Breeding of Collared Pratincoles (*Glareola pratincola*) on a restored saltmarsh island in the Po Delta: a conservation case study

Roberto Valle[1]*, Emiliano Verza[2], Francesco Scarton[3]

Abstract - The Collared Pratincole *Glareola pratincola* colonized a newly constructed artificial saltmarsh, about two ha in size, in the Po Delta in 2023 and bred again in 2024, with colonies of seven and thirteen pairs, respectively. Most nests were located in the bare part of the artificial saltmarsh, ignoring the adjacent, highly vegetated sector. The majority of nests (77%) were placed within tufts of dead *Suaeda maritima* from the previous year, which provided high vegetation cover and concealment, possibly reducing predation risk from Yellow-legged Gulls *Larus michahellis*. Hatching success was very high (95% across the two breeding seasons), likely due to the island elevation above typical tidal levels, the absence of human disturbance and the difficulty for terrestrial predators to access it, as it is separated from the mainland by more than 100 m of lagoon. However, in 2025, Collared Pratincoles did not breed on the island, coinciding with rapid vegetation encroachment that reduced the extent of open ground. This note shows that small-scale restoration interventions can quickly create suitable nesting habitat for Collared Pratincoles, but may require continued management to maintain early-successional conditions.

Key words: artificial habitat, *Glareola pratincola*, habitat selection, hatching success, Po Delta.

Riassunto - Biologia riproduttiva della pernice di mare (*Glareola pratincola*) su un'isola artificiale nel Delta del Po: un caso di studio sulla conservazione.

La Pernice di mare **(***Glareola pratincola***)** ha colonizzato una barena artificiale di circa 2 ha, neo-edificata nel Delta del Po, con una colonia di sette e tredici coppie rispettivamente nel 2023 e nel 2024. I riproduttori hanno collocato la maggior parte dei nidi nella porzione scarsamente vegetata dell'area ripristinata, evitando il settore originario, caratterizzato da una vegetazione più sviluppata. La maggior parte dei nidi (77%) è stata collocata all'interno di cespi di *Suaeda maritima* secca, che fornivano elevata copertura vegetale e occultamento, probabilmente come possibile strategia anti-predatoria nei confronti del gabbiano reale (*Larus michahellis*). Il successo di schiusa è stato molto elevato (95% nei due anni), verosimilmente grazie alla quota della barena artificiale superiore ai livelli di marea ordinari, all'assenza di disturbo antropico e alla sua scarsa accessibilità ai predatori terrestri, trovandosi a 130 m dalla terraferma. Tuttavia, nel 2025 la Pernice di mare non ha nidificato sull'isola, in concomitanza con un rapido infittimento della vegetazione, che ha ridotto l'estensione delle superfici aperte. Questa nota mostra che interventi di ripristino ambientale, su piccola scala, possono creare rapidamente habitat idonei alla nidificazione della Pernice di mare, ma richiedono una gestione continuativa per mantenere condizioni di vegetazione pioniera favorevoli.

Parole chiave: Delta del Po, *Glareola pratincola*, habitat artificiali, selezione di habitat, successo riproduttivo.

[1] Rialto 571, I-30125 Venezia, Italia.
[2] Via F.lli Cairoli 38, I-45100 Rovigo, Italia.
[3] SELC soc. coop., Via dell'Elettricità 3/d, 30175 Marghera (Venezia), Italia.

* Corresponding author: robertovalle@libero.it

© 2026 Roberto Valle, Emiliano Verza, Francesco Scarton

Received for publication: 8 April 2025
Accepted for publication: 30 May 2026
Online publication: 23 November 2026

INTRODUCTION

The Collared Pratincole *Glareola pratincola* is a wader with a large global population, estimated at 218,000-584,000 individuals scattered across Europe, Africa and western Asia (Wetlands International, 2015). The species shows a fragmented but wide distribution in the southern part of the Western Palearctic, ranging from Atlantic Spain to the Caspian coastline, down to the southern coast of the Mediterranean. The European population is estimated at 15,700-29,900 individuals, of which 107-132 pairs occur in Italy according to the most recent estimates (BirdLife International, 2025; Brichetti & Fracasso, 2018). Populations are considered fluctuating at global, European and Italian levels (EIONET, 2021; BirdLife International, 2025). The species uses a relatively broad range of breeding habitats, such as saltpans, steppe areas, uncultivated fields, recently reclaimed lands and small islands within inland and coastal wetlands (Del Hoyo *et al*., 1996). The nest is a simple scrape in the ground, usually without lining, generally in open areas (Cramp & Simmons, 1983).

In Italy, the Collared Pratincole has a predominantly southern distribution, with most breeding pairs concentrated in the major islands, where it mainly uses for nesting agricultural land and saltmarshes (Grussu & Tinarelli, 2000; Brichetti & Fracasso, 2018). In the last twenty years, the species has shown a noticeable northward expansion, colonizing the northern Adriatic coast, first in the Po Delta, using the hunting and fish farms in 2004 (Verza, 2015; Scarton *et al*., 2018), then the Tratauri sandbank in the Marano and Grado Lagoon in 2022 (Sponza & Salvador, 2023) and more recently the Venice lagoon in 2023, again in this case in the hunting and fish farms (Valle *et al*., 2023).

OPEN ACCESS
BY-NC
pagepress

The reproductive biology of the Collared Pratincole has been extensively investigated in several parts of its range, including continental and Mediterranean Europe, the Black Sea region, the Middle East and North Africa (Pozhidaeva & Molodan, 1998; Calvo *et al*., 1993, Calvo, 1994; Calvo & Furness, 1995; Calvo & Vázquez, 1995; Calvo, 1996; Vincent-Martin, 2007; Hanane *et al*., 2010; El Malki *et al*., 2013; Bensaci *et al*., 2014; Kiss *et al*., 2017; Öztürk & Özkan, 2019; Kayser, 2021). Data are available for many breeding sites also for Italy, for many of the breeding nuclei present (Arcamone *et al*., 1982; Canova & Saino, 1983; Mascara, 1987; 1989; Costa & Gustin, 1996; Grussu & Tinarelli, 2000), but analytical information on habitat selection and reproductive success remains limited to colonies in agricultural landscape (Zafarana & Pepi, 2019) or fish farms (Valle & Verza, 2019).

In recent decades, artificial and restored coastal habitats have been increasingly recognized as important breeding sites for many ground-nesting waterbirds, particularly in highly modified wetland systems. Artificial saltmarshes, dredge-spoil islands and managed marsh habitats can provide suitable nesting conditions, especially during early successional stages characterized by open substrates and limited vegetation cover. Several studies have shown that these habitats can support significant breeding populations of *Charadriiformes*, including terns, plovers and other colonial species, although their suitability often declines over time due to vegetation encroachment and habitat succession (Goutner, 1997; Nisbet, 2000; Erwin *et al*., 2003). In the northern Adriatic, artificial saltmarshes created through sediment management have been shown to host diverse and dynamic breeding bird assemblages, with species composition strongly influenced by habitat age and vegetation structure (Scarton *et al*., 2018; Valle & Verza, 2020).

The colonization of a recently restored artificial saltmarsh island in a lagoon of the Po Delta by a small colony of Collared Pratincoles in 2023 offered the opportunity to describe the reproductive biology of the species in a previously undocumented breeding habitat. This note describes the possible role of small, restored marsh islands in the conservation of the species.

METHODS AND STUDY AREA

The study was conducted in the Po Delta, on the north-western coast of the Adriatic Sea (44°46′N, 12°15′E) on a recently built artificial saltmarsh, during the 2023-2024 breeding seasons, with additional observations conducted during the 2025 breeding season. Given the limited sample size, this work is intended primarily as a descriptive conservation case study; statistical outputs are presented to support observed patterns and are interpreted cautiously.

The Po Delta includes a number of shallow lagoons, which are separated from the sea by 20 barrier islands and are bordered, along the inner side, by about 30 fish farms. Less than ten marsh islands are scattered in the lagoons. Some marsh islands underwent restoration interventions in 2022, through the deposition of sediments dredged from the adjacent channels. A mean of 16 pairs (range: 4 - 32) of Collared Pratincoles nested in the Po Delta during the last 22 years (Fig. 1), since its colonisation in 2004 (Verza, 2015). The study marsh island lies in a small coastal lagoon, it is 130 m from the mainland, 400 m from the barrier island and 500 m from the sea, it extends for 2 ha and ranges from 0.1 to 0.8 m above the water level (Fig. 2). Five additional species bred in the marsh island in 2024: one Oystercatcher *Haematopus ostralegus* pair, two pairs of Avocet *Recurvirostra avosetta*, two Kentish Plover *Anarhynchus alexandrinus* pairs, one Redshank

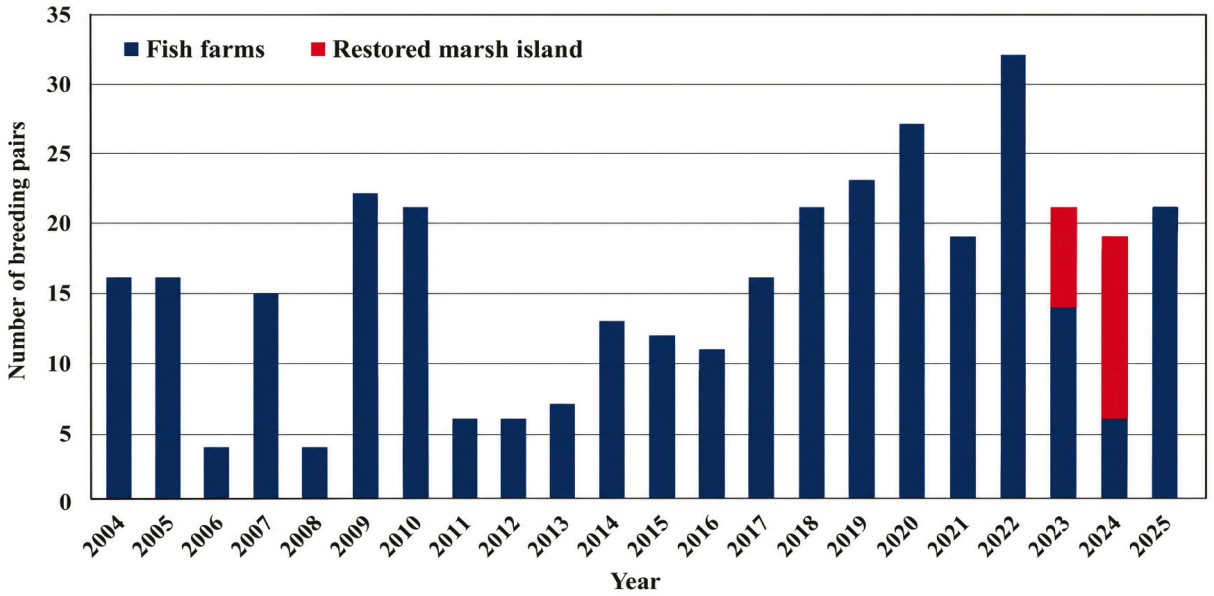

Fig. 1 - Population trend and habitat use of Collared Pratincoles breeding in the Po Delta, since its colonisation. / Andamento della popolazione e uso dell'habitat della pernice di mare nidificante nel Delta del Po, dalla sua colonizzazione. 2004-2007: Verza, 2015; 2008-2014: Scarton *et al*., 2018; 2015-2018: Valle & Verza, 2020; 2022: Verza *et al*., 2023; 2023: Verza *et al*., 2024. 2019-2021 and / e 2024-2025: unpublished data / dati inediti.

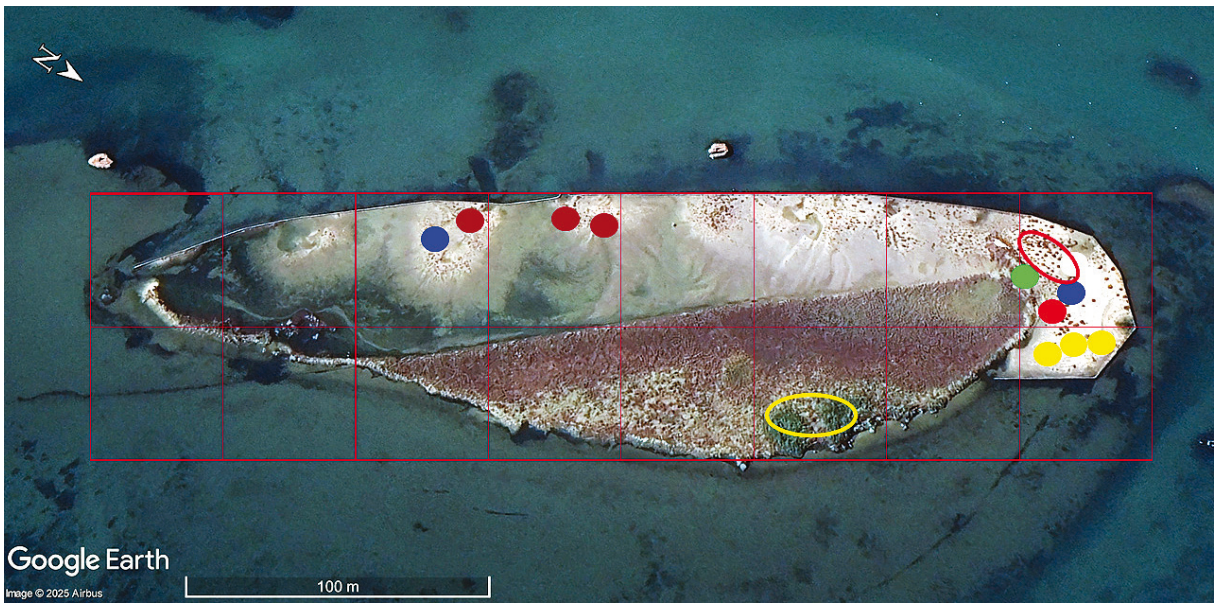

Fig. 2 - Google Earth view of the study site, showing both the original marsh island and the restored part (Po Delta, May 2025). Nest/colony location (dot/ellipse) for all the breeding species is reported. / Immagine da Google Earth dell'area di studio, con evidenza sia della parte oggetto di ripristino ambientale che di quella originaria. I punti e le ellissi indicano rispettivamente la posizione dei singoli nidi e l'estensione delle colonie. *Glareola pratincola*: brown / marrone. *Haematopus ostralegus*: red / rosso. *Recurvirostra avosetta*: white / bianco. *Anarhynchus alexandrinus*: blue / blu. *Tringa totanus*: green / verde. *Larus michahellis*: yellow / giallo.

Tringa totanus pair and 16 Yellow-legged Gull *Larus michahellis* pairs. Field data were collected through systematic nest searches in suitable areas of the island. Though we believed that all nests were found during the egg-laying stage or during the first few days of incubation, we continued searching for nests throughout the breeding season in order to find replacement clutches. Only nests with at least one egg and/or eggshells with yolk (indicating avian predation) were counted. Nests were marked with a uniquely numbered wood tag placed outside the nest bowl to facilitate relocation. All nests were monitored until all eggs were either lost or hatched. We visited nests at 7-day intervals or as frequently as weather conditions permitted, to determine fate. In 2023, visits were more irregular, due to logistical constraints and adverse weather conditions. Nest fate was classified into five categories: 1) successful (presence of egg membranes or hatchlings), 2) predated (by birds if beak marks or yolk were found on shell or by mammals in presence of teeth marks and absence of yolk on shell), 3) flooded (eggs found wet or out of the cup, after exceptional rainstorms / high tides), 4) deserted (eggs found cold in the cup), 5) unknown (otherwise) (Traylor *et al*., 2004). To assess breeding performance, we considered only hatching success, because Collared Pratincoles have nidifugous chicks (Cramp & Simmons, 1983), and access to the colony by researchers during the chick-rearing period would have caused excessive disturbance, forcing the chicks to wander through a mixed colony of Yellow-legged Gulls. We assumed that disturbance associated with our nest visits had a negligible effect on hatching success, because nests were visited infrequently and nest-site parameters were mostly measured on photographic images and/or returning to colony sites after nesting had concluded to minimize disturbance.

Habitat selection was analysed in the 2024 breeding season, at two levels: general habitat and nest site, collecting biotic, abiotic and social parameters (listed in Table 1 and 2) and presence/absence and number of nests of all breeding species, using both ground and drone inspections. Macro-habitat choice was investigated by superimposing a 50 x 50-m quadrat grid (sensu Valle & Scarton, 2022) on drone imagery using QGIS (release 3.12.1; www.qgis.org; Fig. 2) to standardise comparisons among island sectors; we acknowledge that any grid-based partition remains partly arbitrary and results are therefore interpreted descriptively. Micro-habitat (nest site) selection was studied superimposing a 1-m radius circle on each nest and a paired random site, using a randomly generated azimuth (0-359°) and distance (<10 m). We visually estimated nest site elevation in relation to the apparent water level at the time of the visit and grouped it into four arbitrary classes (an approximate measure in a tidal environment): <0.25 m, 0.25 - 0.50 m, 0.50 - 0.75 m and more than 0.75 m. Because elevation above sea level was estimated visually, the results should be regarded as approximate. Substrate was classified into six categories: sand, bivalve shells, mud, sand-shells, sand-mud and mud-shells. The substrates were assigned to a single name-type when the latter covered more than 70% of the surface and to a double-name type when each covered at least 30% (Fasola & Canova, 1991). Nest concealment was estimated by superimposing a circle with a radius of 0.2 m, divided into quarters, on a photograph taken from a height of 1 m above each clutch and calculating (by two different observers) the percentage in which the clutch was detectable, to the nearest 25% and plant species present. We measured the mean vegetation height to the nearest 1 cm in the field with a ruler.

Tab. 1 - Macro-habitat of Collared Pratincoles breeding in an artificial saltmarsh island in the Po Delta (2024). Data from a 50 x 50 m quadrat grid are reported (see text). / Selezione dell'habitat di nidificazione a livello di colonia della pernice di mare in una barena artificiale nel Delta del Po (2024). I dati si riferiscono ad una griglia di quadrati di 50 m di lato (vedi testo).
#) Unpaired t-test conducted on arcsin-square root transformed variable. / Test t non appaiato effettuato su una variabile trasformata mediante arcsin e radice quadrata. §) Unpaired t-test conducted on square root transformed variable. / Test t non appaiato effettuato su una variabile trasformata mediante radice quadrata. *) Pearson Chi^2 test conducted on count data. / Test chi-quadrato di Pearson effettuato su dati di conteggio.

Parameter	Occupied (n=3)	Non occupied (n=13)	P value	All (n=16)
Open water (%)#	18±23	23±29	0.972	22±27
Tidal ponds (%)#	20±26	12±16	0.723	13±17
Vegetation cover (%)#	2±2	35±41	0.008	28±39
Dominant plant type (%)*			0.039	
Psammophilous/Halophilous communities	0	77		63
Suaeda maritima	33	8		13
None	67	15		25
Sandy bare area (%)#	5±9	4±5	0.998	4±6
Muddy bare area (%)#	48±36	20±33	0.151	25±34
Bivalve shells (%)#	7±12	4±8	0.750	4±9
Presence of clay mounds (%)*	67	8	0.018	19
Substrate (natural vs artificial) (%)*	100/0	38/62	0.195	50/50
Elevation above water level (%)*			0.167	
< 25 cm	0	8		6
25 – 50 cm	0	62		50
51 – 75 cm	33	15		19
> 75 cm	67	15		25
Other nesting species (%)*				
Haematopus ostralegus	33	0	0.032	6
Recurvirostra avosetta	33	0	0.032	6
Anarhynchus alexandrinus	67	0	0.002	13
Tringa totanus	33	0	0.032	6
Larus michahellis	0	23	0.837	19

Statistics

Given the limited sample size, statistical analyses were used primarily to support descriptive interpretation rather than to draw general inferences. We used the G-statistic to describe the regularity of nest dispersion (Brown, 1975). Associations between Collared Pratincoles and other nesting birds were described using the phi association coefficient and evaluated with Pearson's Chi^2 test. Relationships between island variables and Collared Pratincole presence/absence or nest density were explored with logistic regression, but results are interpreted cautiously. Differences in continuous variables were examined with unpaired *t*-tests after appropriate transformations when needed (Sokal & Rohlf, 1981); count data were analysed with Pearson Chi^2 tests. Data are reported as mean ± standard deviation (continuous data) and numbers (percentages). Tests were two-tailed with $\alpha = 0.05$. Analyses were performed using SPSS v.20 for Mac (SPSS, Inc., Chicago, IL, USA).

RESULTS

We found seven nests in one of the 16 quadrats in 2023 and thirteen nests in three quadrats in 2024. The quadrat occupied in 2023 was also occupied in 2024, when Collared Pratincoles were found in two more quadrats (Tab. 1 and Fig. 2). In 2024, one quadrat hosting Collared Pratincoles also contained one Oystercatcher nest, two Avocet nests, one Kentish Plover nest and one Redshank nest, whereas another hosted one Kentish Plover nest. None hosted Yellow-legged Gulls. Collared Pratincoles were positively associated with Oystercatchers (Cramer's Phi = 0.787; $P = 0.002$), Avocets (Phi = 0.537; $P = 0.032$), Kentish Plovers (Phi = 0.787; $P = 0.002$), and Redshanks (Phi = 0.537; $P = 0.032$). No association was found with Yellow-legged Gulls (Phi = 0.231, $P = 0.356$). However, these associations should be interpreted cautiously, as their statistical significance may partly depend on the spatial arrangement of the 50 × 50 m sampling grid. Nest dispersion showed a departure from a random spatial pattern (G-statistic = 0.68), although this result should be interpreted cautiously given the limited sample size. Macro-habitat use differed from a random pattern. Positively selected quadrats were far less vegetated and hosted more frequently clay mounds, whereas they did not host Yellow-legged Gulls (Tab. 1). None of these significant variables was retained in the logistic regression model to

Tab. 2 - Micro-habitat selection of Collared Pratincoles breeding in an artificial saltmarsh island in the Po Delta (2024). Data from 1-m radius circles are reported for both 13 nest sites and 13 paired random points (see text). / Selezione dell'habitat di nidificazione a livello di posizionamento del nido della pernice di mare, in una barena artificiale nel Delta del Po (2024). I dati si riferiscono a un cerchio con raggio di 1 m intorno al nido o al corrispettivo punto random (n = 13; vedi testo).
*) Pearson Chi^2 test conducted on count data. / Test chi-quadrato di Pearson applicato a dati di conteggio. #) Unpaired *t*-test conducted on arcsin-square root transformed variable. / Test t non appaiato applicato a una variabile trasformata mediante arcsin e radice quadrata. §) Unpaired *t*-test conducted on square root transformed variable. / Test t non appaiato applicato a una variabile trasformata mediante radice quadrata.

Parameter	Nest sites	Random sites	P value
Substrate*			0.167
Bivalve shells	31	39	
Bivalve shells + mud	23	8	
Mud	38	38	
Sand + bivalve shells	8	15	
Vegetation cover (%)#	42±30	15±24	0.013
Vegetation height (cm)§	35±23	11±20	0.003
Vegetation type			0.192
Suaeda maritima	77	46	
None	23	54	
Elevation above water level (cm)#			0.568
< 25 cm	0	0	
25 – 50 cm	0	15	
51 – 75 cm	23	31	
> 75 cm	77	54	
Distance from nearest conspecific nest (m)§	6.0±9.0	7.1±7.6	0.067
Distance from *Larus michahellis* nest (m)§	43±33	44±33	0.491
Distance from highly vegetated area (m)§	19±16	18±18	0.114
Distance from tideline (m)§	12±6	13±8	0.995
Distance from nearest tidal pond (m)§	14±5	13±5	0.418
Concealment (0.2 m radius) (%)#	56±41	13±30	0.003

discriminate between quadrats with and without Collared Pratincoles. Micro-habitat selection differed between nest sites and random points in two of the studied parameters (Tab. 2). Nest sites had greater vegetation cover and taller vegetation than random points (Tab. 2 and Fig. 3). Both variables were included in logistic regression analyses discriminating between nest sites and random points, and both were statistically significant. Vegetation cover: B = 0.036±0.017, Beta = 1.037, df = 1, $P = 0.029$, correctly reclassified cases = 78.9% and vegetation height: B = 0.037±0.019, Beta = 1.038, df = 1, $P = 0.048$, correctly reclassified cases = 69.2%. Clutches contained 2.0±0.4 eggs; mean hatching date was 2 June ±13 days in 2024. Overall, 19 out of 20 nests (95%) hatched at least one chick across the two breeding seasons, with hatching success of 100% in 2023 and 92% in 2024. At the egg level, 37 out of 39 eggs hatched (pooled hatching success: 95%). In 2024, one nest containing a single egg was deserted, and one egg failed to hatch in another nest. No breeding by Collared Pratincoles was recorded on the restored marsh island in 2025, despite repeated surveys during the expected breeding period. Field observations indicated a marked increase in halophytic vegetation cover compared with the previous two years, with extensive development of dense plant stands replacing formerly open substrates. This vegetation encroachment substantially reduced the availability of sparsely vegetated nesting areas that had been preferentially used by the species in 2023-2024. Although causation cannot be demonstrated, the temporal coincidence suggests that vegetation succession may have contributed to the abandonment of the site.

DISCUSSION

The main result of our work is the demonstration that the Collared Pratincole can successfully nest on a freshly restored saltmarsh island. Although the species is known to use a wide range of habitats (Cramp & Simmons, 1983; Del Hoyo *et al*., 1996), a small restored marsh island, surrounded by a lagoon is unusual. Similar habitat choice has been reported for North Africa (Bensaci *et al*., 2014), where the species used small sandy islands within a saline lake, obtaining very high hatching success, which is consistent with our findings. In our study site, in fact, the choice of restored habitat, which became available temporarily, provided favourable conditions for the high hatching success observed in the colony: 95% of clutches hatched across the two breeding seasons. This is a high value, near the upper end of the range reported in the literature for the species (97%; Bensaci *et al*., 2014), which was already reported obtaining optimal values in marshland habitat (Calvo, 1994). Hatching success is



Fig. 3 - Nest of Collared Pratincole built within a tussock of dead *Suaeda maritima* (Po Delta, May 2024). / Nido di pernice di mare sotto un cespo secco di *Suaeda maritima* (Delta del Po, Maggio 2024).

usually reduced by both direct (egg collectors) and indirect (agricultural activities, fishermen and sun-bathers) human disturbance, both terrestrial and avian predators and flooding during spring storms (Calvo, 1994; Hanane *et al*., 2010; Valle & Verza, 2019). The restored marsh island under study conferred protection from all these threats to Collared Pratincoles. First, the relatively high elevation of the island (up to 1 m when the palisade is included) meant that clutches were safe from extremely high tides, which have severely affected waterbird breeding in the northern Adriatic over the last 20 years (Valle & Scarton, 2023a; 2023b). In addition, it was made of sand, which is permeable, not generating pools and streams during torrential rains, which may wash away eggs on clay substrates in nearby fish farms (pers. obs.). Finally, the island was surrounded by a wooden palisade that may have provided additional protection against waves generated by strong winds and elevated water levels during storms.

Second, our study marsh island is located 130 m from the mainland, from which it is separated by a channel, 3 m deep. This likely reduced access by the terrestrial predators of the study area: feral cats *Felis catus,* dogs *Canis familiaris*, hedgehogs *Erinaceus europaeus and* badgers *Meles meles*. Red Foxes *Vulpes vulpes* are known to cross the lagoons to reach barrier islands, swimming for hundreds of meters (Verza & Cattozzo, 2015). The thick wooden palisade, extending approximately 1 m above the water level along the side facing the mainland, may also have discouraged Red Foxes. On the other hand, nest placement within *Suaeda maritima* tussocks could have conferred protection from aerial predators, through strong concealment (see Borgmann & Conway, 2015 for a review). Many possible avian predators of Collared Pratincole eggs and chicks are present in the Po Delta, including Yellow-legged Gulls, Marsh and Montagu's Harriers *Circus aeruginosus* and *C. pygargus*, Eurasian Magpies *Pica pica*, and Hooded Crows *Corvus cornix*. The presence of Oystercatchers and Avocets, whose clutches were intermixed with those of Collared Pratincoles in our study colony, could have contributed to preventing predation from avian predators, through their defensive behaviour towards potential predators (see Roberge & Angelstam, 2004 for a review). Third, anthropogenic disturbance is virtually absent from the island, owing to its relative isolation and lack of recreational use. These circumstances helped to eliminate one of the main factors of reduction in productive success observed for other nesting areas as reported above.

In our study site, Collared Pratincoles avoided the area with high vegetation cover of *Ammophila arenaria* (which reaches heights exceeding 70 cm), as reported for other breeding areas (Calvo, 1994). This is consistent

with the importance of maintaining an unobstructed view of the surroundings for predator detection (Götmark *et al.*, 1995). As regards the micro-habitat selection, the difference between our small population (with nest placement in predominantly vegetated sites) and the data reported for fish farms in the same area, where the species reproduced in areas with 0% cover, stands out (Valle & Verza, 2019). This difference may depend on at least two factors: (1) the availability of small, isolated vegetation clumps, far from the intensely vegetated area (absent in the nest sites of the fish farms) and (2) the presence of Yellow-legged Gulls in our colony, virtually absent in the fish farms, forcing Collared Pratincoles to conceal clutches. Importantly, the suitability of the restored sector proved to be transient. In 2025, no breeding was recorded, and the previously open nesting substrate was largely replaced by dense halophilic vegetation (vegetation encroachment). This suggests that restoration works creating early-successional open habitats may provide breeding opportunities for only a few years unless followed by maintenance actions. Depending on local constraints, periodic disturbance (e.g. sediment redistribution, shallow scraping, or targeted vegetation removal) could help preserve a mosaic of bare ground and sparse vegetation that appears favourable to the species.

From a conservation perspective, the Collared Pratincole is strongly influenced by habitat availability and quality, with breeding distribution often reflecting land-use changes, wetland degradation, and vegetation dynamics (BirdLife International, 2025). Across much of Europe, traditional breeding habitats such as coastal marshes, saltpans, and open agricultural landscapes have declined or undergone substantial modification (Calvo & Furness, 1995; Brichetti & Fracasso, 2018). Under these conditions, artificial or restored habitats – including fish farms, reclaimed wetlands, dredge-spoil islands, and managed saltmarshes – are increasingly used by the species and may locally compensate for the loss of natural breeding areas (El Malki *et al*., 2013; Valle & Verza, 2019). Our study site represents a clear example of this process. The restored island provided, at least temporarily, a combination of features favourable for breeding: open ground, limited vegetation cover, reduced accessibility to terrestrial predators, and reduced disturbance. Similar situations have been documented in other Mediterranean coastal wetlands where newly created or managed habitats supported breeding Collared Pratincoles and other ground-nesting waterbirds. However, the absence of breeding in 2025 highlights a potential limitation of such restoration interventions. Rapid vegetation encroachment markedly reduced the extent of open substrates, likely decreasing habitat suitability for a species that typically requires sparsely vegetated nesting areas. Although the causal link cannot be demonstrated conclusively, this temporal pattern suggests that habitat suitability may decline rapidly unless vegetation succession is actively managed.

Comparable dynamics have been described in restored coastal wetlands and artificial nesting sites used by ground-nesting waterbirds, where vegetation development progressively reduces habitat suitability unless active management is implemented. Studies on dredge-spoil islands and managed marshes have shown that many *Charadriiformes*, including terns, plovers, and other colonial waterbirds, initially benefit from newly created open substrates but may abandon sites as vegetation cover increases (Erwin *et al*., 2003; Nisbet, 2000). Similar patterns have also been documented in Mediterranean coastal systems, where rapid colonisation of restored wetlands by halophytic vegetation can quickly reduce the availability of sparsely vegetated nesting habitat (Scarton *et al*., 2013). These findings suggest that vegetation control and periodic habitat maintenance are often necessary components of effective conservation strategies for open-ground nesting waterbirds. Therefore, restoration projects aimed at supporting Collared Pratincoles should not focus solely on habitat creation, but also on its maintenance. Vegetation management and/or sediment renewal may be necessary to preserve early-successional conditions favourable to breeding. More generally, these parallels suggest that long-term management should be considered an integral component of restoration projects targeting open-ground nesting waterbirds.

Ideally, the creation of small areas similar to our study site could allow the settlement and conservation of small- to medium-sized breeding nuclei, free from the main usual causes of clutch loss, and could therefore play a role in the conservation of the species in the lagoons of the north-eastern Adriatic coastline. The effectiveness of restoration interventions in promoting the resettlement of the species has been demonstrated both at the national level, in wet meadows (Casini & Tinarelli, 2012), and in other European countries (Kiss *et al*., 2024).

As an aside, we mention that our breeding nucleus, although it originated following the displacement by a severe storm of a nearby colony located in a fish farm, represented a significant share of the entire population of the Po Delta in the two-year study period. The study artificial island hosted 33% (7 out of 21) and 68% (13 out of 19) of the population of the Po Delta, respectively for the 2023 and 2024 breeding season. In 2024, our marsh island hosted a colony comparable in size to the mean annual breeding population of the whole Po Delta, since its colonisation in 2004 (Fig. 1), showing the importance of this restored habitat for the conservation of the Collared Pratincole in our area.

Some limitations of this study should be acknowledged. Sample size was relatively small, the study period short, and some environmental variables – particularly elevation relative to tidal levels – were estimated approximately. Consequently, the analyses should be interpreted primarily as descriptive. Nevertheless, the consistency of breeding occurrence in 2023-2024 and the subsequent abandonment in 2025 provide useful insights into habitat dynamics affecting the species in highly modified coastal lagoons.

Overall, our results suggest that restored marsh islands may represent valuable supplementary breeding habitat for Collared Pratincoles in the northern Adriatic, but their effectiveness likely depends on continued habitat management preventing excessive vegetation encroachment.

Acknowledgements

We are grateful to Giuliano Zanellato for his help in the field and Gabriele Vianello for sharing the fieldwork challenges, including the considerable exposure to mosquitoes. AI-assisted tools (ChatGPT, Elicit) were used to support data analysis checks and improve the clarity of the manuscript. All analyses, results and interpretations were independently verified by the authors. This study was self-funded by the Authors. We appreciate the time and effort of the Editor and the Referees and we believe that addressing and accepting their suggested revisions has greatly enhanced the quality of the paper.

REFERENCES

Arcamone E., Baccetti N., Mainardi R. & Spina F., 1982 – Nidificazione della Pernice di mare, *Glareola pratincola* in Toscana. *Rivista italiana di Ornitologia*, 52 (3-4): 187-190.

Bensaci E., Boutera N., Cherief A., Saheb M., Moali A. & Houhamdi M., 2014 − Breeding ecology studies of Collared Pratincoles *Glareola pratincola* in the Central Hauts Plateaux of Algeria. *Wader Study Group Bulletin*, 121 (1): 43-48.

BirdLife International, 2025 – Species factsheet: Collared Pratincole *Glareola pratincola*. <https://datazone.birdlife.org/species/factsheet/collared-pratincole-glareola-pratincola> (On 26/01/2025).

Borgmann K.L. & Conway C.J., 2015 – The nest-concealment hypothesis: new insights from a comparative analysis. *The Wilson Journal of Ornithology*, 127 (4): 646-660.

Brichetti P. & Fracasso G., 2018 – The Birds of Italy: Anatidae-Alcidae. *Edizioni Belvedere*.

Brown D., 1975 – A test of randomness of nest spacing. *Wildfowl*, 26: 102-103.

Calvo B., 1994 − Effects of agricultural land use on the breeding of Collared Pratincole *Glareola pratincola* in south-west Spain. *Biological Conservation*, 70 (1): 77-83.

Calvo B., 1996 − Feeding Habitats of Breeding Collared Pratincoles (*Glareola pratincola*) in Southern Spain. *Colonial Waterbirds*, 19 (Special publication 1): 75-77.

Calvo B. & Furness R.W., 1995 − Colony and nest-site selection by Collared Pratincoles (*Glareola pratincola*) in southwest Spain. *Colonial Waterbirds*, 18 (1): 1-10.

Calvo B. & Vázquez M., 1995 − Field technique suggestions for the study of Collared Pratincoles *Glareola pratincola*. *Wader Study Group Bulletin*, 78 (1): 14.

Calvo B., Mañez M. & Alberto L.J., 1993 − The Collared Pratincole *Glareola pratincola* in the National Park of Doñana, south west Spain. *Wader Study Group Bulletin*, 67 (1): 13.

Canova L. & Saino N., 1983 – Conferma della nidificazione della Pernice di mare, *Glareola pratincola*, nella bonifica del Mezzano (Emilia-Romagna). *Rivista italiana di Ornitologia*, 53 (3-4): 196-197.

Casini L. & Tinarelli R., 2012 – Le zone umide per l'avifauna acquatica. Pernice di mare *Glareola pratincola*. In: Aggiornamento della Carta delle Vocazioni Faunistiche della Regione Emilia-Romagna. *Regione Emilia-Romagna, Assessorato Agricoltura, Economia ittica, Attività faunistico-venatorie - ST.E.R.N.A*. <https://www.sterna.it/AggCartVocCD/specie_cap_vi-00004d.htm> (Downloaded on 25 October 2026).

Costa M. & Gustin M., 1996 – Ulteriore conferma della nidificazione della Pernice di mare, *Glareola pratincola*, in Emilia-Romagna e considerazioni sullo stato di conservazione. *Rivista italiana di Ornitologia*, 66 (2): 178-180.

Cramp S. & Simmons K.E.L., 1983 − The Birds of the Western Palearctic, Volume 3. *Oxford University Press*, Oxford.

Del Hoyo J., Elliott A. & Sargatal J., 1996 − Handbook of the Birds of the World. Volume 3. Hoatzin to Auks. *Lynx Edicions*, Barcelona, Spain.

EIONET, 2021 – Reporting under Article 12 of the Birds Directive. Period 2013-2018. <https://www.eionet.europa.eu> (Accessed 7/2/2025).

El Malki S.E., Hanane S., Joulami L. & Hamoumi R.E., 2013 − Nesting performance of the Black-winged Stilt and Collared Pratincole on a Moroccan coastal wetland: a comparison between natural and artificial habitats. *Wader Study Group Bulletin*, 120 (1): 47-52.

Erwin R.M., Allen D.H. & Jenkins D., 2003 – Created versus natural coastal islands: Atlantic waterbird populations, habitat choices, and management implications. *Estuaries*, 26: 949-955.

Fasola M. & Canova L., 1991 – Colony site selection by eight species of gulls and terns breeding in the «Valli di Comacchio» (Italy). *Bollettino di Zoologia*, 58 (3): 261-266.

Götmark F., Blomqvist D., Johansson O.C. & Bergkvist J., 1995 – Nest site selection: a trade-off between concealment and view of the surroundings? *Journal of Avian Biology*, 26: 305-312.

Goutner V., 1997 − Use of the Drana Lagoon (Evros Delta, Greece) by threatened colonially nesting waterbirds and its possible restoration. *Biological Conservation*, 81 (1-2): 113-120.

Grussu M. & Tinarelli R., 2000 – Pernice di mare *Glareola pratincola*, in Italia. *Quaderni di Birdwatching*, 4.

Hanane S., Boukhriss J. & Selmi S., 2010 − Breeding ecology of Collared Pratincoles *Glareola pratincola* in two coastal habitats in northwest Morocco. *Bird Study*, 57 (2): 236-243.

Kayser Y., 2021 − Suivi de la reproduction de la Glaréole à collier - année 2020. *Tour du Valat*, Arles. <https://tourduvalat.centredoc.fr/index.php?lvl=notice_display&id=58327>

Kiss Á., Monoki Á. & Végvári Z., 2017 − Nest-site selection and population trend of Collared Pratincoles (*Glareola pratincola*) breeding in agricultural habitats of the Nagykunság region (Hungary). *Ornis Hungarica*, 25 (1): 25-38.

Kiss Á., Végvári Z., Kubelka V., Monoki Á., Kapocsi I., Gőri S. & Székely T., 2024 - Breeding in an agricultural landscape: conservation actions increase nest survival in a ground-nesting bird. *Oryx*, 58: 240–249.

Mascara R., 1987 – Accertata nidificazione di Pernice di mare, *Glareola pratincola*, in un'area cerealicola della Sicilia. *Rivista italiana di Ornitologia*, 57 (1-2): 137.

Mascara R., 1989 – Nuovi dati sulla riproduzione della Pernice di mare, *Glareola pratincola*, nella pianura di Gela (Sicilia centro-meridionale). *Picus*, 15 (3): 99-103.

Nisbet I.C.T., 2000 – Disturbance, habituation, and management of waterbird colonies. *Waterbirds*, 23 (2): 312-332.

Öztürk Y. & Özkan L., 2019 – Breeding Data of Collared Pratincole (*Glareola pratincola*) Population of Boğazkent/Antalya (Southwest Turkey) in 2016. *Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi*, 22: 436-439.

Pozhidaeva S. & Molodan G.N., 1998 – Productivity of the Collared Pratincole *Glareola pratincola* on the northern coast of the Azov Sea. International *Wader Study*, 10: 268.

Roberge J.M. & Angelstam P., 2004 – Usefulness of the umbrella species concept as a conservation tool. *Conservation Biology*, 18 (1): 76-85.

Scarton F., Cecconi G., Cerasuolo C. & Valle R.G., 2013 – The importance of dredge islands for breeding waterbirds. A three-year study in the Venice Lagoon (Italy). *Ecological Engineering,* 54: 39-48.

Scarton F., Verza E., Guzzon C., Utmar P., Sgorlon G. & Valle R.G., 2018 − Laro-limicoli (Charadriiformes) nidificanti nel litorale nord adriatico (Veneto e Friuli-Venezia Giulia) nel periodo 2008-2014: consistenza, trend e problematiche di conservazione. *Rivista Italiana di Ornitologia - Research in Ornithology*, 88 (2): 33-41.

Sokal R. & Rohlf F.J., 1981 – Biometry. *W.H. Freeman*, New York.

Sponza S. & Salvador P., 2023 – A new successful breeding site of Collared Pratincole *Glareola pratincola* along the northern Adriatic coastline. *Rivista Italiana di Ornitologia*, 93 (1): 17-22.

Traylor J.T., Alisauskas R.T. & Kehoe F. T., 2004 – Nesting ecology of White-winged Scoters (*Melanitta fusca deglandi*) at Redberry Lake, Saskatchewan. *Auk*, 121: 950-962.

Valle R.G. & Scarton F., 2022 – Nest-site selection of Sandwich Terns Thalasseus sandvicensis (Latham, 1787) on marsh island habitat. *Bollettino del Museo di Storia Naturale di Venezia*, 73: 79-88.

Valle R.G. & Scarton F., 2023a – The effects of tidal flooding on colonisation of the Venice Lagoon, Italy, by Mediterranean Gulls. *British Birds*, 116: 720-726.

Valle R.G. & Scarton F., 2023b – One thousand nesting pairs packed into one hundred square meters: the sad story of the Sandwich Terns (*Thalasseus sandvicensis*) of the Venice Lagoon. *Ardeola*, 70 (1): 89-103.

Valle R.G. & Verza E., 2019 – La selezione di habitat e il successo riproduttivo della Pernice di mare, *Glareola pratincola*, (*Charadriiformes: Glareolidae*) nidificante nel Delta del Po (Provincia di Rovigo). In: Atti 8° Convegno Faunisti Veneti. Bonato L., Spada A., Cassol M. (a cura di). *Bollettino del Museo di Storia Naturale di Venezia*, suppl. 69: 162-165.

Valle R.G. & Verza E., 2020 – I laro-limicoli (Charadriiformes) nidificanti nel delta del Po veneto (RO) nel periodo 2015-2018. *Bollettino del Museo di Storia Naturale di Venezia*, 71: 123-126.

Valle R.G., Sattin L., Verza E. & Scarton F., 2023 – Glareola pratincola (Linnaeus, 1766): recent settlement as a breeding species in the Lagoon of Venice (NE Italy) (Aves, Charadriiformes, Glareolidae). Bollettino del Museo di Storia Naturale di Venezia, 74: 97-98.

Verza E., 2015 − Popolazione e scelta dell'habitat riproduttivo di pernice di mare *Glareola pratincola* e sterna zampenere *Gelochelidon nilotica* nella parte veneta del Delta del Po (Rovigo); analisi del periodo 2001-2012. In: XVII Convegno Italiano di Ornitologia: Atti del convegno di Trento. Pedrini P., Rossi F., Bogliani G., Serra L. & Sustersic A. (a cura di). *Ed. MUSE*, Trento: 75-77.

Verza E. & Cattozzo L., 2015 – Atlante lagunare - costiero del Delta del Po. *Regione del Veneto. Associazione Culturale Naturalistica Sagittaria. Consorzio di Bonifica Delta del Po*.

Verza E., Valle R.G., Zanella L., Corvino R. & Sartori A., 2023 – Avifauna acquatica nidificante in provincia di Rovigo anno 2022. *Associazione culturale naturalistica Sagittaria***,** Rovigo. <http://www.birdingveneto.eu/pubbl/RO_nidificanti_2022.pdf>

Verza E., Valle R.G., Zanella L., Corvino R., Sartori A., Bellettato V. & Barbieri F., 2024 – Avifauna acquatica nidificante in provincia di Rovigo. Anno 2023. *Associazione Culturale Naturalistica Sagittaria*, Rovigo. < https://www.birdingveneto.eu/pub/Relazione_Nidificanti_Rovigo_2023-gennaio_2024_def.pdf>

Vincent-Martin N., 2007 – Statut de conservation de la Glaréole à collier *Glareola pratincola* en Camargue: identification des facteurs limitant la reproduction. *PhD Thesis, Ecole Pratique des Hautes Etudes*, France.

Wetlands International, 2015 – Waterbird Population Estimates. <wpe.wetlands.org> (Accessed March 3rd, 2025).

Zafarana M.A. & Pepi D., 2019 – Status della popolazione di Pernice di mare *Glareola pratincola* (*Aves*, Glareolidae) nella piana di Gela (Sicilia). *Naturalista Siciliano*, 43 (1): 35-44.