the number of wild birds found dead or sick by the authorities, so the ecological impact can be assessed and to develop prevention plans, not only for poultry and humans, but also for wild birds. It should also be noted that the World Organisation for Animal Health (WOAH) emphasises that the current wide range of subtypes of avian influenza circulating shows continuously evolving complexity, both in the genetics of the virus and its spatiotemporal distribution. The detection of the H5N1 virus in dozens of species of wild mammals during the current period is also

¹³ <https://www.ecdc.europa.eu/sites/default/files/documents/Avian%20Influenza%20Overview%20Sep-Dec%202022.pdf>

alarming, with heavy losses recorded on coastal Peru, where amongst the thousands of seabirds, 600 sea lions also died¹⁴. According to WOA, all the data indicate a dynamic situation that is not expected to be resolved quickly¹⁵.

Investigation of the vulnerability of the Dalmatian pelican to avian influenza – a new research programme by the SPP

With a sense of responsibility, having worked for over 30 years on the research and protection of pelicans, the SPP immediately responded to the huge blow that the population of Dalmatian pelicans in Prespa had had to face. During July of 2022, a wide ranging genetic and toxicological research programme was launched, in collaboration with Prof Ursula Höfle of the University of Castilla-La Mancha and her team, Grupo SaBio Instituto de Investigación en Recursos Cinegéticos I.R.E.C., Ciudad Real, in Spain, and with the participation of Dr Panos Asmanis, a veterinarian specialised in wild birds. It should be noted that both scientists are members of the expert panel (OEP) that advises the SPP about infectious diseases of wild birds, and their contribution during the 2022 crisis was very important.

The aim of this research is to understand the factors involved in the vulnerability of the species to avian flu, in order to organise a better management of the risk for this threatened species. This investigation aims to clarify, as much as possible, some crucial issues regarding the possible biological or genetic basis of the high vulnerability of the Dalmatian pelicans in Prespa, to explore the possible involvement of other infectious factors, and to improve our understanding of the transmission mechanisms, as well as the survival and preservation of the virus.



Image 16. Genetic samples were collected from Dalmatian and great white pelican chicks in the Lesser Prespa colony by the SPP team, accompanied by a veterinarian, in July 2022. (L. Nikolaou/ SPP archive).

¹⁴ <https://www.cidrap.umn.edu/avian-influenza-bird-flu/peru-confirms-h5n1-avian-flu-marine-mammals-part-southward-spread>

¹⁵ <https://www.woah.org/en/disease/avian-influenza/>

As part of the research that will last until mid-2024, the collection of samples, mouth swabs, cloacal swabs and feather samples is planned from both juvenile and adult pelicans of both species. Collecting samples from great white pelicans is expected to help understand the Dalmatian pelican vulnerability, as they are closely related species that nest side by side in the Prespa colony. At the same time, samples will also be taken from Dalmatian pelican chicks in all the colonies of the country, both eastern and western sub-populations, that were not affected. The comparative study of the dynamics of the virus and other pathogens between different colonies of the species is expected to highlight the causes of the particularly devastating effects on Prespa's population.

At the beginning of 2023, as part of a programme of satellite transmitter deployment on Dalmatian pelicans (following the long-term telemetry programme initiated by the SPP, which started in 2012), genetic samples were collected from 21 adult or immature birds that were trapped and fitted with transmitters.

In addition, the SPP will work during the coming years to mobilise other researchers in SE Europe who are active in the Dalmatian pelican colonies in the Black Sea/Mediterranean region, in order to investigate the risks that may be associated with the potential loss of genetic diversity.

Lessons learned and future challenges

It is apparent from the above description that serious concerns have arisen regarding the survival of the species in the event of a recurrence of a similar epidemic in the future. Therefore, it is important, having learned from the devastation of 2022, to prepare ourselves in the best possible way for the future.

The lessons learned from the dramatic losses of wildlife due to avian influenza in the past years on a global scale are significant and cover various issues. The lack of preparedness and planning for such massive phenomena has been obvious not only in Greece but also in many other countries. This is related to the ambiguous legislative framework, which often leads to confusion about responsibilities amongst the authorities, the deficiency in relevant scientific studies, shortages in equipment and an inability to manage events of such scale. The key conclusions from the management of the catastrophic event of the mass deaths of the Dalmatian pelicans in 2022 are summarised below.

SCIENTIFIC RESEARCH

Monitoring the genetic sequence of avian influenza viruses is necessary for basic biological research, and according to experts, this basic research, along with surveillance, are the main tools that need to be developed worldwide¹⁶.

Encouraging research by international and domestic research institutions/universities on zoonotic diseases is essential for understanding and addressing avian influenza, which has been declared a new threat to biodiversity.

¹⁶ <https://www.sciencemediacenter.de/en/our-offers/press-briefing/details/news/avian-influenza-a-devastating-pandemic-for-birds-and-a-threat-for-global-health/>

Greater involvement/specialisation of domestic researchers and the establishment of properly equipped multiple laboratories in the country will create the conditions for real-time monitoring of the phenomenon. Processing and analysis of biological materials must be done within a short period of time, as it becomes futile after a certain period.

ANNUAL MONITORING OF POPULATIONS AND HABITATS OF WATERBIRDS

The systematic scientific monitoring of breeding, feeding and resting sites of waterbirds is a prerequisite for both monitoring and organising any operational planning. A waterbird monitoring programme should be organised and implemented, with the aim of identifying breeding, feeding and resting areas, providing information on population trends over time, and reporting on dead or sick birds.

It is worth noting that within this exact framework, the SPP has been preparing a national report on pelicans since 2015, in implementation of its co-operation agreement with 12 management bodies for wetlands that are important for pelicans, and HOS. This annual national report includes the presentation, composition and analysis of annual data related to breeding of the two species of pelicans in all colonies of the country. Furthermore, important observations, developments, and notable events of the year related to pelicans are provided, while dead and injured birds recorded during the year are also documented. The systematic monitoring of populations at national level and the recording of all the above information in the form of an annual report has been shown to be particularly useful, amongst other things, for assessing the status of the Dalmatian pelican population in the country after the 2022 destruction.

Since bird mortality is not a rare occurrence, it might be useful to establish numerical thresholds for each area. When these thresholds are exceeded, authorities should be mobilised, especially for colonial species. Given the wide spread of avian influenza, it might be advisable to carry out sampling and transport carcasses to laboratories for examination even when a single dead bird is detected. The collection and transportation of samples is under the responsibility of the respective Forestry Department. However, they may not always have the means to access wetland areas, so co-operation with Management Units of protected areas, where they exist, is necessary.

There is an urgent need to ensure regular patrols in wetland areas, especially during the breeding season, for the timely detection of suspicious incidents and immediate notification of veterinary authorities.

It is considered important to maintain a simple protocol that includes species identification, if possible, date, location and relevant photographs. A detailed archive aids in assessment, research and accurate information for national and international agencies, as well as updating national and international databases.

SAMPLING OF DEAD – SICK – HEALTHY BIRDS

The limited formal responsibilities of the veterinary authorities with regard to wildlife creates problems in managing a large-scale disaster such as that of 2022. Within the current institutional framework, during an epidemic affecting wildlife the interest of veterinary

authorities is only activated when public health and economic activities (such as poultry farming) are threatened. In the face of an emerging significant threat to wildlife on a global level, there should be greater involvement of the competent state services.

There is an urgent need to ensure that sampling is carried out on a larger scale. Taking 2-3 samples from dead birds per wetland, the veterinary authorities confirm the presence of the disease and facilitate the implementation of biosecurity measures for poultry farms. However, this does not contribute sufficiently to comprehensive research and better understanding of the disease in wildlife. In the context of the prevention and surveillance of avian influenza, authorities in many developed countries take samples even from seemingly healthy birds, either through targeted trapping of wild birds or as part of research initiatives by various entities with potentially different objectives.

MANAGEMENT OF LARGE NUMBERS OF SICK WILD BIRDS

There is no management plan for diseased or dying wild birds found in nature, especially in large numbers. The question remains: should they be removed or euthanised? In countries like Israel, where access to the sick birds was immediate and easy, appropriate measures were taken to prevent the spread of the disease, and dying birds were euthanised by veterinarians. In other countries, dying birds were left to die and then collected. There is no clear directive from international organisations regarding the management of these dying birds, and this lack of guidance may potentially lead to further disease dispersal.

COLLECTION AND MANAGEMENT OF LARGE NUMBERS OF DEAD WILD BIRDS

It is crucial to intervene immediately to remove carcasses. According to current knowledge, it is the only known measure for limiting the spread of the disease and consequently for protecting wildlife and ecosystems. However, the collection and management of dead birds in our country faces the following issues that need to be resolved:

- The legal framework regarding the authorities' responsibilities and the procedures they should follow to collect carcasses of wild animals, especially birds, from mass mortalities is unclear. The collection of samples from colonies in wetlands by untrained personnel, the management of infected samples and the handling of large-scale viral loads were issues that were resolved with great effort, dedication and a positive attitude from all stakeholders. Based on this experience it would be beneficial to re-evaluate the demarcation and description of responsibilities, making them sufficiently clear and ensuring that everyone feels much safer and more confident about the steps to be taken in such circumstances.
- It is necessary to anticipate how related costs (collection, transportation, incineration, or alternatively, or for smaller scale incidents, provision of sanitary burial sites in each wetland) should be covered. The cost of transportation and incineration is covered by a related regional programme, but the cost of collecting dead birds from their breeding colonies has not been foreseen as an additional expense. Obviously, it was not possible for everyone to envision the scale of this destruction, but the events of 2022 have shown us a different and much more demanding reality.

- The timely acquisition of the necessary permits from the authorities is essential. Due to the long-standing presence of researchers and other agencies in the Prespa National Park, as well as the presence of the PAMU/N.E.C.C.A, mobilisation was immediate. The co-operation with the relevant authorities at the Ministry of Environment was seamless. The long-term waterbird monitoring programme, knowledge of the area and the access points as well as the extensive experience of the Department of Wildlife at the Ministry of Environment, resulted in the relevant permits being issued quickly. These permits should include measures for the protection of other species, measures for the collection of dead birds and complementary measures for the biosecurity of the team, such as monitoring by the Hellenic National Public Health Organisation.
- The existence of site-specific operational planning is important. Related legislation provides for actions to be taken on a large scale across the country to address such incidents. However, each site has its own particularities, and it would be beneficial to use local stakeholders' knowledge, experience and resources to organise a local plan for the immediate intervention and handling of similar incidents. The existing plan "Contribution to the management of incidences of disease outbreaks in waterbirds in the Prespa National Park", which was created as part of the LIFE Prespa Waterbirds project, as well as the ongoing communication in Prespa through the Wetland Management Committee¹⁷ with all stakeholders regarding water and vegetation management, had helped familiarise all the relevant stakeholders with wetland issues and had already discussed the possibility of such an event as a hypothetical scenario. In the case of Prespa, both knowledge and resources (flat-bottomed boats, amphibious machinery for marshy areas, local infrastructure) were available for the immediate collection of dead birds. However, it cannot be assumed that every region in the country would have similar infrastructure. It would be beneficial to engage in local planning prior to the occurrence of any such phenomenon, including the participation of stakeholders and identification of resources that could be utilised in such situations.
- The activation of all local stakeholders, in addition to the competent authorities, is necessary for a fast and successful response to such incidents, as well as for social cohesion and participation in the events. However, when stakeholders are to be involved it is essential to provide prior training and information, as this specific disease is infectious to humans. During an outbreak, panic and misinformation may arise, making pre-existing awareness crucial.

¹⁷ The wetland Management Committee was established in 2008 following a proposal by the SPP. It served as an advisory committee to the Management Body of Prespa National Park, with the aim of involving all stakeholders in the decision-making process for wetland management. The wetland Management Committee included representatives from the Ministry of Environment and Energy, the Region of Western Macedonia (Water Department, Environmental Planning Department), the Municipality of Prespa, the Local Land Improvement Agency and the SPP. In 2012, the Wetland Management Committee was expanded to include members from local livestock and fishing co-operatives, whose activities were directly affected by and had an impact on the condition of the wetlands. It constituted a unified framework in which all stakeholders participated in the decision-making process for wetland management.

INFORMATION-NETWORKING

The existence of the team of scientists and experts that provided advisory support to the SPP was crucial for information and decision making during the crisis, both at local and regional-transboundary level.

In general, the established networks of the SPP proved to be highly effective in exchanging information and expertise, mutual awareness and guidance, especially in the early stages of the crisis. The open line of communication between local stakeholders, stakeholders from other wetlands of the country, HOS volunteers, the PrespaNet environmental NGO network, stakeholders participating in the Transboundary Prespa Park, and the *PELECANUS GROUP* for international-level information, particularly in the Southeastern Europe region, demonstrated that long-standing collaborations provide significant assistance during times of crisis.

Moreover, the continuous updating of international organisations significantly contributed to accurately capturing the phenomenon and assessing the situation at the international level.

COMMUNICATION

The communication of incidents of mass mortality in wild birds at a national level, which was also foreseen in the SPP's Plan for Co-ordinated Action, proved to be crucial for countering misinformation, preventing panic and a climate of insecurity amongst the local population, and assisting the efforts of the competent authorities in taking measures. Furthermore, it was demonstrated that an informed local community acts as an ally in the efforts to document such incidents.

Regarding the dissemination of information to the wider public, the main lesson learned from the mass deaths of pelicans in 2022 was that it is important for the different organisations involved to be organised, in order to have a co-ordinated and careful voice in the media. This helps to avoid misinformation or over-dramatisation of the situation and also protects the wild birds from additional disturbance.

Epilogue

While biodiversity is declining worldwide at alarming rates, primarily due to human activities, a new threat is emerging for wildlife, especially for wild birds. The change in the epidemiology of avian influenza, the adaptation in wild bird populations and the impact it has on many different populations and biodiversity have raised the alarm within the global community.

The minimal measures to counter the threat to Dalmatian pelicans include vigilance, increased protection measures in their colonies and focused research across all areas of their range. At the same time, it is more urgent than ever to effectively protect all the areas that are significant for the species and equally crucial to mitigate other threats.