GORTANIA
Botanica, Zoologia | 41 (2019) | 99-108 | 30.IV.2020 | ISSN: 2038-0402

Antonio Borgo
Maria Giovanna Mitri
Stefano Castelli
Federico Antinori
Marcello Rossani

RESTORATION OF THE GUARDIAN SPECIES AS A STRATEGY FOR KENTISH PLOVER (*CHARADRIUS ALEXANDRINUS*) CONSERVATION IN THE VENICE BEACHES

RIPRISTINO DELLA SPECIE GUARDIANA COME STRATEGIA PER LA CONSERVAZIONE DEL FRATINO (*CHARADRIUS ALEXANDRINUS*) NELLE SPIAGGE VENEZIANE

Abstract: In 2018 we positioned decoys in two selected and fenced areas and we induced the settlement of a colony of Little Terns, with the aim to bring a "guardian" species back and to restore the bird community, in order to reduce predation on nests and broods of Kentish Plovers nesting on Venetian beaches. Surveys for individuals, pairs and nests checking of both Little Tern and Kentish Plover were conducted every 1-3 days from March to mid August. The abundance of predators and stranded deposits were surveyed too. Little Tern settled a colony of 28 simultaneously active nests, and almost 25 young fledged. The settlement of the Little Tern colony determined an increase of 73% in the number of both pairs and nests of Kentish Plover in comparison with 2016-2017, with an increase of nests starting brood in late May and June, following the settlement of terns. The hatching trend of Kentish Plovers nests was strongly related to the trend in size of the tern colony suggesting an adaptive response to the presence of the guardian species. Kentish Plovers broods distribution was affected by the availability of stranded algae and seagrass and the position of the tern colony, settled in a bathing concession and facing a shoreline without stranded deposits and unsuitable for chicks feeding, make the "umbrella" obtained in 2018 low effective in chicks' protection. Both the productivity was of 0.31 youngs/nest and the proportion of fledged/dead chicks were significantly higher than those of the previous two years. Preliminary results suggest that promoting the return of the guardian species can represent an effective strategy for Kentish Plover conservation.
Key words: Decoys, Biological fight, Community restoration, Venetian littoral, Umbrella species.

Riassunto breve: *Nel 2018, abbiamo testato la possibilità di indurre l'insediamento di una colonia di fraticello (*Sternula albifrons*) sulla spiaggia di San Nicolò al Lido di Venezia attirandoli con alcuni stampi (sagome), con l'obiettivo di ripristinare l'originale comunità di specie e riportare sulla spiaggia una "specie guardiana" per ridurre la predazione di nidi e pulcini di fratino (*Charadrius alexandrinus*). Si è insediata una colonia composta da 28 coppie, che ha portato all'involo almeno 25 giovani. L'insediamento della colonia si è associato ad un aumento del 73% del numero di coppie e di nidi di fratino rispetto al 2016-2017, con un aumento dei nidi dopo l'insediamento della colonia di fraticello. L'andamento della schiusa dei nidi di fratino è risultata correlata con l'andamento della numerosità della colonia di fraticello, suggerendo una risposta adattativa alla presenza della specie guardiana. La distribuzione delle covate di fratino è risultata condizionata dalla disponibilità di detriti vegetali spiaggiati. Dal momento che la colonia di fraticello era insediata in un tratto in cui la battigia veniva quotidianamente rastrellata dal concessionario balneare e quindi non era idoneo all'alimentazione dei pulcini di fratino, l'effetto protettivo offerto alle covate dalla colonia è risultato limitato. La produttività è risultata di 0,31 giovani/nido, ma la proporzione tra pulcini involati/morti è risultata comunque significativamente maggiore del biennio precedente. I risultati preliminari suggeriscono che promuovere il ritorno della specie guardiana può rappresentare un'efficace strategia per la conservazione del fratino.*
Parole chiave: *Stampi, Lotta biologica, Ripristino di comunità, Litorale veneziano, Specie ombrello.*

Introduction

Kentish Plover *Charadrius alexandrinus* breeds along beaches, coastal habitats and salt lakes from western Paleartic to central Asia (Cramp & Simmons 1983; Delany et al. 2009). At the global level, its population size allows IUCN to evaluate Kentish Plover as a least concern species (www.iucnredlist.org). At the European scale, the species is declining in the most of its range (Birdlife International 2015) and it is already extinct in a few regions (Schulz & Stock 1993; Domínguez & Vidal 2003).

The Italian population of Kentish Plover showed a strong decrease from 1901-1554 breeding pairs in 2009-2010 (Biondi & Pietrelli 2011), through 1281-1072 in 2016 (CNCF 2017) to 570-691 pairs in 2018 (CNCF 2019).The Italian IUCN red list (Rondinini et al. 2013) considers Kentish Plover as endangered (EN)

because of this strong negative trend in the breeding population.

In the Veneto region, which hosts 19-22% of the Italian Kentish Plover population (CNCF 2019) the number of breeding pairs decreased by 68% from 2009 to 2016 (CNCF 2017). The decrease is mainly due to the desertion of beaches by Kentish Plover caused by the increase in anthropic recreational pressure and by the increase of predation pressure by Black-billed Magpies *Pica pica* and Hooded Crows *Corvus cornix* (Scarton et al. 2004; Antinori et al. 2011; Borgo et al. 2016; 2018; Baldin et al. 2018; Mitri et al. 2019). At the end of the previous century, 85% of pairs nested on sandy beaches of the littoral and only 15% on marsh islands in the Venice lagoon (Valle et al. 1995), but in the last two decades the number of pairs nesting on the beaches collapsed (Scarton 2005; Antinori et al. 2011; Scarton et al. 2013; Baldin et al. 2018; Borgo et al. 2018). Moreover, in the last two decades corvids have increasingly affected survival rates of clutches and chicks of Kentish Plovers nesting on the beach (Antinori et al. 2011; Borgo et al. 2016; Mitri et al. 2019). Until the end of the previous century, Venetian beaches typically hosted a community of nesting species composed by Kentish Plovers and Little Terns *Sternula albifrons* (Valle & D'Este 1992; Borgo 1995; Antinori et al. 2011). From 1982 to 1991 nearly all the Little Terns were found on beaches (Fasola 1986; Scarton 2008), but from 1999 onwards, beaches were used for breeding only occasionally and by only a few pairs, mainly because of the increased humane disturbance (Scarton 2008; Scarton et al. 2009; Antinori et al. 2011; Sartori 2014; Scarton & Valle 2017). Since 1998 the settlement of colonies on natural beaches of the Lido of Venice became occasional and no pairs nested after 2010 (Antinori et al. 2011; Borgo et al. 2018). Terns (*Sterna* spp.) have a strong anti-predator behaviour, and they play a role of guardian or umbrella species for other species nesting close to or within their colonies (Dyrcz et al. 1981; Burger 1987; Alberico et al. 1991; Valle & Scarton, 1999; Powell 2001; Nguyen et al. 2003, 2006; Scarton et al. 2009; Hanane 2014; Rocha et al. 2016; Borgo et al. 2018; Valle 2019).

Considering the increase in corvid presence on the beaches, the disappearance of the Little Tern could therefore have strongly affected both the quality and

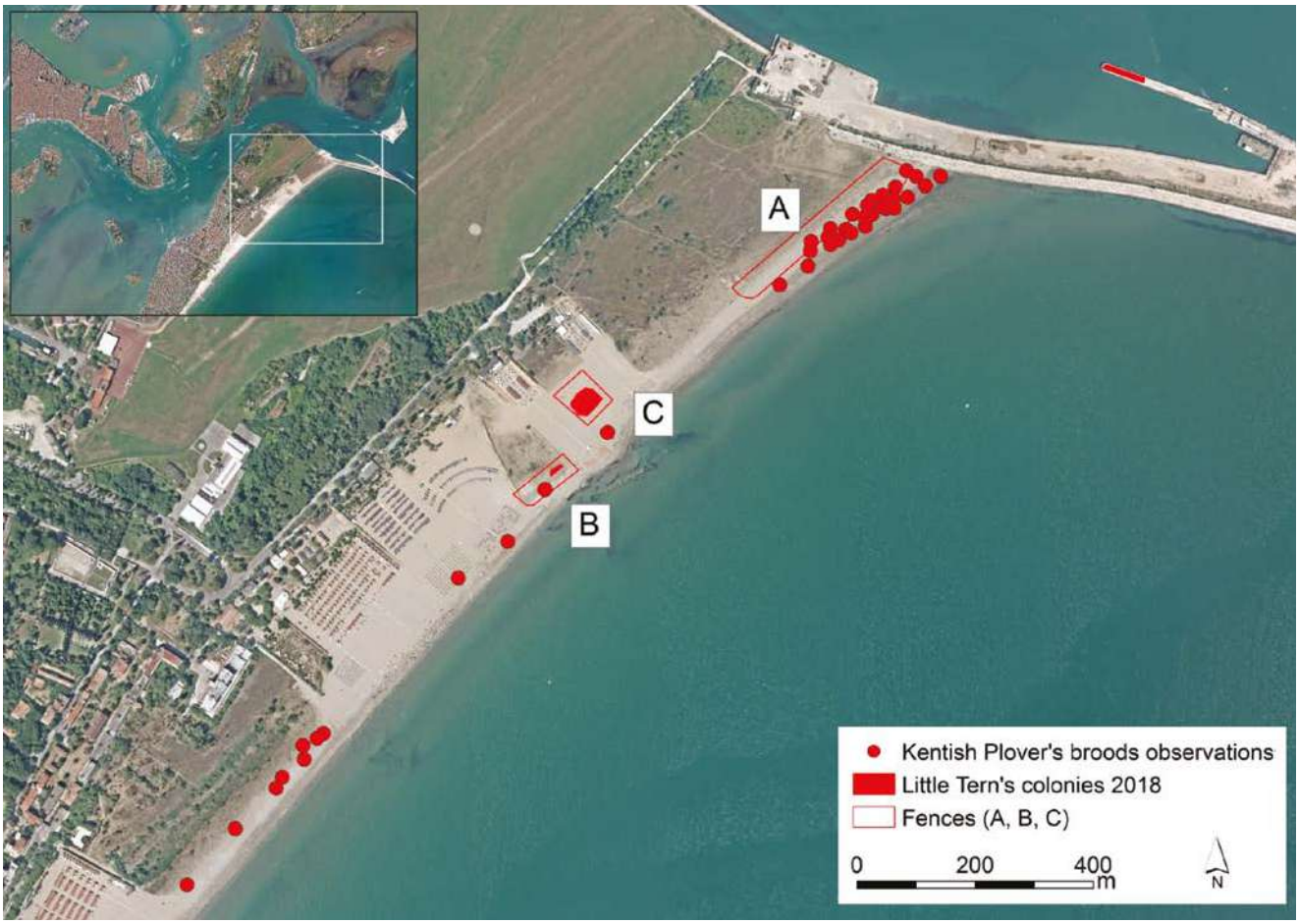

Fig. 1 - Position of enclosures (A, B, C) and of little tern colonies settled at St. Nicolò in 2018 and distribution of observations of Kentish Plovers broods.
- *Posizione delle recinzioni (A, B, C) e delle colonie di fraticello insediate a San Nicolò nel 2018, e distribuzione delle osservazioni di covate di fratino.*

the suitability of Kentish Plover habitat, worsening the impact of corvids on the breeding success of the latter. Referring to the European Directives 92/43/CE and 2009/147/CE, and to the European Natura 2000 protected areas network, policy and criteria, Little Terns disappearance could therefore affect the degree of conservation of "the features of the habitat important for" Kentish Plover on the areas of the network Natura 2000.

In order to improve the conservation of Kentish Plovers on Venetian beaches, we tested the possibility to re-induce the settlement of a colony of Little Terns by using decoys. The latter have been already successfully used to encourage settlement of terns (Veen 1977; Kress 1983; Kotliar & Burger 1984; Dunlop 1987; Burger 1988; Blokpoel et al. 1997; Jeffries & Brunton 2001; Feare et al. 2015). In our case we used for the first time decoys not only with the goal to attract the target species in a area suitable for nesting, but above all in order to bring a guardian species back and to restore the functions of the inter-specific relationships inside a bird community.

Material and methods

The study was carried out at St. Nicolò, the northern portion of the Lido of Venice beach. The Lido island separates the Venice lagoon from the Adriatic Sea. St. Nicolò is a part of the fragmented Special Area for Conservation (SAC) IT3250023 of the Natura 2000 network. The shoreline of the St. Nicolò beach faces to southeast, and the north side of the beach is bordered by the dam of the port channel. The beach of St. Nicolò is 1.8 km long and in the central 800 m long portion it hosts a few bathing concessions. Northern and southern portions of the site are characterized by littoral habitats and a natural landscape. They do not host bathing concessions but are of free access for people and bathers. In the northern natural and unexploited sectors, raking the shoreline band is forbidden and stranded algae and seagrass offer a great availability of amphipods and insects (Zanella et al. 2009). On the contrary, the shoreline facing bathing concession is daily raked, and stranded deposits are absent. The southern natural portion is weekly raked by neighboring concession managers in order to improve the attractivity of the beach for sunbathers.

From June 1st to September 15th, bathing concessions host umbrellas, deck chairs and beach huts, but during winter and early spring they provide a wide surface of bare sand with scattered shell fragments. At the bathing concessions, the surface of bare sand extends up to 150-200 m from the shoreline, whereas in the sectors of natural beach the aphytoic strip between shoreline and vegetated dunes is much narrower, measuring 40-50 m in width, thus affecting the width of the habitat suitable for nesting. Since 2014, fences have been seasonally built from late March to late August in order to protect nesting areas (Borgo et al. 2016). Two fences, A (350 m long, that delimited an area of 1.5 ha) and B (100 m long, 0.4 ha) were built in natural sectors of the beach, whereas fence C (80 m long, 0.5 ha wide) was located in an unexploited bathing concession, completely free of vegetation because raked by nearby concession managers in order to prevent the vegetation development (Fig. 1).

Surveys for both Little Tern and Kentish Plover counts were conducted from 2016 to 2018. For 2013-2015 we have data concerning the position of 43 nests. Since 2016, individuals, pairs and nests of both Little Tern and Kentish Plover were countedevery 1-3 days from March to mid August, systematically screening the area by walking, according to Székely et al. (2008). Nests were mapped with a GPS Garmin 62S device.

On May 19th 2018 we positioned 4 and 6 decoys of little terns respectively in fences C and B, both characterised by the greatest abundance of shells and by a bare surface large enough to allow Little Tern settlement considering an initial flight initiation distance of

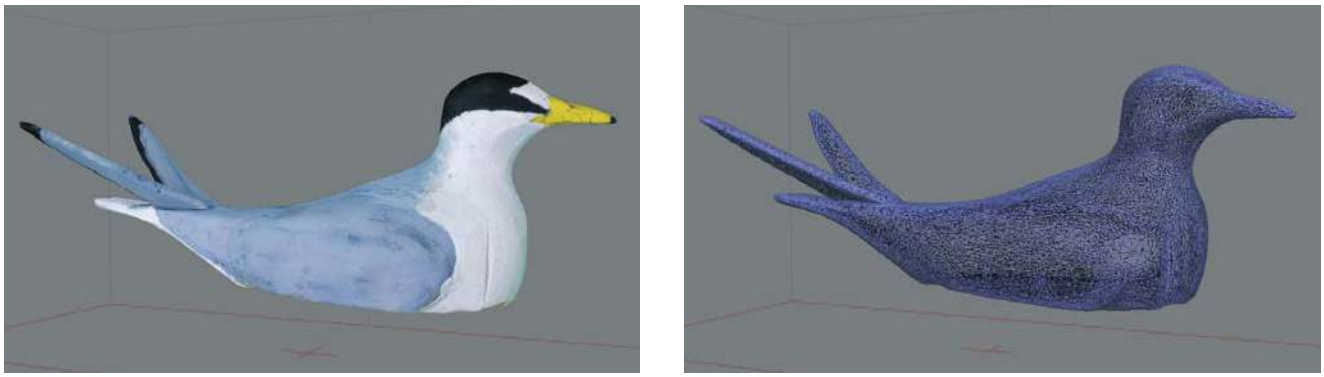

Fig. 2 - The prototype of Little Tern carved in wood (left) and the 3D model obtained by photo-scanning (right), and available for decoys replication by 3D printer.
- *Il prototipo di fraticello scolpito in legno (a sinistra) e il modello 3D ottenuto mediante fotoscansione (a destra) e utilizzato per la stampa 3D dei richiami.*

25 m (pers. obs). Decoys, made with a 3D printer from a wooden prototype scanned with the software Agisoft Photoscan (Fig. 2), were positioned scattered 3-10m from each other.

We compared the frequencies of Kentish Plover nests in presence (2018) and absence (2013-2017) of the tern colony in and out a 100 m radius buffer around the centre of the area occupied by the colony by Chi squared (with Yates correction). In order to test possible effects of the guardian species on breeding success of Kentish Plovers, we compared the ratio fledged/dead young between years of presence (2018) and absence (2013-2017) of a Little Tern colony by Chi squared (with Yates correction).

In 2018 we mapped Kentish Plover broods. To ensure data independence, broods mapping was performed only once a day. In order to verify the spatial use by broods, we divided the beach in 6 sectors 300 m long and we compared observed and expected frequency of broods by Chi squared test.

From 30 March to 20 July 2018, the abundance of Black-billed Magpies, Hooded Crows and Yellow-legged Gulls *Larus michahellis* was surveyed walking all the shoreline and groups (≥1 individual) were mapped. Individuals flying over the area were not considered. The survey effort was equally divided between morning (6 am - 12 am) and afternoon (3 pm - 9 pm), with 19 repetitions each. In order to verify whether potential predators affected Kentish Plover nests or broods distribution, we divided the beach in 18 sectors 100 m long and we analysed correlation between the density of corvid and gull groups, and the density of Kentish Plovers nests and broods by Spearman Rho. In order to verify the effect of beach management on species distribution, we compared by oneway ANOVA the density of corvid groups and of Kentish Plovers nests and broods in sectors managed as bathing concessions (N = 8) and in those of natural beach (N = 10). We used regression analysis we verify whether the availability (m^2) of stranded deposits of algae and seagrass in the 10 sectors of natural beach, measured from Google aerial photos taken in April 2018, affected the distribution of Kentish Plover broods. All statistics were performed by mean the software SPSS 14.0 for Windows.

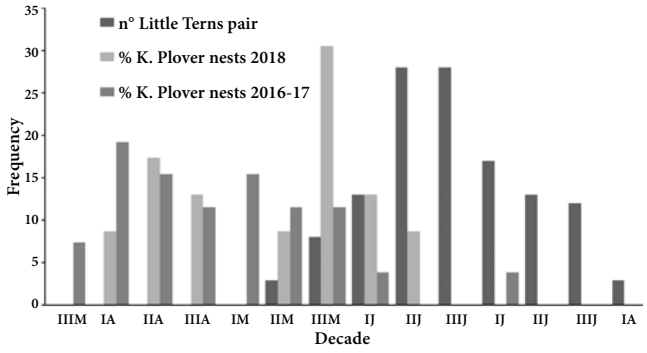

Fig. 3 - Phenology of Kentish Plover nesting (brood starting) in presence (2018) or absence (2016-2017) of a Little Tern colony, and trend of the colony dimension.
- *Fenologia della nidificazione (avvio della cova) del fratino in presenza (2018) e in assenza (2016-2017) della colonia di fraticello e andamento della dimensione della colonia.*

Results

In 2017, a colony of at least 14 pairs of Little Terns settled on an undisturbed sector of the concrete pier of the port channel close to the San Nicolò beach. On June 26th, we found 13 nests and 1 chick, but few days later, a strong storm destroyed the whole colony. In 2018, the same concrete of the port pier was colonized again. The maximum number of pairs, about 25, was observed on June 13th, but a storm at the mid of June completely destroyed the colony.

In early May 2018, three pairs of Little Terns attempted to nest on a bathing concession before the beginning of the mechanical raking and the opening of the bathing season. On May19th 2018, 5 minutes later we positioned decoys in the fence B and C, three pairs landed in the two fences, very close (0.5-2m) to decoys. On May 25th and 26th we observed the first nests in both fences. In the fence B only two pairs nested (probably due to the greater vegetation cover), but both nests were rapidly preyed on and the fence are abandoned by terns. In the fence C, the number of landing and laying pairs raised rapidly, reaching the maximum number of 28 simultaneously active nests on June 19th. Hatching began on June 21st, but first chicks systematically disappeared. We observed two chicks being caught by a Common Kestrel *Falco tinnunculus* and one by a Yellow-legged Gull. No mammal footprints were found around the fence. Since the beginning of July the number of chicks rapidly grew, and almost 25 young fledged from July 21st to July 26th. Exploring the area after the colony departure, we found two mummies of precociously dead chicks.

The settlement of the Little Tern colony attracted Kentish Plovers to nest in the area. In 2018, the 26.9% (N = 26) of the Kentish Plover nests was concentrated in the 100 m buffer around the colony, against the 6.8% (N = 73) recorded in previous years of absence of a Little Terns colony ($\chi^2 = 5.68$, $P < 0.05$). In 2018 we recorded 13 pairs of Kentish Ploverbreeding at the same time in the study area and a total of 26 nests, whereas in the previous two years we recorded an average of 7.5 (SE = 0.5, N = 15) pairs and 15.0 (SE = 1.0, N = 30) nests. The settlement of the Little Tern colony determined an increase of 73.3% in the number of both pairs and nests of Kentish Plover.

The comparison between the Kentish Plover nesting phenology recorded in 2018 and in the previous two

years, evidenced that the settlement of the Little Tern colony attracted Kentish Plovers, with an increase of pairs starting brood in late May and June, following the terns settlement (Fig. 3), and a consequent increase in the numberg of clutch hatched in June and July. Comparing years with (2018) and without (2016-2017) settlement of a Little Terns colony, both nesting (rs = 0.31, N = 11, P = 0.351) and hatching phenologies (rs = 0.11, N = 11, P = 0.758,) were not correlated. Within the nesting period of the Little Terns (from last decade of May to last decade of July), the frequency of hatching of Kentish Plovers' nests was strongly related to the size (N° of pairs) of the tern colony (rs = 0.93, N = 7, P = 0.001; Fig 4).

In 2018, we recorded a breeding success of 0.31 young/nest (N = 26), higher than the value of 0.11 (SE = 0.7, N = 30) recorded in the same site in the previous two years. The proportion of fledged/dead young in 2018 (8/45; N = 53) is greater (χ^2 = 6.07, p < 0.05) than in 2016-2017 (1/53; N = 54) when Little Terns were absent. The mortality of chicks recorded in 2018 was of 84.9% (N=54), lower than the value of 98.1% (N=54) of the previous two years.

In spite of the attraction of nesting pairs, the Little Tern colony didn't attract Kentish Plover broods. Adults with broods searching for food showed a clear preference for the shoreline of the northern natural sectors (χ^2 = 63.92, P < 0.01). The density of brood observations was significantly higher (F= 5.17, P = 0.037) in natural sectors (3.26, SE = 1.15, N = 10) of beach than in exploited ones (0.30, SE = 0.11, N = 8), whereas no difference was recorded in the density of nests (F = 0.14, P = 0.714). The preference for natural sectors didn't depend on predator distribution, because Yellow-legged Gulls resulted scattered all the beach long, and no differences in density of corvid groups were recorded between natural and exploited sectors (F = 2.68, P = 0.121). Linear regression analysis evidences that density of broods observations in the sectors of natural beach varied in function of the availability of stranded algae and seagrass (t = 2.54, P = 0.035). The availability of stranded deposits also attracted corvids for food, so much so that broods and corvids densities were positively related (rs = 0.88, N = 18, P < 0.001; Fig. 5).

Discussion

The raising human pressure on the Venetian natural beaches recorded in last three decades impacted on the birds community typically nesting on the Venetian beaches (Valle & D'Este 1992; Borgo 1995; Antinori et al. 2011). According to similar dynamics recorded in other coastal sites, the Little Tern was the first species deserting beaches, because of its high susceptibility to humane disturbance (Catry et al. 2004; Medeiros et al. 2007; Cramm & Muselet 2004; Fasola & Canova 1996; Ratcliffe et al. 2008). Paradoxically, the policy of littoral habitat conservation emphasizes the impact of humane disturbance, by reducing the habitat available for nesting. The prohibition to mechanically raking the beach determined the advance of vegetation towards the shoreline, reducing the amplitude of the habitat suitable for nesting and its distance from the shoreline. In a human deserted beach, the natural aphytoic band of bare sand occurring between dunes and high tide shoreline surely represents a suitable habitat for nesting Little Terns (Valle & Scarton 1999). However, if a regular human presence occurs, the same band becomes too narrow for hosting both humans and breeding colonies.

The disappearance of the Little Tern affected Kentish Plovers too, because of the loss of the interspecific relations. Little Terns, typically adopting a strong, communal anti-predator behaviour, indirectly offers the species nesting inside or close to its colonies strong benefits in terms of protection from preda-

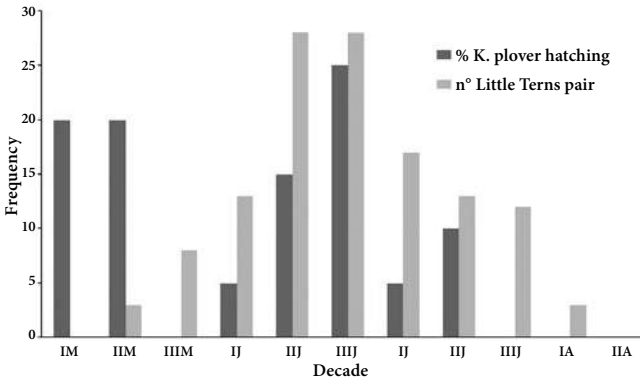

Fig. 4 - Comparison between the phenology of the Kentish Plover hatching and the trend in the Little Terns colony dimension.
- *Confronto tra la fenologia di schiusa dei nidi di fratino e l'andamento della dimensione della colonia di fraticello.*

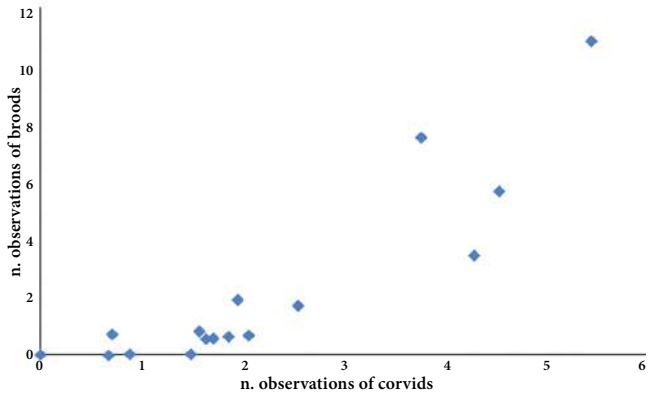

Fig. 5 - Relation between the frequency of observations of kentish plover's broods and corvids in 15 sectors of beach.
- *Relazione tra la frequenza di osservazioni delle covate di fratino e dei corvidi nei 15 settori di spiaggia.*

Fig. 6 - Mating of Little Terns in the study area.
- *Accoppiamento di fraticelli nell'area di studio.*

Fig. 7 - Kentish Plover female warming and protecting its brood one day old.
- *Femmina di fratino che scalda e protegge la sua covata di un giorno d'età.*

Fig. 8 - Breeding Little Tern attacking a juvenile Yellow-legged Gull flying near the colony.
- *Fraticello nidificante che attacca un giovane gabbiano reale nei pressi della colonia.*

tors (Burger 1987; Valle & Scarton 1999; Powell 2001; Scarton et al. 2009). The benefits of nesting near aggressive colonial species have been inferred from studies of survival of natural nests of different shorebirds (Dyrcz et al. 1981; Burger 1987; Alberico et al. 1991; Valle & Scarton 1999; Powell 2001; Nguyen et al. 2003; Nguyen et al. 2006; Scarton et al. 2009; Hanane 2014; Rocha et al. 2016; Borgo et al. 2018; Valle 2019). The dramatic increase of corvids in the last years in the Venetian islands (Valle & D'Este 1992; Borgo 1995; Bon et al. 2000, 2014), makes the loss of the "guardian species" an increasingly serious problem. In the last decade, corvids heavily affected the survival of nests and chicks of Kentish Plovers along the Venetian beaches (Antinori et al. 2011; Borgo et al. 2016; Baldin et al. 2018; Mitri et al. 2019). Although the use of net-box for nest protection allowed to preserve nests and strongly increase the hatching success of the population (Borgo et al. 2016; Mitri et al. 2019), no solutions were still found to reduce predation on chicks and to increase their survival; the latter recently dropped to 0-10% (Mitri et al. 2019). Searching for a new strategy in sustaining breeding success of Kentish Plovers, we tried to restore the guardian species Little Tern.

First results of the project confirm the efficacy of decoys in attracting Little Terns to settle a colony, and highlight the feasibility of the project to restore the typical community of species breeding on Venetian beaches. Decoys showed to be realistic enough so that in the first days they were object of fish offer by a few males. According with previous experiences (Feare et al. 2015), decoys did no miracles and their efficacy resulted subordinated to the habitat suitability of the site. Indeed, only few Little Terns started to nest in the less suitable fence B, and they soon abandoned it. Moreover, decoys proved to be effective only when placed in a safe fenced area wide enough to provide a nesting habitat unaffected by humans (sunbathers and walkers) and dogs.

The strong increase (86%) in the number of pairs simultaneously breeding in the study area evidenced the effectiveness of the settlement of a Little Tern colony in attracting Kentish Plovers and increasing their breeding density. The same rapid response of the species to the settlement of tern colonies was recorded also in dredge island of the Venice lagoon (Borgo et al. 2018). Considering the European Natura 2000 network, the occurrence of Little Tern colonies could therefore becomes strategic in rating the role of littoral protected areas in Kentish Plover conservation and in achieving the goals of the network. Considering the data collected along the Venetian beaches (Baldin et al. 2018; LIPU, unpubl.), St Nicolò hosted in 2018 the 75% of the Kentish Plover population breeding on the SAC IT3250023 and the 100% of the Little Tern population. These numbers confirm the endangered status of both species in the Venetian littoral, and the primary role of St Nicolò beach for their conservation. This evidence must be carefully considered in management of the humane pressures acting in this small site.

In the Venetian coastal area, Little Terns start to breed in May (Fig. 3), later than Kentish Plover (Borgo et al. 2016; Borgo et al. 2018). In the study area we observed that the settlement of Little Terns attracts Kentish Plovers to nest close to their colony, with a consequent increase of the number of broods hatching in June (Fig. 2), when the colony reached its full size. The differences in nesting phenology recorded at the same site in the years with (2018) or without (2016-2017) colony of Little Tern reflects an adaptive strategy. The relation between hatching trend of Kentish Plovers' nests and the trend in size of the Little Terns colony evidences that broods hatched from nests laid in May and June can benefit of the protective umbrella provided by the Little Tern colony (Fig. 4). This apparent synchronicity between hatching trend of Kentish Plover nests and the increase in number of Little Terns implies that Kentish Plovers bet on the settlement of a colony, converging to nest and to lay eggs in the area were Little Terns land and display, since the beginning of the settlement of the colony. This strategy of prompt and precocious settlement in areas were terns just begin to settle, allows Kentish Plovers to maximize the benefits of the settling colony and its efficacy as "umbrella" for their broods.

In 2018 we recorded a productivity of 0.31 young/nest, higher than the average value recorded in the same site in the previous years (Borgo et al. 2016; Mitri et al. 2019). The mortality of chicks recorded in 2018 (85%) was very high in comparison with values (27%) recorded in areas protected by the presence of tern colonies (Borgo et al. 2018). The increase in breeding success obtained in 2018 is therefore only a preliminary and partial result, due to the distance of the Little Tern colony from the areas were Kentish Plover broods feed and are raised (Fig. 1). Our results evidence that broods are reared in the more natural sectors of beach, richer in stranded algae and seagrass remains, where amphipodes abundance is greater. Broods converge towards this nursery area from all the beach length (Borgo et al. 2016; Mitri et al. 2019). The position of the Little Tern colony, settled in a bathing concession and facing a shoreline daily raked and unsuitable for chicks feeding, make the "umbrella" obtained in 2018 weakly effective in chicks' protection. The abandonment of the protection of tern colony by adults with broods was not obvious, but it is explainable in terms of costs-benefits. In Kentish Plover, like in other species, decisions made during the course of breeding are sequential in time and space, and made independently based on different criteria (Doligez

& Boulinier 2008; Borgo et al. 2018). For nesting Kentish Plover select areas following criteria of habitat selection aimed to protect clutch from flooding and predation independently from the suitability for brood feeding (Borgo et al. 2018). After hatching, criteria in habitat selection change and the access to areas suitable for chicks feeding became a new priority. Therefore, the abandonment of the tern colony by adults with broods underlines the impact of the shoreline daily raking and evidence that stranded deposits availability along the shoreline is a priority factor limiting broods survival.

The overlap of preferences of both broods and corvids for shoreline sectors richer in stranded deposits, stresses the potential impact of the increase of corvids on survival rates of Kentish Plover chicks and the urgency to restore an effective umbrella. The next step, necessary for increase and maximize the efficacy of the guardian species strategy, will be therefore to improve the settlement of a Little Tern colony in the northern sector of natural beach in which broods of Kentish Plovers feed. Considering the initial flight initiation distance of Little Terns, the settlement of a colony in this sector of beach requires to widen the aphytoic band of bare sand occurring between dunes and high tide shoreline suitable for colony settlement in presence of human disturb. In order to allow the settlement of a large colony of Little Terns, LIPU proposed to the administration the enlargement of the aphytoic band of bare sand suitable for Little Tern settlement by a beach nourishment (artificial increase of te beach area) expressly aimed to species conservation (Mamprin & Borgo 2018). We consider that this strategy, joined to a management allowing the conservation of the bare sand surface and human disturbance exclusion, could represent the milestone of Kentish Plover conservation in the Venetian beaches.

Considering both the colonies settled on the beach and on the concrete pier of the port, in 2018 more than 50 pairs of Little Terns simultaneously nested at St. Nicolò. This evidences the potential importance that beaches could still play in the species conservation and the possibility to induce the settlement of a colony large enough to make the interspecific umbrella effective both in attracting Kentish Plovers pairs and in reducing predation on chicks. The importance of the study area is not only related to the colony size, but it also depends on the fact that it provides a breeding habitat less exposed to flooding during the high tides that periodically destroy the colonies settled in the marsh islands located inside the lagoon (Scarton 2008; Borgo et al. 2018).

The experiment designed to induce the settlement of Little Terns could be applied in other beaches potentially suitable to host colonies, but only if effective efforts and strategies in management and monitoring will be guaranteed. Inducing the settlement of a colony in an area not safe from human and dogs, could in fact transform the site in a sink. The efficacy of the safe area is subordinated to fence building characteristics, because a Little Tern colony is very conspicuous and enclosures must therefore be absolutely effective in hindering the access of dogs (Borgo et al. 2016; Mitri et al. 2019). The breeding success obtained by our colony despite the daily presence of free dogs is mainly due to the efficacy of the enclosure in preventing dogs access; we found that the simple placing of signals to keep dogs on a leash are not sufficient in our social and cultural context.

The conspicuousness of a Little Tern colony helps sharing the importance and necessity of fences to the public, making easily visible the results of the efforts, helping bathers and recreationists to understand and accept the limitations required for Kentish Plover protection. Indeed, speaking with people on the beach, the authors observed that the presence of a Little Terns colony always improves the perceived quality and value of a littoral site, making easier to improve the conservation policy. The sharing of biodiversity as a perceived value of the beach, suggests to maximise the synergy with bathouse managers, in order to obtain their collaboration and support to species conservation efforts. Kentish Plover and man are competing species for the use of the beach (Schultz & Stock 1993). The man is surely the dominant species and the only chance for Kentish Plover to survive on the beaches is that mans want to do it possible, reserving areas for bird nesting and allowing the chicks to feed.

Our experiment seems to be the first attempt to contrast the impact of corvids on breeding Kentish Plovers by using a guardian or umbrella species as an instrument of biological fight. We evidence that Little Tern is a protected and locally threatened species too, and any attempt to force its settlement must be carefully evaluated, in order to avoid any loss in the fitness of the pairs and population. In our area we observed a lacking of suitable breeding sites for Little Tern colony, evidenced by attempts to breed on unsuitable surfaces as the concrete of the port. Therefore, our experiment was aimed to conservation of both Kentish Plovers and Little Terns. On the other and, the effectiveness of the "umbrella specie" depends on the possibility of the tern colony to breed successfully. The main limitation of the present study is the small sample size; nevertheless, first results suggest that restoring the guardian species can really represent an effective strategy for Kentish Plover conservation, inducing an increase in its nesting population and breeding success.

In conclusion, decoys induced the return of Little Terns in the study area, showing that the restoration of a breeding community in some Venetian beaches is a realistic goal. Preliminary results confirm the impor-

tance of the presence of the "guardian" species as key factor affecting nesting habitat selection, phenology and breeding success of Kentish Plover (Valle & Scarton 1999; Scarton et al. 2009; Rocha et al. 2016; Borgo et al. 2018). An effective reduction of chicks predation will strictly depend on the possibility to induce the settlement of the colony in the areas where Kentish Plover concentrate their broods for feeding.

Manuscript received on 14.II.2020, accepted on 05.III.2020.

Acknowledgements

Authors thank Raffaele Tomasella, Mario Burlin, Marcello Rossani, and the volunteers of the LIFE 16 Project ESC/IT/002 CHOO-NA Valeria Vavalà, Marta Dall'Olivo, Sara Detela, Mattia Burlin, Caterina Garbin, Cecilia Proto, Eleonora Marin, for collaboration in the field activities. Authors and LIPU staff are grateful to bathing managers, and firstly the Italian Navy, for their cooperation in conservatory actions.

References

Alberico, J.A.R., J.M. Reed & L.W. Oring. 1991. Nesting near a Common Tern colony increases and decreases Spotted Sandpiper nest predation. *Auk* 108: 904-10.

Antinori, F., M.G. Mitri, S. Castelli & A. Borgo. 2011. La tutela delle popolazioni nidificanti del fratino *Charadrius alexandrinus* sui litorali veneziani (1985-2010). In *Il fratino: status, biologia e conservazione di una specie minacciata*, cur. M. Biondi & L. Pietrelli, 21-33. Latina: Edizioni Belvedere.

BirdLife International. 2015. *European Red List of Birds*. Luxembourg: Office for Official Publications of the European Communities. http://datazone.birdlife.org/info/euroredlist

BirdLife International. 2017. *European birds of conservation concern: populations, trends and national responsibilities*. Cambridge, UK: BirdLife International.

Blokpoel, H., G.D. Tessier & R.A. Andress. 1997. Successful restoration of the Ice Island Common Tern colony requires ongoing control of ring-billed gulls. *Colonial Waterbirds* 20: 98-101.

Borgo, A. 1995. Avifauna del litorale di San Nicolò. *Boll. Centro Ornit. Veneto Orientale* 6: 30-3.

Borgo, A., M.G. Mitri, F. Antinori, S. Castelli, R. Gottipavero, M. Pegorer & R. Tomasella. 2016. Dati preliminari sull'incidenza delle cause di fallimento delle nidificazioni di fratino *Charadrius alexandrinus* sul litorale veneziano. *Boll. Mus. St. Nat. di Venezia* 66: 188-93.

Borgo, A., S. Carrer & A. Regazzi. 2018. Primi dati sulla biologia riproduttiva del Fratino *Charadrius alexandrinus* nidificante in strutture morfologiche artificiali della laguna di Venezia. *Boll. Mus. St. Nat. di Venezia* 69: 77-89.

Burger, J. 1987. Physical and social determinants of nest-site selection in piping plover in New Jersey. *Condor* 89: 811-8.

Burger, J. 1988. Social attraction in nesting Least Terns: effects of numbers, spacing and pair bonds. *Condor* 90: 575-82.

Catry, T., J.A. Ramos, I. Catry, M. Allen-revez & N. Grade. 2004. Are salinas a suitable alternative breeding habitat for Little Terns? *Ibis*, 146: 247-57.

CNCF. 2017. Censimento nazionale della popolazione nidificante di Fratino (*Charadrius alexandrinus*): primi risultati. Comitato Nazionale per la Conservazione del Fratino. *XIX Conv. italiano di Ornitologia*. Torino.

CNCF. 2019. Censimento nazionale della popolazione nidificante di Fratino (*Charadrius alexandrinus*): aggiornamento al 2018 e considerazioni preliminari. Com. Naz. Conservazione del Fratino. *XXI Conv. italiano di Ornitologia*. Napoli.

Cramm, P., & D. Muselet. 2004. *Sterne naine* Sterna albifrons. In *Oiseaux marins nicheurs de France métropolitaine (1960-2000)*, cur. B. Cadiou, J.M. Pons & P. Yésou, 169-75. Mèze: Edition Parthénope.

Cramp, S., & K.L. Simmons. 1983. *The birds of the western Palearctic*. Oxford University Press.

Delany, S., D. Scott, T. Dodman & D. Stroud. 2009. *An atlas of wader populations in Africa and Western Eurasia*. Wageningen: Wetlands International.

Doligez, B., & Boulinier T. 2008. Habitat Selection and Habitat Suitability Preferences. In *Encyclopedia of Ecology*, 5 vols, cur. S.E. Jørgensen & B.D. Fath, 1810-30. Oxford: Elsevier. Behavioral Ecology 3.

Domínguez, J., & M. Vidal. 2003. Influencia del investigador en el éxito reproductivo del Chorlito Patinegro *Charadrius alexandrinus*. *Ardeola* 50: 15-9.

Dunlop, J.N. 1987. Social behavior and colony formation in a population of Crested Terns, Sterna bergii, in Southwestern Australia. *Australian Wildlife Research* 14: 529-40.

Dyrcz, A., J. Witkowski & J. Okulewicz. 1981. Nesting of 'timid' waders in the vicinity of 'bold' ones as an anti-predator adaptation. *Ibis* 123: 542-5.

Fasola, M. 1986. Laridae and Sternidae breeding in Italy: Report on the 1982-84 Census Project. In *Mediterranean Marine Avifauna. Population Studies and Conservation*, cur. Medmaravis & X. Monbailliu, 13-8. Berlin: Springer Verlag. NATO ASI Series 12 (G).

Fasola, M., & L. Canova. 1996. Conservation of Gull and Tern colony sites in northern Italy, an internationally important bird area. *Colonial Waterbirds* 19: 59-67.

Feare, C.J., G.C.A. French, J.E.G. Nevill, V.S. Pattison-Willits, V. Wheeler, T.L. Yates, C. Hoareau & C. Prescott. 2015. Attempted re-establishment of a sooty tern *Onychoprion fuscatus* breeding colony on Denis Island, Seychelles. *Conservation Evidence* 12: 19-24.

Filesi, L., F. Antinori, E. Bizio, A. Borgo, S. Castelli, A. Manzini, A. Marotta, M. Rizzieri & M.G. Mitri. 2017. Pregio naturalistico del settore costiero antistante l'ex Ospedale al Mare (Isola di Lido - Venezia). *Lavori Soc. Venez. di Sc. Nat.* 42: 61-88.

Hanane, S. 2014. Factors influencing nest location and breeding density in the woodpigeon (*Columba palumbus*). *Integrative Zoology* 9: 349-59.

Jeffries, D.S., & D.H. Brunton. 2001. Attracting endangered species to 'safe' habitats: responses of fairy terns to decoys. *Animal Conservation* 4: 301-5.

Kotliar, N.B., & J. Burger. 1984. The use of decoys to attract Least Terns (*Sterna antillarum*) to abandoned colony sites in New Jersey. *Colonial Waterbirds* 7: 134-8.

Kress, S. 1983. The use of decoys, sound recordings, and gull control for re-establishing a tern colony in Maine. *Colonial Waterbirds* 6: 185-96.

Mamprin, L., & A. Borgo. 2018. Mitigare i danni sugli habitat di interesse comunitario. *Quaderni della Laguna* 1: 114-32.

Medeiros, R., J.A. Ramos, V.H. Paiva, A. Almeida, P. Pedro & S. Antunes. 2007. Signage reduces the impact of human disturbance on little tern nesting success in Portugal. *Biological Conservation* 135: 99-106.

Mitri, M.G., A. Borgo, E. Antinori, S. Castelli, M. Scarpa, L. Bonotto & C. Cesarotto. 2019. Allarmante situazione del Fratino *Charadrius alexandrinus* sul litorale veneziano: l'emblematico caso dell'area di San Nicolò nel SIC/ZPS "Lido di Venezia: biotopi litoranei". *Boll. Mus. St. Nat. di Venezia* 69: 148-54.

Nardelli, R., A. Andreotti, E. Bianchi, M. Brambilla, B. Brecciaroli, C. Celada, E. Dupré, M. Gustin, V. Longoni, S. Pirrello, F. Spina, S. Volponi & L. Serra. 2015. *Rapporto sull'applicazione della Direttiva 147/2009/CE in Italia: dimensione, distribuzione e trend delle popolazioni di uccelli (2008-2012)*. Roma: ISPRA, Serie Rapporti, 219/2015.

Nguyen, L.P., E. Nol & K.F. Abraham. 2003. Nest success and habitat selection of the Semipalmated Plover on Akimiski Island, Nunavut. *Wilson Bulletin* 115: 285-91.

Nguyen, L.P., K.F. Abraham & E. Nol. 2006. Influence of Arctic Terns on Survival of Artificial and Natural Semipalmated Plover Nests. *Waterbirds* 29 (1): 100-4.

Powell, A.N. 2001. Habitat characteristics and nest success of snowy plovers associated with California least tern colonies. *Condor* 103: 785-92.

Ratcliffe, N., S. Schmitt, A. Mayo, J. Tratalos & A. Drewitt. 2008. Colony habitat selection by Little Terns Sternula albifrons in East Anglia: implications for coastal management. *Seabird* 21: 55-63.

Rocha, A.D., D. Fonseca, J.A. Masero & J.A. Ramos. 2016. Coastal saltpans are a good alternative breeding habitat for Kentish plover Charadrius alexandrinus when umbrella species are present. *Journal of Avian Biology* 47: 1-10.

Rondinini, C., A. Battistoni, V. Peronace & C. Teofili. 2013. *Lista Rossa IUCN dei Vertebrati Italiani*. Roma: Comitato Italiano IUCN e Ministero dell'Ambiente e della Tutela del Territorio e del Mare.

Sartori, A. 2014. Nidificazioni di fratino *Charadrius alexandrinus* e fraticello *Sternula albifrons* sul litorale dell'isola di Pellestrina - Venezia. *Lavori Soc. Venez. di Sc. Nat*. 39: 49-53.

Scarton, F. 2005. Breeding birds and vegetation monitoring in recreated saltmarshes of the Venice lagoon. In *Flooding and environmental challenges for Venice and its lagoon*. State of knowledge, cur. C.A. Fletcher & T. Spencer, 573-9. Cambridge: Cambridge University Press.

Scarton, F. 2008. Population trend, colony size and distribution of Little Terns in the lagoon of Venice (Italy) between 1989 and 2003. *Waterbirds* 31: 35-41.

Scarton, F., & R. Valle. 1999. The use of dredge island by birds in northern Adriatic lagoons. *Avocetta* 23: 75.

Scarton, F., & R. Valle. 2017. Andamento recente (2013-2015) delle popolazioni di uccelli acquatici nidificanti nella laguna aperta di Venezia. *Boll. Mus. St. Nat. di Venezia* 67: 113-23.

Scarton, F., R. Valle, M. Baldin & M. Scattolin. 2004. La nidificazione del Fratino *Charadrius alexandrinus* e del Fraticello *Sterna albifrons* lungo i litorali del comune di Venezia: un triennio di censimenti. *Lavori Soc. Venez. di Sc. Nat*. 29: 17-21.

Scarton, F., E. Boschetti, C. Guzzon, K. Kravos, L. Panzarin, P. Utmar, R. Valle & E. Verza. 2005. Caradriformi e volpoca Tadorna tadorna nidificanti sulle coste del Nord Adriatico (Friuli e Veneto) nel triennio 2000-2002. *Riv. it. di Ornitologia* 75: 23-38.

Scarton, F., M. Baldin & M. Scattolin. 2007. Fratino *Charadrius alexandrinus*, Fraticello *Sterna albifrons* e Gruccione *Merops apiaster* nidificanti lungo i litorali del comune di Venezia: aggiornamento al 2005. *Lavori Soc. Venez. di Sc. Nat*. 32: 77-9.

Scarton, F., M. Baldin. & R. Valle. 2009. L'avifauna acquatica nidificante nelle barene artificiali della laguna di Venezia. *Boll. Mus. St. Nat. di Venezia* 60: 127-41.

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

Scarton, F., G. Cecconi & R. Valle. 2013b. Use of dredge islands for a declining European shorebird, the Kentish Plover *Charadrius alexandrinus*. *Wetlands ecology and management* 21: 15-27.

Schulz, R., & M. Stock. 1993. Kentish plovers and tourists: competitors on sandy coasts? *Wader Study Group Bulletin* 68: 83-91.

Szekely, T., A. Kosztolanyi & C. Kupper. 2008. *Practical guide for investigating breeding ecology of Kentish plover Charadrius alexandrinus*. Unpub. Report, vol 3. Bath: University of Bath.

Valle, R. 2019. Uno studio decennale sulla biologia riproduttiva della pettegola Tringa totanus nidificante nella Laguna di Venezia: una questione di maree e sterne? *Boll. Mus. St. Nat. di Venezia* 69: 155-61.

Valle, R., & A. D'Este. 1992. Un triennio di osservazioni ornitologiche nell'area del porto di Lido (Venezia) con note sulla biologia riproduttiva del Fratino *Charadrius alexandrinus* e della Ballerina bianca *Motacilla alba*. *Lavori Soc.Venez. di Sc. Nat*. 17: 121-9.

Valle, R., & F. Scarton. 1999. Habitat selection and nesting association in four species of Charadriiformes in the Po delta (Italy). *Ardeola* 46: 1-12.

Veen, J. 1977. Functional and causal aspects of nest distribution in colonies of the sandwich tern (*Sterna sandvicensis*). *Behaviour* 20: 1-193.

Zanella, L., M. Uliana, F. Scarton, F. Barbieri & E. Ratti. 2009. Valutazione ambientale di alcuni arenili veneti con formazioni a dune mediante lo studio della coleotterofauna specializzata (Insecta, Coleoptera). *Boll. Mus. St. Nat. di Venezia* 60: 43-88.

Indirizzi degli Autori - Authors' addresses:
- Antonio Borgo
  BIO.M.A. Via Lemno 8, I-30126 VENEZIA
  LIPU, sezione di Venezia
  Via G. Matteotti 26, I-30020 GAGGIO DI MARCON (VE)
  email: antonioborgo@bioma.it
- Maria Giovanna Mitri
- Stefano Castelli
- Federico Antinori
- Marcello Rossani
  LIPU, sezione di Venezia
  Via G. Matteotti 26, I-30020 GAGGIO DI MARCON (VE)