Data on the breeding biology of the Eurasian Spoonbill Platalea leucorodia (Linnaeus, 1758) in the Northern Adriatic wetlands. Bollettino del Museo di Storia Naturale di Venezia

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DATA ON THE BREEDING BIOLOGY OF THE EURASIAN SPOONBILL *PLATALEA LEUCORODIA* (LINNAEUS, 1758) IN THE NORTHERN ADRIATIC WETLANDS

Riassunto. *Dati sulla biologia riproduttiva della spatola* Platalea leucorodia *(Linnaeus, 1758) nelle aree umide dell'Adriatico settentrionale.* Si riportano i risultati di osservazioni triennali sulla biologia riproduttiva della Spatola *Platalea leucorodia* nidificante nel Delta del Po e nella Laguna di Venezia nel 2019-2021, mediante l'impiego di droni. Nel primo anno si è verificato l'insediamento di sei coppie, aumentate a dieci nel 2020 e 15 nel 2021. La massima parte delle nidificazioni si è concentrata in una valle da pesca dismessa del Delta del Po, dove la specie si è riprodotta in piccole aggregazioni nell'ambito di colonie miste di piccole dimensioni di altri Pelecaniformes. L'analisi dell'habitat di nidificazione (quadrati di 1 ha attorno al nido) indica come i nidi fossero costruiti nelle aree centrali della valle da pesca, lontane dagli argini esterni, in zone ricche di arginelli interni. Inoltre le aree di nidificazione delle Spatole contenevano un maggior numero di altre specie di Pelecaniformes e dei nidi di queste. Il sito di nidificazione (quadrati di 100 m^2 attorno al nido) era invece sempre costituito da arbusti di sambuco (*Sambucus nigra*) e rovo (*Rubus* sp.) a un'altezza di 1-3 m. Il successo riproduttivo medio nel triennio è stato di 1.8 ± 0.9 (N = 25) giovani per nido. Il presente studio riporta la colonizzazione del nord Adriatico da parte della Spatola con una popolazione di modeste dimensioni, ma con una chiara tendenza all'incremento.

Summary. We report on the recent establishment of a small breeding population of Eurasian Spoonbills *Platalea leucorodia* occurring in the northern Po Delta and in the Lagoon of Venice in 2019-2021, obtained using drone flights. We found six pairs in 2019, ten pairs in 2020 and 15 pairs in 2021. Mean colony size was 4 ± 3 nests, without significant differences among years. Almost all of these pairs were found on a disused fish farm in the northern Po Delta, where they usually bred in small aggregations near small mixed colonies of Pelecaniformes. Analysis of the nesting habitat (area of 1 ha around the nest) showed birds bred in areas which were exclusively located in central position of the fish farm, contained more internal dikes and internal pools, but less external dikes. In addition, they hosted more other wading species and more nests of the latter. Nevertheless, the results of the nest site selection analysis (10x10 m around the nest) found that nests were mostly built on Elder (*Sambucus nigra*) and brambles (*Rubus* sp.) at a height of 1-3 m, and not on reeds. Pooled data for the three years give a fledging success of 1.8 ± 0.9 (N = 25) fledglings/breeding attempt, without differences among years. The present study suggests that along the Veneto coastline the Eurasian Spoonbill is nowadays occurring with a small but increasing population.

Keywords: breeding, drones, Eurasian Spoonbill, Lagoon of Venice, *Platalea leucorodia*, Po Delta, UAV.

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INTRODUCTION

The Eurasian Spoonbill *Platalea leucorodia* (hereafter Spoonbill) breeds in shallow wetlands with mud, clay or fine sand substrates in flat, open areas of either fresh or saline marshes, rivers, lakes, flooded areas, in particular those scattered with islands or reedbeds with trees or shrubs for nesting (BIRDLIFE INTERNATIONAL, 2021). Due to their typical breeding habitat, collecting data on its breeding biology could be troublesome to gather up and may expose the breeding birds to high level of disturbance.

In Europe, the nesting population of the Spoonbill amounts to 8,400-12,000 pairs, with a positive trend in the short period (EIONET, 2021). Two distinct flyway populations are recognized: the Western Europe population, which is showing a marked increase over the last two decades, and the Central Southeastern population, to whom belong the Italian birds, which shows contrasting trend among different countries (LOK, 2020).

In Italy, the species first nested in the Valli di Comacchio lagoon in 1989 with two pairs (CANOVA & FASOLA, 1989), and then expanded to other wetlands in Emilia-Romagna, Tuscany, the northern Adriatic coastline and the western Po Valley (BRICHETTI & FRACASSO, 2018). The Italian population was estimated at 77-80 pairs in 2004 (GUSTIN et al., 2009), about 100-110 pairs at 3-5 sites in 2008 (VOLPONI et al., 2008), updated to 190 pairs in 2011 (NARDELLI et al., 2015); the very last assessment indicates the occurrence of 230-240 pairs in 2011-2018 (ERCOLE et al., 2021).

In the Veneto region (NE Italy) the Spoonbill was never described as a breeding species by historical authors, and it was considered accidental in both the Venetian Lagoon and the Po Delta. In the former, CONTARINI (1843) defined it as "Accidental. Rare", NINNI A.P. (1879) "Rare" and NINNI E. (1938) "Species of accidental occurrence". In the Po Delta, DAL FIUME (1896) did not mention it among the species present.

The first confirmed breeding event in the Veneto took place in 1998, with one pair nesting in the Valle Figheri fish farm (BON et al., 2000). Later, at least one pair bred in Valle Dogà fish farm in 2004 (BON et al., 2005) and 2006 (BON et al., 2007). Between 2007 and 2012 the nesting of Spoonbill was not observed during a breeding bird atlas project (BON et al., 2014); between 2013 and 2017 a few breeding records are known for a freshwater wetland, in the province of Venice about 20 km from the coast (BON et al., 2014; www.ornitho.it). For the Caorle lagoon, which lays about 30 km north

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of the Lagoon of Venice, the nesting of the Spoonbill has never been reported.

It may be thus concluded that the reproduction of the Spoonbill has been always very rare in the whole littoral strip of the Venice province, i.e. between the mouths of Tagliamento (to the north) and Adige rivers (to the south). South of the Adige river, in the Northern Po Delta (i.e., the area of the Po Delta included in the Veneto region), the first nesting event since ever was observed in 2008; two pairs of Spoonbill nested in the heronry of Po di Maistra in 2008, while in 2014 one pair nested in the heronry of Golena di Ca' Pisani (Verza et al., 2020).

The breeding biology of the Spoonbill in Italy has been studied by Volponi et al. (2008), Tenan et al. (2017), Volponi (2018). For the very small population nesting in the Veneto region, detailed data on the same topic are completely lacking.

In this note, we report on the recent increase of the small breeding population occurring in the whole Veneto coastline and present the first data on habitat selection and productivity, collected on seven colonies, plus two isolated pairs, of the Spoonbill in 2019-2021, obtained using drone flights.

Study area and methods

Fieldwork was conducted during the 2019-2021 breeding seasons, in wetlands of the northern Adriatic coastline, between the mouth of Tagliamento River (45°38'N, 13°06'E) and Po di Goro River (44°47'N, 12°24'E; fig. 1) within the framework of a broader project aimed at monitoring the breeding species of herons (Scarton et al., 2020). In 2019, the area hosted about 3,200 pairs of seven Ardeidae: Grey Heron *Ardea cinerea*, Cattle Egret *Bubulcus ibis*, Little Egret *Egretta garzetta*, Night Heron *Nycticorax nycticorax*, Purple Heron *Ardea purpurea*, Great White Egret *Ardea alba*, Squacco Heron *Ardeola ralloides* (Scarton et al. 2020). A colony was defined as a group of at least two nesting pairs; thus, in the following elaborations, a single pair was included but not considered as a "colony".

All data in the present study were collected exclusively using drones (DJI Mavic Pro in 2019, DJI Mini in 2020, and DJI Mini2 in 2021) through approximately weekly surveys. Due to COVID-19 restrictions, limiting our access to the colonies, in 2020 field surveys could not be made as planned. No ground surveys were conducted in order to avoid disturbance to the breeding birds.

Nests were searched and monitored flying at elevations above ground level (AGL) higher than the agitation distance (i.e., adults opening wings to cover newly hatched chicks in response to low AGL overflights) for the species (pers. obs.; fig. 2). According to the current recommendations (Hodgson & Koh, 2016; Valle & Scarton, 2018), the drone was launched at least at 150 m from each colony (according to the current laws), in order to minimize disturbance to birds. The drone reached the vertical point of the colony (where nest attendance was checked) through a lawn-mower flight pattern, flying 70 m AGL. Then, the drone was slowly driven once more through a lawn-mower flight pattern to an altitude of 15 m AGL (which allows clutches, eggs and chicks to be clearly detected upon post-processing, when not incubated by adults; fig. 2) and it slowly flew over the colony at a speed of 2-5 km/h. During each drone flight, an assistant researcher observed the colony from afar to exclude possible predation of unattended clutches and/or chicks by possible predator, such as the Marsh Harrier *Circus aeruginosus* (Valle & Scarton, 2021).

Habitat choice was investigated at two levels: colony site and nest site. The former was investigated superimposing an arbitrary grid of 100 x 100 m quadrats (sensu Marchesi & Sergio, 2005) on the Google Earth (GE) imagery of the study site in the northern Po Delta (taken on 2020, April 3) using the free software QGIS (fig. 3). The feasibility of detecting nests of large, white birds in the Po Delta using GE imagery has been recently validated for Mute Swans *Cygnus olor* (Valle et al., in press). The data set obtained from GE imagery was integrated by data collected by drone flights. Each quadrat was characterized (when applicable) for the following parameters: 1) number of Spoonbill nests, 2) % reedbed cover, 3) % area of external earth dikes (i.e., those bordering a fish farm), 4) % area of internal earth dikes (i.e., those bordering the reedbed islands), 5) % area of channels, 6) % area of internal pools (i.e., those located within the reedbed islands), 7) % area of external pools (i.e., those located among two or more reedbed islands), 8-9) other breeding species (including the number of their nests), 10) location, classified as "central" (the quadrat was separated from the water edge by at least another quadrat) or "peripheral" (the quadrate was at the water edge), 11) distance from the mainland, 12) distance from the coastline, 13) presence of anthropic disturbance (roads, huts, houses, etc.) categorized as present vs. absent.

Nest site choice was investigated superimposing a grid of 10 x 10 m quadrats on drone imagery of the reedbed island hosting the main colony of 2020 in the Po Delta using QGIS (fig. 4). Each quadrat was characterized for the parameters listed above, except for points 10-13 and integrated with the distance from the water edge. Nest elevation above ground level (AGL) was estimated from the drone altimeter, lowering the drone to the same elevation of nests at a safe distance. Distances were visually estimated on videos thus being to be considered approximate.

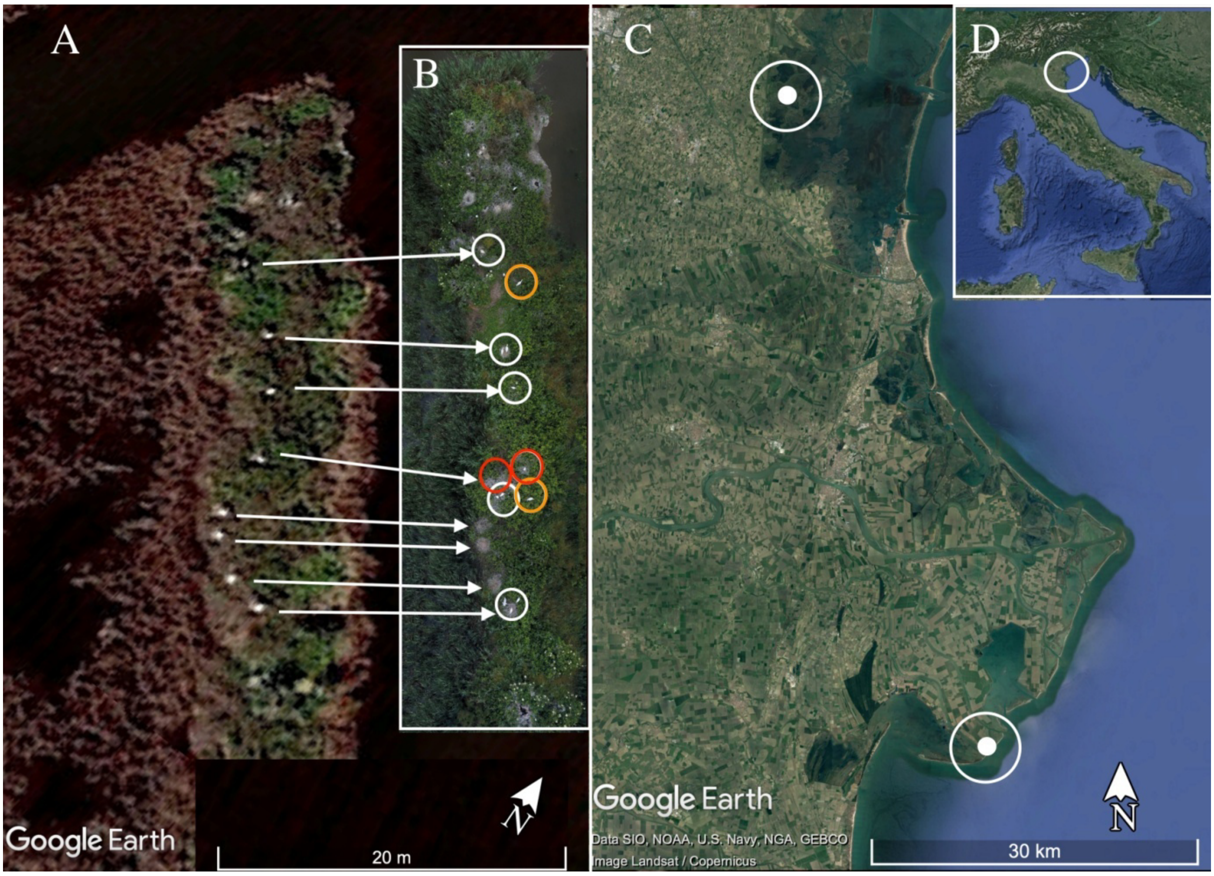

Fig. 1. Some aspects of breeding Spoonbills in 2020 along the north-western Adriatic coastline, April 2020. **A:** Google Earth image of the main colony in the northern Po Delta. **B:** the same colony on drone derived imagery, May 2020. White circles: nests detectable in the Google Earth image of the same colony site, with arrows indicating respective locations; yellow circles: adults in the proximity of nest; red circles: additional late nests, not present in April image. **C:** the two study fish farms (empty circles) with nest sites (full circles). **D:** study area.

Fig. 2. Drone view of a Spoonbill clutch of two chicks guarded by an adult in the northern Po Delta, June 30, 2021. The image was shot cautiously flying 15 m above ground level in order to avoid disturbance. Incubating Sacred Ibises are also visible.

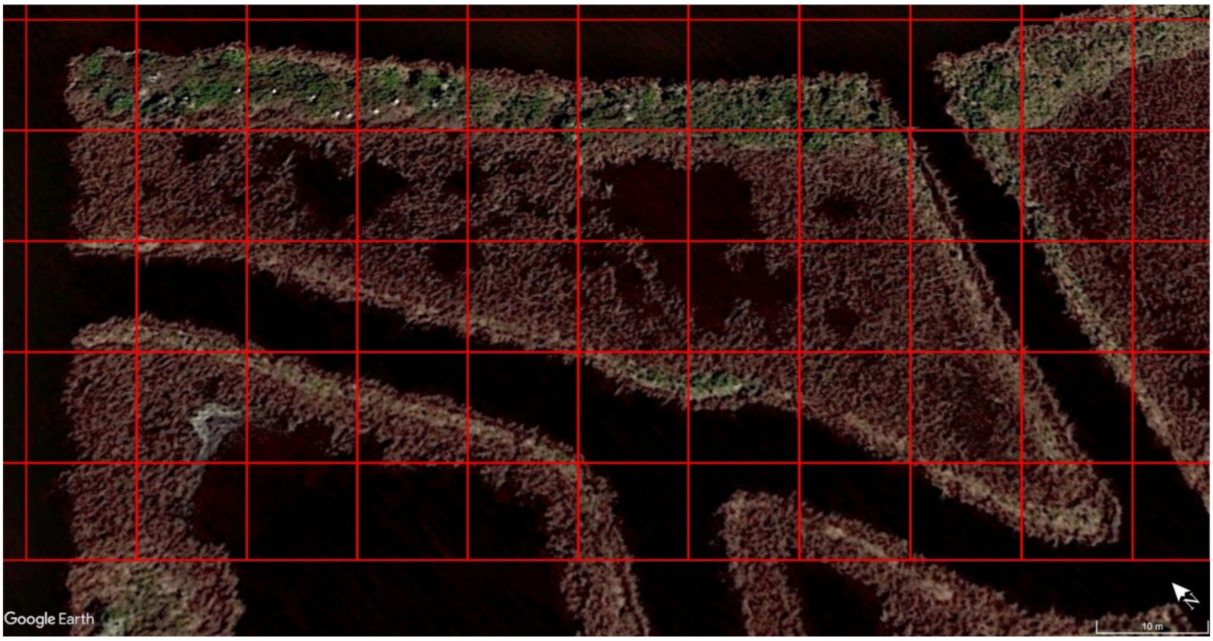

Fig. 3. Google Earth imagery (with superimposed a 10 x 10 m grid) of the study colony in a fish farm of the northern Po Delta, April 2020.

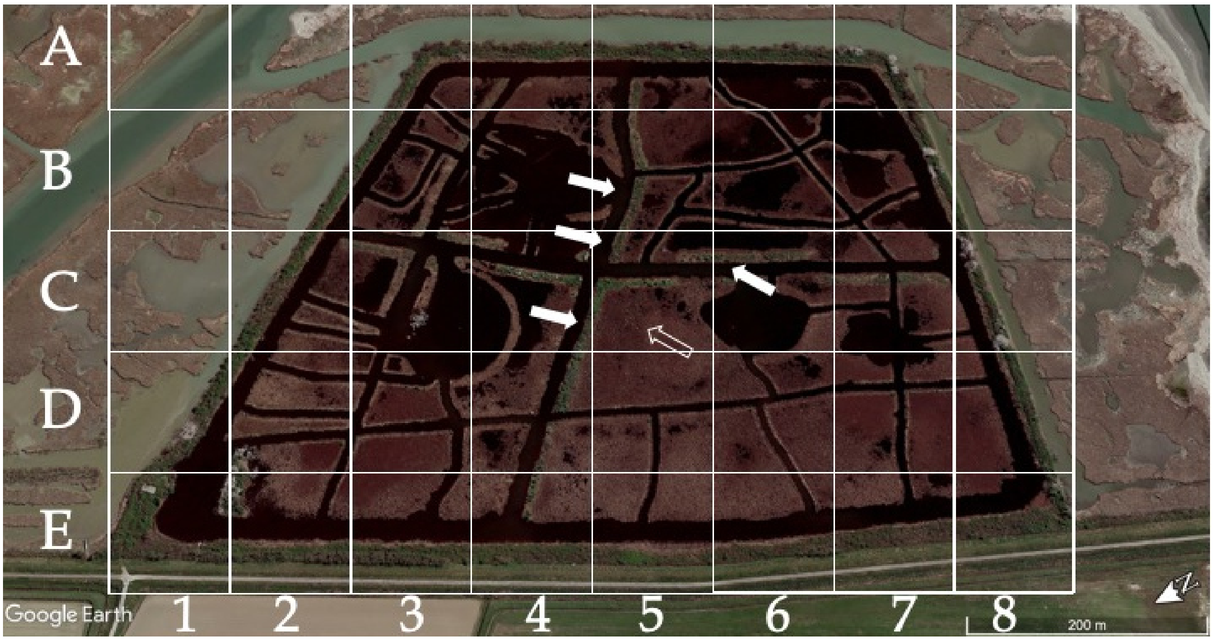

Fig. 4. Google Earth imagery (with superimposed a 100 x 100 m grid) of the study fish farm of the northern Po Delta, April 2020. Filled arrows: nests of Spoonbills. Empty arrow: colony of Great White Egrets; other groups of nests of the latter can be seen in quadrats B5, B6, C5, and C6 in the relative Google Earth imagery of April 2021 (www.google.it/intl/it/earth/).

We did not plan to assess clutch size and hatching success to avoid low altitude drone flights during the vulnerable phases of egg laying and hatching, whereas we recorded fledging success, since juveniles are easily detectable by drone surveys and apparently indifferent to the latter (fig. 5). Fledging success was available for four, nine and twelve nests in 2019 (one colony), 2020 (two colonies), and 2021 (two colonies) respectively. Both timing of laying and hatching were retrospectively estimated on the basis of the approximate age of chicks and/or juveniles. Chick age is difficult to be determined, so that our estimates have to be regarded as approximate. Fledging success was defined as the number of chicks that survived to 3 weeks of age per nesting pair, which was estimated for each colony from the third survey (at 21 days from hatching). These surveys, which were carried out from laying up to three weeks

Fig. 5. Aerial image of Spoonbills in the proximity of the nest with two fledglings, northern Po Delta, June 2021.

of age, permit only a conservative estimate of productivity, but we chose not to fly over older chicks that would be capable of flying away in response to drone intrusion.

In the post-processing phase, individual nests were assigned a number (fig. 1) and counts were performed by two observers using imagery obtained stitching videos with the free software ICE (Microsoft's Image Composite Editor, release 2.0; www.microsoft.com; VALLE, 2021).

The amount of disturbance during each flight was estimated from the number of adults, chicks, or juveniles that: 1) showed alert behavior or 2) moved from nest or flew away during the surveys as a consequence of census activities.

Categorical data are presented as percentages, and continuous data as mean $\pm$1 standard deviation. Differences in count data were tested by means of a χ^2 test. Differences in mean values were tested using unpaired t-test. Differences between methods in calculated mean values of continuous variables were analyzed with unpaired t-tests and One-way ANOVA. We investigated the relationships of the biotic and abiotic variables of reedbed islands with Spoonbill presence-absence and density by means of logistic regression. We conducted correlation analyses (Spearman's test) to reduce collinearity and the number of variables used in multivariate analyses; we retained the variable perceived as more biologically important among two or more of strongly inter-correlated variables ($r > 0.60$), since they may be considered as estimates of a single underlying factor. The strength of the association between Spoonbills and other nesting birds was studied using the *phi* association coefficient (PARTRIDGE, 1978). This coefficient may range between -1 (complete avoidance) and +1 (complete association). The significance for each combination of two species was examined by 2 x 2 Fisher exact probability test. Based on the observed Cramer's V values, the association was considered very weak (<0.1), weak (0.1-0.19), moderate (0.20-0.29), strong (>0.30). Variables were square root transformed as necessary to meet the assumptions of normality of the parametric tests. All tests are two-tailed, and a value of $P < 0.05$ was considered significant. The software used for the statistic was SPSS for Mac, v. 19.

RESULTS

In the whole study area, we found six nests (in one colony) in 2019, ten pairs (in two colonies plus an isolated pair) in 2020 and 15 pairs (14 in three colonies plus an isolated pair) in 2021. Mean colony size was 4 ± 3 nests, without significant differences among years: 2019 = 3 ± 0, 2020 = 6 ± 5, and 2021 = 5 ± 4 (One-way ANOVA, F = 0.246, P = 0.793; tab. 1). Almost all of these pairs were found on a disused fish farm in the northern Po Delta (44°47'29.26"N, 12°24'25.59"E), where they usually bred in small aggregations near small mixed colonies of Great Cormorants (*Phalacrocorax carbo*), Pygmy Cormorants (*Microcarbo pygmeus*), Grey Herons, Little Egrets, and Sacred Ibises (*Threskiornis aethiopicus*) (tab. 1).

Both in 2020 and 2021, one pair of Spoonbill nested in a large (about two hundred nests) pluri-specific colony in the Po Delta hosting all the species mentioned in the Methods section. Only two pairs of Spoonbill nested in the Lagoon of Venice in 2021, in the heronry of Valle Figheri (45°19'43.46"N, 12°08'13.95"E), along with 500-550 pairs of Pelecaniformes species of all the above-mentioned species except for Great White Egrets and Sacred Ibises (tab. 1). At the general habitat scale, Spoonbills were significantly (and positively) associated to Pygmy Cormorants (Cramer's V = 0.530; P = 0.002), Little Egrets (Cramer's V = 0.530; P = 0.002), Grey Herons (Cramer's V = 0.685; P < 0.001), Great White Egrets (Cramer's V = 0.532; P = 0.022) and Sacred Ibises (Cramer's V = 0.685; P < 0.001; tab. 1).

Spoonbills used four 1 ha quadrats in three reedbed islets (in the Po Delta fish farm in 2020; fig. 3). Birds bred in quadrats which were exclusively located in central position, contained more internal dikes and internal pools, but less external dikes. In addition, they hosted more other wading species and more nests of the latter. Only the number of other breeding species entered the binary logistic multiple regression for Spoonbill presence prediction (parameter estimate ± SE = 0.822 ± 0.371; *df* = 1; *P* = 0.027). A ROC curve (not illustrated) was traced to estimate the predictive power of the model (AUC ± SE = 0.950 ± 0.047; CI = 0.858-1.000).

On the contrary, at a nest site scale, Spoonbills selected quadrats (N = 4) containing less reedbed cover, far more internal earth dikes, and internal pools. Occupied quadrats hosted more wading bird species

Parameter	All N = 34	Occupied N = 4	Non occupied N = 30	P
Number of Spoonbill nests	0.3 ± 1.1	2.5 ± 2.4	0 ± 0	<0.001
Reedbed cover (%) [a]	31 ± 25	48 ± 19	29 ± 25	0.186
Area of internal earth dikes (%) [a]	5 ± 5	10 ± 4	4 ± 5	0.028
Area of external earth dikes (%) [a]	10 ± 10	0 ± 0	12 ± 6	0.015
Area of channels (%) [a]	16 ± 6	13 ± 3	17 ± 6	0.271
Area of internal pools (%) [a]	7 ± 8	16 ± 6	6 ± 7	0.011
Area of external pools (%) [a]	8 ± 14	26 ± 13	24 ± 14	0.163
Area of external pools + channels (%) [a]	24 ± 14	19 ± 9	25 ± 15	0.725
Location (n/%) [b]				0.022
peripheral	20 (59)	0 (0)	20 (67)	
central	14 (41)	4 (100)	10 (33)	
Number of other breeding species [a]	0.8 ± 1.5	4 ± 2.4	0.4 ± 1.0	<0.001
Number of nests of other species [a]	10 ± 26	45 ± 59	5 ± 15	0.003
Other breeding species (n / %) [b]				
Sacred Ibis	2 (6)	2 (50)	0 (0)	0.011
Great White Egret	5 (15)	2 (50)	3 (10)	0.022
Grey Heron	2 (6)	2 (50)	0 (0)	0.011
Cattle Egret	1 (3)	1 (25)	0 (0)	0.118
Little Egret	3 (9)	2 (50)	1 (3)	1.000
Night Heron	1 (3)	0 (0)	1 (3)	0.882
Purple Heron	2 (6)	0 (0)	2 (7)	0.775
Squacco Heron	1 (3)	1 (25)	0 (0)	0.118
Great Cormorant	9 (27)	2 (50)	7 (23)	0.281
Pygmy Cormorant	3 (9)	2 (50)	1 (3)	0.031
Minimum distance from the mainland (m) [a]	154 ± 131	170 ± 82	151 ± 136	0.477
Minimum distance from the coastline (m) [a]	220 ± 128	270 ± 82	213 ± 132	0.325
Anthropic disturbance (y vs. no) [b]	8 (23)	0 (0)	8 (27)	0.551

Tab. 1. Google Earth-derived, drone-integrated imagery-based assessment of colony site selection of Spoonbill nesting in the northern Po Delta in 2020. See also figure 3. Environmental variables were measured at 1 ha quadrats occupied or not by the species. N= number of 100 x 100 m quadrats. Data refers only to the 2020 breeding season, since the same 4 quadrats have been occupied in all the three years of the study. The data set was obtained from GE imagery and integrated by data collected by drone flights (see text). The mean ± SD is shown.
[a] *t* test carried out on the variable square root or arc-sin square root transformed.
[b] Difference tested by means of a χ^2 test on the count data.

Parameter / quadrats	All N = 31	Occupied N = 4	Non occupied N = 27	P
Number of Spoonbill nests per quadrat	0.3 ± 1.1	3 ± 1	0 ± 0	<0.001
Reedbed cover (%) [a]	45 ± 33	14 ± 3	49 ± 33	<0.001
Area of internal earth dikes (%) [a]	16 ± 23	56 ± 12	10 ± 17	<0.001
Area of channels (%) [a]	8 ± 20	0 ± 0	23 ± 30	0.123
Area of internal pools (%) [a]	5 ± 15	0 ± 0	11 ± 17	0.142
Area of external pools (%) [a]	2 ± 11	30 ± 14	7 ± 19	0.005
Distance from the water edge (m)	25 ± 24	0 ± 0	4 ± 5	0.120
Number of other breeding species [a]	0.1 ± 0.5	1.3 ± 1.9	0.2 ± 0.7	0.033
Number of nests of other species [a]	0.4 ± 2.5	3.3 ± 5.9	0.3 ± 1.4	0.025
Quadrats with other breeding species (n / %) [b]				
Grey Heron	1 (0.2)	1 (25)	0 (0)	0.008
Sacred Ibis	4 (0.7)	1 (25)	1 (4)	0.029
Little Egret	22 (3.6)	1 (25)	2 (7)	0.389
Great Cormorant	4 (0.7)	1 (25)	2 (7)	0.067
Area of channels (%) [a]	8 ± 20	0 ± 0	23 ± 30	0.123

Tab. 2. Drone-derived, imagery-based assessment of nest site selection of Spoonbill nesting in a colony of the northern Po Delta in 2020 (illustrated in figure 1 - box A and figure 4). Environmental variables were measured at 100 m^2 quadrats occupied or not by the species. N= number of 10 x 10 m quadrats. The mean ± SD is shown.
[a] *t* test carried out on the variable square root or arc-sin square root transformed.
[b] Difference tested by means of a χ^2 test on the count data.

Year	No. of colonies	No. of isolated pairs	Total no. of pairs	Fledging success#
2019				
Po Delta	2	1	7	1.75 ± 0.97
2020				
Po Delta	2	1	12	1.44 ± 0.88
2021				
Po Delta	2	1	13	2.0 ± 0.85
Lagoon of Venice	1	0	2	Not known

Tab. 3. Sites, number of pairs, hatching success, and productivity of Spoonbills breeding along the north-western Adriatic coastline in 2019-2021.
#: number of young, aged 21 days or more, per breeding attempt.

and a larger number of nests of the latter species (tab. 2). None of the above-mentioned environmental variables entered the multivariate Cox regression model as predictors of Spoonbill presence (data not shown).

Nests (all three years pooled) were mostly built on Elder (*Sambucus nigra*) and brambles (*Rubus* sp.) at a height of 1-3 m, but one nest was located directly on the ground both in 2020 and 2021. Four more nests were built on trees, two of which in the site found in the Lagoon of Venice in 2021 (at a height of 5 and 8 m respectively) and two in the Po Delta in the same strand of shrubs both in 2020 and 2021 (both at a height of 5 m). Nests were frequently built close to one another (often less than a meter apart; fig. 1) in colonies, though isolated pairs could nest tens of meters apart from the nearest nest or group of nests. Nearest neighbor distance was 14 ± 10, 8 ± 12, and 10 ± 12 m in 2019, 2020, and 2021 respectively, without significant differences among years (One-way ANOVA, F = 1.029, P = 0.374).

Hatchings were spread over late April, May and early June, with two peaks, respectively in late April and late May (> 20th), though a few late nesters were still incubating in the third decade of June both in 2020 and 2021 breeding seasons. Nest fate was ascertained in four (out of six) cases in 2019, nine (out of 12) in 2020, and 12 (out of 15) in 2021. No nest was preyed upon. Pooled data for the three years give a fledging success of 1.8 ± 0.9 (N = 25) fledglings/nest. No difference was found among years: 1.8 ± 1.0, 1.4 ± 0.9, and 2.0 ± 0.9 in 2019, 2020, and 2021 respectively (One-way ANOVA, F = 0.726, P = 0.492) (tab. 3).

Disturbance due to drone surveys was negligible. No Spoonbill was flushed away as a consequence of close-up drone intrusions. Only in two cases (one in 2020 and one in 2021), the incubating adults showed agitation behavior (opening wings to cover newly hatched chicks) in response to close-up surveys.

Discussion

After about two decades of irregular and very scarce occurrence, during the years 2019-2021 the Spoonbill began to nest regularly in the study area, with up to 15 pairs in a single breeding season. We cannot exclude some other colonies were present, given that we could not survey all the possible breeding sites due to logistical constraints.

It must also be stressed that without the use of drones the nesting of a few pairs would have been (and indeed it was) completely unnoticed, given their particular nesting sites; a similar remarkable increase in nesting counts accuracy, compared to the usual ground surveys, has been documented in the study area for the Purple Heron (pers. obs.).

In any case, despite being at short distance (less than 100 km) from what was until a few years ago the Italian stronghold of the Spoonbill population, i.e., the wetlands of the southern Po Delta (VOLPONI et al., 2008), the northern Po Delta and the lagoon of Venice have never hosted a stable population of the species so far. The reasons of this ephemeral occurrence are difficult to understand, given that apparently suitable breeding sites, such as fish farms, do exist and cover a large extension in the study area. In these man-made sites several colonies of herons regularly occur, some of which being present continuously over the last three decades (MEZZAVILLA et al., 2016). Thus, the lack or scarcity of suitable habitat must be ruled out. On the other hand, spoonbills are generally philopatric and the successful establishment of stable colonies is strongly linked to the presence of adequate numbers of conspecifics (TENAN & VOLPONI, 2017; TENAN et al., 2017). Similarly, positive effects to breeding birds due to a recent reduction in the human disturbance (as that prompted by COVID-19 restrictions: MANENTI et al., 2020) or to some changes in management of the fish farms taking place in these very last years must also be excluded, according to our personal and long-standing knowledge of these man-made habitats (VERZA & TROMBIN, 2012). The Spoonbill pairs nested always in fish farms occurring since centuries; thus, the creation of new sites or the restoration of existing ones cannot be considered as a possible cause of the colonies settlement, for a species which is known to take readily advantage of new suitable sites (RAMO et al., 2013; GARAITA & ARIZAGA, 2015).

A sudden increase of prey abundance and/or its availability could also be another possible driving cause: Spoonbill diet is composed of small fishes in freshwater waters, crustaceans (mainly shrimps), aquatic insects, frogs, leeches and other worms in brackish waters (TRIPLET et al., 2008; OUDMAN et al., 2017). In the study area during the daytime the Spoonbill seems to use mostly brackish, shallow waters inside fish farms, and secondary tidal flats in the lagoons (pers. obs.), while nocturnal feeding has been recorded by camera trapping (Borella & Scarton, pers. obs.). Elsewhere, the large occurrence of Red Swamp Crayfish *Procambarus clarkii* has also been suggested as a possible cause for the growth of the wading bird populations (TABLADO et al., 2010; but see RAMO et al. (2013) for different opinions). Since no data are available about prey availability for the Spoonbill in our study area, this hypothesis cannot be confirmed.

As a matter of fact, in the same three years of this study two other wading species began to nest for the first time in the study area (the Sacred Ibis: SARTORI et al., 2021; SCARTON et al., 2021) or established a stable population after years of occasional nesting events (the Great White Egret: VALLE et al., 2021), suggesting that some change in the ecological status of the coastal wetlands, prompting the settlement of nesting birds, should be on going.

The origin of the new Spoonbill breeders is not known, due to absence of ringed-bird or otherwise marked birds, mostly due to our exclusively drone-based approach. They could come from the population nesting since decades in the near Emilia-Romagna wetlands (as well as for other Italian localities in Emilia, Tuscany, etc.), due to the positive growth of the population in the historical nucleus (Ferrara and Ravenna, partly Bologna) and in some cases favored by the environmental degradation of some of the traditional nesting sites, which has led the breeders to colonise new sites chosen on the basis of the presence of other colonials (Ardeidae, etc.; Volponi pers. com.). There are many observations along the Northern Adriatic coastline of birds ringed in the Southern Po Delta (VOLPONI, 2015). It is less likely that our breeders come from abroad, as from the Danube basin and the Balkans, a source of birds for the Italian population (VOLPONI et al., 2008). It must be added that in the very last years the wintering number of Spoonbills in the whole Veneto coastline showed a remarkable increase from 97 bird in 2016 to 238 birds in 2020 (BASSO & BON, 2016; BASSO, 2020; ASSOCIAZIONE CULTURALE NATURALISTICA SAGITTARIA, 2021).

Despite limited to a few colonies, our data indicate that several breeding parameters are mostly in agreement with what observed both in Italy and elsewhere (TRIPLET et al., 2008; MIKUSKA et al., 2015; TENAN et al., 2017; BLOOMFIELD, 2019). All the colonies were located in large reedbeds, while abroad colonies may also use small woodlots or alluvial forests (PIGNICZKI & VÉGVÁRI, 2015); nevertheless, at our study area the nests were never built on reedbeds, but on shrub and trees and only occasionally directly on the ground. A possible terrestrial predator of eggs and chicks such as the Red Fox *Vulpes vulpes* is common in the fish farm, and this may be a reason for avoiding nesting on or near the ground.

In the Veneto coastlines, Spoonbill colonies were inside other colonies with herons and cormorants, an association which has been commonly observed both in Italy and abroad (TRIPLET et al, 2008; BARTOLINI & VERDUCCI, 2014; VOLPONI, 2018).

The mean breeding success observed across three years in Veneto region (1.8) was slightly higher than that recorded by LOK et al. (2009) over 17 years in Dutch colonies (1.67). Nevertheless, our very small sample does not allow further considerations about the apparent higher reproductive success in small colonies compared to traditional ones, a finding often reported in the scientific literature (see LAMB et al., 2017) but which does not always hold true (SCHMIDT et al., 2021).

In conclusion, the present study suggests that along the Veneto coastline the Spoonbill is nowadays occurring with a small but increasing population. Further observations and search for marked birds may ascertain the origin of the immigrant breeders.

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