Behavioural response of breeding Mute Swans *Cygnus olor* to lockdown measures: a case study

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Abstract

In spring 2020, human activity was strongly reduced because of restrictions in movements imposed during the Covid-19 pandemic. In Poland, traditional recreational areas and tourist attractions were closed to the public from 24 March to 20 April 2000, which coincided with the time when Mute Swan *Cygnus olor* pairs establish their breeding territories. Following withdrawal of the restrictions at the end of April, people's access to the countryside in May and June returned to normal levels. This study compares the breeding performance of Mute Swans at two distinct locations which differ in the level of human activity: a private fish farm closed to the public *vs.* a dam reservoir which is open to visitors. Fishponds at the Sarnów fish farm are visited on a regular basis only by workers at the site (5–6 people per day), whereas Sulejowski Reservoir is a popular recreational area, especially during weekends, for hundreds of visitors. The reduction in human activity during spring 2020 resulted in a significant increase in the number of breeding pairs at the reservoir (6–7 pairs in years 2015–2019 *vs.* 15 pairs in year 2020), but the number of breeders on the fishponds did not change significantly (8–11 in years 2015–2019; 10 in year 2020). New territories appeared later at the reservoir in the pandemic year (median laying dates: 8–16 April in 2015–2019; 24 April in 2020). The breeding success of pairs at new locations was very low, with most losing their broods during the fledging period. Nonetheless, the marked change in the year 2020 in the number of Mute Swans breeding at a recreational site suggests that human-related activity may limit the nesting distribution of this species.

Key words: behaviour, human pressure, Mute Swan, pandemic restrictions.

Human presence can influence all types of habitats, and consequently the distribution and behaviour of many wild species (*e.g.* McKinney 2002; Vitousek *et al.* 2007; Bateman & Fleming 2012). It is especially pronounced in densely occupied areas with highly developed infrastructure (McKinney 2006; Luck 2007). Urban development results in massive local extinctions and frequently eliminates many native species

(Aronson *et al.* 2014). Two main scenarios are currently thought to occur in different parts of the world: local fauna will increasingly adapt to human presence, or alternatively they will reduce their home range to areas where pressure from people is at a low, acceptable level for them (Marzluff 2001; McKinney 2002).

The recovery of the Central European Mute Swan *Cygnus olor* population in the 1960s was related to behavioural change, associated with a reduction in their fear of humans (Wieloch 1991). As a result, increasing numbers of pairs started to occupy small water bodies, often within villages or towns (Wieloch 1984; Włodarczyk & Wojciechowski 2001). At present, a large proportion of the territories are located on artificial water bodies (with *c.* 80–90% on ponds and reservoirs; Włodarczyk & Minias 2016), although population size, distribution and breeding performance may be regulated by human activity. For instance, modern water sports can have an adverse effect on the suitability of traditional moulting sites (Clausen *et al.* 2020; Morkūnė *et al.* 2023), whilst the presence of lead fishing weights in sediments may lead to increased mortality rates (Wood *et al.* 2019; Wood & Newth 2024). Additionally, the unpredictability of human-related activities can have a significant influence on the reproductive output of swan pairs in certain areas (Włodarczyk & Minias 2016).

The outbreak of the Covid-19 pandemic in spring 2020 caused drastic changes to daily life in many ways (Haleem & Javaid 2020). For example, the implementation of lockdown measures resulted in a major reduction of human pressure on wildlife in many areas, especially these regularly occupied by people (*e.g.* beaches, reservoirs and city parks; Manenti *et al.* 2020; Silva-Rodríguez *et al.* 2021). Moreover, the main lockdown period in Europe (March–April) coincided with the period when many wild species select their breeding sites and establish territories. In consequence, whereas in most years there would be quite marked variation in disturbance levels across the breeding grounds depending on human access to different sites, in 2020 the breeding territories were more likely to experience comparable levels of human pressure. This unique event provided a great opportunity to study the behavioural response of animals to novel conditions, especially for large-bodied species that are sensitive to human activity (Rutz *et al.* 2020).

This study therefore aimed to compare the number of territories and the breeding performance of Mute Swans in two areas that have differed in their levels of human disturbance over many years. The existence of long-term monitoring data enabled detection of any major changes in the performance of the local population in the 2020 breeding season, when human activity was reduced to a minimal level. For instance, occupancy of new territories could reflect an influx of inexperienced, young individuals that were able to obtain a territory in areas traditionally used by the public. Additionally, new pairs usually start to breed later in the season than established pairs, and to have lower reproductive success (Birkhead & Perrins 1986; Rees *et al.* 1996), so a higher proportion of inexperienced pairs may also be detected using long-term data.

Methods

Study area

The study was conducted in two discrete breeding areas for the Mute Swan in central Poland: the Sulejowski Reservoir (51°26'N, 19°55'E, Fig. 1A) and the Sarnów fish farm (51°51'N, 19°06'E, Fig. 1B). Both sites annually host 4–16 breeding pairs (Table 1). The first site is a dam reservoir which is one of the biggest waterbodies in the region, with the total area of surface water exceeding 2,700 ha. Its southern part is shallow and overgrown, with reed beds and macrophytes that form excellent breeding conditions for swans, although breeding territories can be found along the banks of the whole reservoir. The second study site is a private complex of fishponds where mass production of Carp *Cyprinus carpio* takes place. The total area of the whole complex is 183 ha and it is divided into 27 separate ponds of different size (ranging from 2.6–21.0 ha). Each pond is shallow (maximum depth < 1.2 m) with reed beds growing along the dikes. Ten of the ponds have small islands covered with Common Alder *Alnus glutinosa* trees.

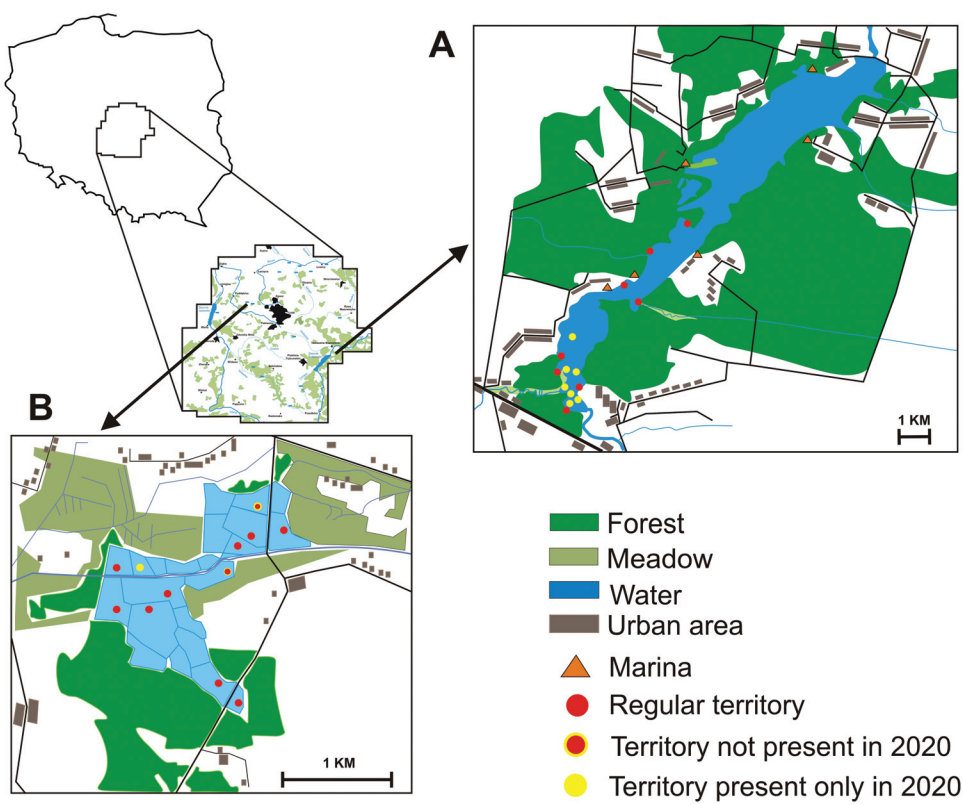

Figure 1. Distribution of Mute Swan breeding territories at two study sites in central Poland from 2018–2022. A = the Sarnów fish farm, B = the Sulejowski Reservoir.

Table 1. Breeding performance of Mute Swan pairs at sites open *vs.* closed to public access: Sulejowski Reservoir (open) and the Sarnów fish farm (closed). Bold font indicates the year of the Covid-19 pandemic (*i.e.* 2020).

Year	Site	No. of breeding pairs/ successful pairs	First egg-laying date (median)	Clutch size (mean ± s.e.)	Mean breeding success (mean brood size ± s.e.)	Mean breeding success of pairs at new territories
2015	Fish farm	8/7	10 April	5.9 ± 0.4	3.8 ± 0.7	5.0
	Reservoir	7/6	16 April	6.7 ± 0.2	1.7 ± 0.9	–
2016	Fish farm	11/11	7 April	5.7 ± 0.4	3.7 ± 0.5	3.2 ± 1.1
	Reservoir	6/6	8 April	7.8 ± 0.3	5.4 ± 0.6	–
2017	Fish farm	9/8	23 April	5.1 ± 0.5	3.4 ± 0.6	0.0
	Reservoir	4/4	5 May	4.0 ± 0.1	2.0 ± 0.6	–
2018	Fish farm	9/8	26 April	5.4 ± 0.6	3.1 ± 0.5	4.3 ± 0.3
	Reservoir	6/5	11 April	6.4 ± 0.9	2.7 ± 0.9	1.3 ± 0.9
2019	Fish farm	10/8	5 April	6.0 ± 0.6	4.0 ± 0.9	2.0 ± 0.0
	Reservoir	6/5	8 April	6.5 ± 0.6	4.2 ± 1.0	2.7 ± 1.3
2020	**Fish farm**	**10/9**	**6 April**	**5.3 ± 0.6**	**3.6 ± 0.6**	**4.5 ± 0.5**
	Reservoir	**15/9**	**24 April**	**5.8 ± 0.5**	**2.4 ± 0.6**	**1.8 ± 0.6**
2021	Fish farm	12/10	18 April	5.8 ± 0.5	2.8 ± 0.5	2.7 ± 0.3
	Reservoir	8/6	22 April	5.6 ± 0.3	3.6 ± 0.8	5.0
2022	Fish farm	16/14	2 April	6.3 ± 0.4	4.5 ± 0.7	4.5 ± 1.6
	Reservoir	11/7	20 April	6.2 ± 0.5	2.3 ± 0.7	1.0 ± 1.0

Data collection

Regular monitoring of Mute Swans breeding in central Poland has been undertaken annually since 1998 (Włodarczyk & Wojciechowski 2001); however, the more detailed material presented in this paper was collected during 2015–2022. This study period was considered of sufficient duration to describe trends in the local population size in recent years. Each territory is visited at least three times every year during the breeding season, and the number and location of breeding pairs (defined as pairs that build a nest where the female lays at least one egg) are recorded. The first visit takes place in March–April during the egg-laying period, when clutch size and onset of laying (*i.e.* the date on which the first egg is laid) are determined for each nest. The egg-laying date is assessed using the flotation technique, which is based on there being a consistent change in the angle of the long axis of the egg relative to vertical as incubation progresses in wildfowl (Brua & Machin 2000), and also assumes that the first four eggs are laid at 24 h intervals with further eggs at 48 h intervals (Czapulak 2002). The second visit is organised for May–June, when data on hatching success or possible nest failure are collected. The final visit, in August–September, focusses on ringing cygnets and (if not ringed in previous years) their parents. The size of the family group found that time is treated as the measure of breeding success for each pair.

A new territory (nest location) was defined as a pond, bay of reservoir or patch of reed beds that had not been occupied in the previous season. In the fish farm complex, where each water body is surrounded by dikes, it was generally straightforward to identify new nest locations. The classification of old *vs.* new territories was strengthened, if possible, by identifying (by ring code) birds recorded on the territory in previous years, or through the presence of unmarked birds within the new territory. Field observations indicated a high level of fidelity by regular breeders to their nesting locations. The presence of a new nest > 100 m from the previous year's location therefore was considered indicative of a new territory being established. Moreover, a previous study found low dispersal levels for Mute Swans in Poland, with 78.5% of individuals not changing their territory, and the same study also reported short dispersal distances for breeders that did move, with females dispersing an average of 0.66 ± 0.19 km and males 0.35 ± 0.14 km from one nest site to another (Włodarczyk *et al.* 2013). This suggests that new breeding pairs were detected with some accuracy at both sites covered during the study presented here. All values of breeding performance presented include failed broods, which were lost during the incubation or fledging period.

The two study sites selected differ significantly in the level of human disturbance during the whole breeding season. Sulejowski Reservoir, one of the most important recreational areas in the region, is used for yachting, kayaking and angling by citizens of three large towns (Łódź, Piotrków Trybunalski and Tomaszów Mazowiecki – *c.* 820,000 inhabitants in total). There are numerous private summer houses along the banks of the whole reservoir; also, four yacht marinas and many unguarded beaches (Fig. 1A). The reservoir is utilised by

significant numbers of people that take fishing boats, yachts or kayaks onto its waters, especially during weekends. Illegal car parking occurs along the banks of the reservoir, very close to the water's edge. Moreover, many of visitors sleep in tents on visiting the reservoir for a few nights. Sarnów fish farm, in contrast, is a private area totally closed to the public, and any unauthorised visit to the site is forbidden. Only workers (up to 5–6 people) regularly enter the pond complex, and there is no possibility of using boats or kayaks in this area. Overnight stays within the fish farm complex is also forbidden. The only place where people have access to the ponds is a public road, which passes through the southern part of the complex (Fig. 1B).

Covid-19 restrictions in Poland in 2020

In Poland, the first restrictions on human movement to control for the Covid-19 outbreak were introduced on 10–12 March 2020 (Dziennik Ustaw 2020). Subsequently, on 25 March, all types of movement except for business travel was forbidden. People were not allowed to enter parks, forests or any other recreational areas, and all hotels, guest houses and any other accommodation sites were closed for visitors. Only everyday activities that qualified as being "necessary" were permitted (Bielecki *et al.* 2022).

The prohibition on travel and visiting recreational areas was rescinded on 20 April 2020; however, hotels and guest houses remained closed until 4 May. After that date, although most daily activities could potentially return to normal levels, many Poles decided to keep their contact with other people to a minimum. On 30 May all restrictions were lifted, and people were able to live as in pre-pandemic times.

Data analysis

Data from the annual monitoring of the Mute Swan pairs at Sulejowski Reservoir and the Sarnów fish farm collected in 2015–2022 inclusive were used to describe the breeding performance of the birds nesting at these two sites. A two-way ANOVA compared the number of breeding pairs at the two locations, and also the clutch sizes recorded, in the Covid and non-Covid breeding seasons. A one-way Mann-Whitney U-test (corrected for ties; Zar 1996) was used to test for a difference in the median first egg-laying date recorded for old and new nests at each type of habitat. The median egg-laying date for each site in each year can be regarded as proxy for the percentage of new breeders that had started to breed for the first time. A one-way ANOVA was used to analyse differences in brood sizes observed during the last visit (August–September), referred to hereafter as breeding success, between years. All analyses were performed using STATISTICA 13.0 software (StatSoft, Tulsa, OK, USA). Values are reported as means ± standard error (s.e.).

Results

The period of total lockdown in Poland during spring 2020 overlapped with timing of territory occupancy and egg laying by Mute Swans breeding in the country. The number of breeding territories at the two study sites was higher in 2020 (with 25 pairs recorded: 10 on the fish farm, 15 on the reservoir) than in most other years (peaking

at 27 pairs in 2022), but this was attributable to more swans being seen on territories at the dam reservoir in 2020 (two-way ANOVA: $F_{1,12} = 5.21$, $P = 0.041$; Table 1, Fig. 2, Fig. 3A). There was no such marked change in the numbers nesting at the fish farm complex, where the percentage of new territories was low (20% *vs.* 60% at the fish farm and reservoir respectively, Supporting Materials Table S1). Of the new territories at the reservoir, 44% were in a small bay usually used as a picnic area by anglers and tourists (Fig. 1A).

In general, all pairs that occupied new territories started to breed significantly later in the season than pairs found on regularly occupied territories, with median first egg-laying dates of 19 April *vs.* 11 April, respectively (Mann-Whitney U test: $Z = 1.97$, $n1 = 37$ and $n2 = 102$, $P = 0.05$). In the Covid-19 year the significant difference in median laying date between new and old territories was observed only at the dam reservoir (Mann-Whitney U test: $Z = 1.95$, $n1 = 9$ and $n2 = 6$, $P = 0.05$). The median laying date at fish farm was similar at two types of territories (Mann-Whitney U test, $Z = 0.14$, $n1 = 7$ and $n2 = 2$, $P = 0.88$, n.s.). Late breeders were mainly at the dam reservoir and the difference in the median laying date recorded for swans nesting at the fish farm compared to those at the reservoir

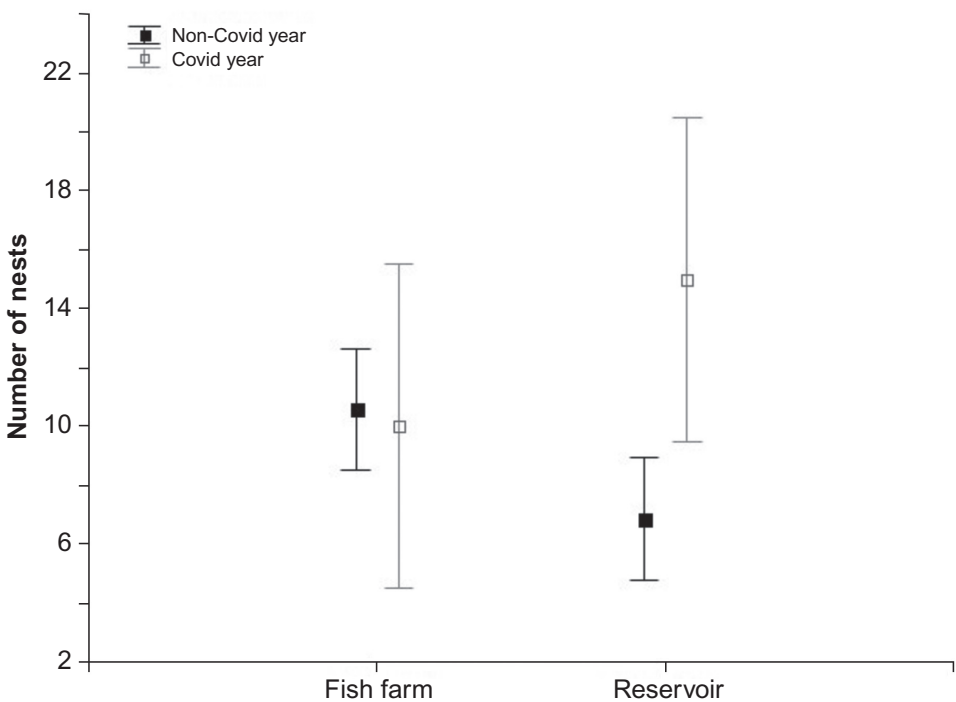

Figure 2. The number of Mute Swan breeding territories (least square means ± s.e. derived from the ANOVA) at the two study sites – the Sulejowski Reservoir and the Sarnów fish farm – in Covid (dashed line) and non-Covid (solid line) years.

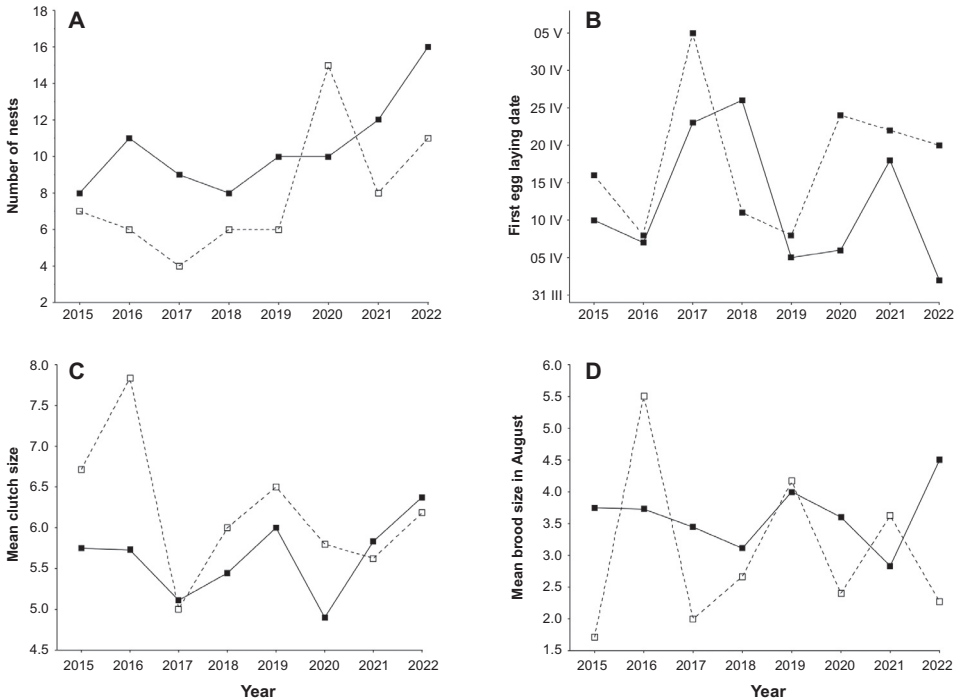

Figure 3. Breeding performance of Mute Swans at the two study sites: the Sarnów fish farm (solid line), and the Sulejowski Reservoir (dashed line). A = total number of Mute Swan nests; B = median date of first egg; C = mean clutch size; D = mean brood size in August.

was 18 days in 2020 (Fig. 3B). The mean clutch size in year 2020 was smaller than in other breeding seasons ($mean_{covid}$ = 5.42 ± 0.4, $mean_{non\text{-}Covid}$ = 6.04 ± 0.1; two-way ANOVA $F_{1,138}$ = 5.21, P = 0.024; Fig. 3C) but the difference was not statistically significant (Tukey test: P = 0.16, n.s.).

The breeding success of pairs with nests in a new location at the reservoir was very low in 2020 (mean = 1.8 ± 0.6, range = 0–5; Table 1), as half of them lost whole broods during the fledging period. However, annual variation in the breeding success for Mute Swans nesting at the reservoir was not statistically significant ($F_{7.54}$ = 1.96, P = 0.08, n.s.; Fig. 3D). In contrast, pairs that established new territories within the fish farm complex in 2020 successfully fledged their cygnets (mean = 4.5 ± 0.5, range = 4–5 cygnets, Table 1) but, as for swans nesting around the reservoir, breeding success did not vary significantly between years for those nesting on the fishpond habitat ($F_{7.77}$ = 0.77, P = 0.612, n.s.; Fig. 3D). One year after the Covid-19 pandemic, the total number of territories at the reservoir was markedly lower, as all new territories from 2020 were abandoned (Fig. 3A). A different situation was observed at the fish farm, however, where the number of territories occupied increased in 2021 and 2022 (Fig. 3A).

Discussion

The comparison of two Mute Swan breeding sites in central Poland under Covid-19 pandemic restrictions found that there was a significant increase in the number of breeding pairs on territories, but only in areas where human disturbance levels were reduced (*i.e.* at the recreational site). New territories were occupied later during the breeding season and pairs at these locations had relatively low breeding success. A large proportion of the broods were lost during the fledging period, which could be attributed to cancellation of lockdown restrictions. New territories in 2020 were not reoccupied in 2021, when human activity at the reservoir returned to normal or was perhaps even higher, attributable to an early spring combined with an increase in outdoor activities following the Covid year (Massar *et al.* 2022).

The impact of lockdown measures on local fauna, especially in urban areas, has been observed in many countries (*e.g.* Bar 2021; Łopucki *et al.* 2021; Silva-Rodríguez *et al.* 2021). Most studies confirmed a quick behavioural response which allowed animals, birds in particular, to adapt to reduced human activity (Derryberry *et al.* 2020; Estella *et al.* 2021; Gordo *et al.* 2021; Wereszczuk & Zalewski 2022). However, the positive relationship between population size or reproductive success and low human disturbance was difficult to detect because the period of lockdown was too short to cause a significant change at the population level (Seress *et al.* 2021). In the Mute Swan population, which has a high proportion of non-breeders and intraspecific competition for territories can be intense (Coleman *et al.* 2001), individuals may however be able to respond quickly to new situations. Any vacant or new territory that appeared early during the breeding season should be occupied promptly (Wieloch *et al.* 2004). Possible plasticity in the swans' nesting behaviour could be associated with the majority of pairs making only one or two breeding attempts during their lifetime (Coleman *et al.* 2001), so individuals should react fast if any chance of successful breeding arises. The sudden influx of new recruits into breeding population could explain why pairs at new territories at the reservoir laid their eggs later than those in established breeding pairs returning to their previously-used nest sites (Rees *et al.* 1996).

The size of the Central European Mute Swan population is strongly controlled by weather conditions during winter. Mild winters allow birds to start breeding earlier and achieve higher breeding success (Beekman 1991; Wieloch *et al.* 2004). Winter 2019/2020 was very warm in Poland with mean temperatures much higher than in the previous few years (*e.g.* the mean temperature for December 2019–January 2020 was +3.03°C, compared with –1.56°C to +1.92°C for winters 2015/16–2018/19; Łódź weather station data). We therefore cannot exclude the possibility that good weather conditions during winter 2019/2020 were at least partially responsible for the increase in the number of breeding pairs observed in spring 2020, but interestingly there was a marked increase in the number of new territories found in one small bay at the reservoir, suggesting that local conditions

(in this case presence of rich plant cover, shallow water and the lack of human disturbance) could have had a major influence on the birds' use of this area. In contrast, on a larger scale, a national Mute Swan monitoring programme did not confirm an unusual increase in the species' abundance in Poland in 2020 (Chodkiewicz *et al.* 2021). The mean density of breeding pairs was 2.4 pairs per 100 square km, which falls within the observed range recorded between 2015 and 2022 (2.1–2.8 pairs per 100 square km; Chodkiewicz *et al.* 2022). This suggests that an exceptionally good breeding season was not evident in the year when Covid restrictions were implemented.

It should be noted that this study describes the breeding performance of Mute Swan from only two locations, which each hosted < 20 breeding pairs in year 2020. The results and conclusions therefore should be treated with caution, but it may be assumed that that differences between the two study sites were related to the level of human disturbance. It means that some populations, especially in areas where natural water bodies are scarce, could be limited by the extent of human pressure.

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