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To change not to drown: Eurasian Oystercatchers *Haematopus ostralegus* adopt pole tops as safe nesting sites in the Lagoon of Venice

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Abstract - Eurasian Oystercatchers have increasingly adopted pole tops in the last decade in the Lagoon of Venice (NE Italy). At the end of the study, 7% of the breeding population of the Lagoon (n = 180) nested on pole tops. Nests built in these structures are safe from flooding due to extremely high tides, thus allowing a high hatching success: 42 clutches out of 43 (97.7%) hatched. We hypothesise that this is an adaptive behaviour to the increased frequency of extreme high tides in the last decade and is a good omen for the species. The good availability of pole tops suitable for nesting in the Lagoon allows breeding in areas otherwise unsuitable for nesting due to the lack of sites safe from flooding. Placement of artificial nests on pole tops is also feasible and could be an easy and cheap strategy for the conservation of the breeding population of Oystercatchers in the Lagoon of Venice as extreme high tides and spring storms will likely increase in the future.

Keywords: breeding, Eurasian Oystercatcher, *Haematopus ostralegus*, Lagoon of Venice, sea level rise

INTRODUCTION

As recently stated in the last Intergovernmental Panel on Climate Change report (IPCC 2023), human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming, with surface temperature reaching 1.1°C above the 1850-1900 levels in 2011-2020. This is leading to a pronounced climate change, which is having several effects, among which sea level rise and the increase of formerly rare events, such as coastal storms, are some of the more common (Vousdoukas et al. 2018, Taherkhani et al. 2020). These phenomena are particularly serious on coastal wetlands, which support many globally threatened waterbirds and may thus be critical for their conservation. Sea level rise dramatically affects coastal tidal marshes and other intertidal sites (Newton et al. 2020, Saintilan et al. 2022), thus posing the greatest threat to the survival of many waterbirds, including some gulls and terns, which use them for nesting (Van de Pol et al. 2010,

Reynolds et al. 2015, Dias et al. 2019, Zhao et al. 2019, Saunders et al. 2021). Worldwide, it has been already observed that previously suitable and safe nesting sites have progressively become unstable and unreliable due to frequent flooding by previously uncommon high tides occurring in spring, i.e., during the breeding season (Bonter et al. 2014, Scarton & Valle, 2015, Koffijberg et al. 2016, Tattoni et al. 2020, Ritenour et al. 2022, Breiner et al. 2022; Nagi et al., 2022). Indeed, the frequency of extremely high tides, particularly during periods of syzygies, has much increased compared to the past, even during periods of the year (spring-summer) when their occurrence has been exceptional for centuries. This results in the submergence of the lower areas of seashores, riverbanks, marsh islands, etc., which represent the nesting habitat of most waterbirds (Parmesan 2006, Bayley et al. 2019). The phenomenon is so extensive that it is considered one of the main threats, if not the greatest one, to the survival of many species of waterbirds (Reynolds et al. 2015, Ramirez et al. 2018, Dias et al. 2019).

The Eurasian Oystercatcher *Haematopus ostralegus* is no exception, breeding on a diversity of habitats just above the tideline, such as sandy barrier islands, shingle or sandy beaches, saltmarshes and river shores, where it places nest on bare substrates close to water (Snow & Perrins 1998, Hockey et al. 2020, Scarton 2022). This species spreads over a huge breeding range extending from Kamchatka to Iceland, the subspecies *ostralegus* has a population of about 800,000 birds, while the *longipes* population accounts for about 27,000 birds (Hockey et al. 2020)

The Lagoon of Venice, together with the nearby Po Delta, hosts what is probably the largest population of Eurasian Oystercatchers in the Mediterranean (Valle & Scarton 1998), with around 200 pairs in the last years (Scarton & Valle 2021 and *pers. obs.*). Oystercatchers traditionally nested on barrier islands of the Po Delta, but since the late Nineties of the past century, they spread to the Lagoon of Venice settling first on dredge islands and then on saltmarsh islets (Valle & Scarton 1998 and *pers. obs.*). Oystercatchers and other Charadriiformes, such as Sandwich Tern *Thalasseus sandvicensi*s or Slender-billed Gull *Larus genei* breeding along the northwestern Adriatic coastline have already been suffering from the increasing impact of high tides and spring-summer storms on reproductive success, which is a major limiting factor (Valle & Scarton 2023, Valle et al. 2023).

In the Lagoon of Venice (Italy), the largest around the Mediterranean, the sea level is rising and an increase in amplitude and frequency of high tides has been documented by several authors (Lionello et al. 2021, Ferrarin et al. 2022, Baldan et al. 2023). Some of these works predict an increase in extreme flooding events during the next 50 to 100 years (Baldan et al. 2023).

During regular surveys of Oystercatchers breeding in the Lagoon of Venice, which began in 1996 (Scarton & Valle 1996), a nest of this species was observed for the first time on a pole top in 2013. This behaviour has been widely reported for the congeners of northern Europe (Duncan et al. 2001 for a review), but it is unprecedented for the Mediterranean.

Here, we report the systematic adoption by Oystercatchers of pole tops as nesting sites, safe from flooding, in the Lagoon of Venice over the last decade and its effect on hatching success.

MATERIALS AND METHODS

Fieldwork took place between the breeding seasons 2013 and 2020, in the Lagoon of Venice (45°26’ N, 12° 20’ E), which covers 55,000 ha. The community of breeding waterbirds is one of the largest in the Mediterranean, with ~ 8,000 pairs (Scarton & Valle 2021). The Lagoon is dotted with hundreds of natural saltmarsh islets (about 3,600 ha overall) and more than one hundred dredge islands, i.e. artificial intertidal islands made with sediments dredged from nearby channels, that are covered with halophilic vegetation (Day et al. 2019). Noteworthy, dredge islands have a mean elevation above sea level which is slightly higher than that on saltmarsh islets; this causes dredge islands to be flooded for shorter times than saltmarsh islets. Poles and *bricole* (groups of three poles placed

side by side in a trefoil pattern) are present all over the Lagoon and have been used to delimit the navigable channels from the adjoining shallows since immemorial time. Their number is in the order of thousands; they are made of wood, mostly Sessile Oak *Quercus petrea* or Chestnut *Castanus sativa* trunks, with a diameter of 40-50 cm. The *bricole* protrude from the water level for about three meters. Quite often, their tops are characterized by a cup, 5-10 cm deep, formed by the rotting of the wood. Due to several cracks occurring in the wood forming the cup, rain usually does not stagnate into it.

During the study period, we searched the entire Lagoon for breeding Oystercatchers by boat or by drone (DJI Mavic Pro, Mini, Mini 2, and Mini 3) according to previous investigations in the study area (Valle & Scarton 1999, Valle & Scarton 2019). Each site was visited weekly from laying to hatching. No systematic data are available on chick fate after hatching. Hatching success was assessed by inspecting nests through an iPhone5 (Apple, Cupertino, US) mounted on the tip of a telescopic stick from a boat, which was driven close to the nest pole or through a drone. Clutches were considered successful when: 1) hatchlings were found in the nest; 2) the pole top was found empty, and no sign of predation was found. For each nesting pole, we measured the diameter and height of the cup, elevation above the upper tidal limit, distance from the nearest marsh islet, and presence of suitable nesting habitat in the latter. Categorical data are presented as numbers (percent) and continuous data as means ± 1 SD. The significance of the correlation between years and the number of nests was assessed with the Spearman test. Analyses were performed using SPSS software for Mac, release 20.0 (SPSS, Inc., Chicago, US).

RESULTS

The first nest was found in 2013 in a *bricola* in the southern Lagoon and contained only one egg. In the following years, a rapid, significant increase in the number of nests was observed with a spreading to all parts of the Lagoon (Spearman test: $r = 0.98$, $p < 0.001$, Figure 1). Overall, fifty nests were found during the study period. At the end of the study, 7% of the breeding population of the Lagoon (n = 180) nested on pole tops. Overall, all clutches on poles during the study period (n = 43) contained on average 3.2 ± 0.9 eggs with a range of 1-5, one nest (2%) containing five eggs, thus suggesting the contribution of two females. Hatching success (i.e. the number of clutches which hatched at least one egg) was 97.7%, with only one nest (the first in 2013) being flooded by torrential rain during a spring storm with egg loss. Clutches were placed in all cases on a cup formed by the erosion of the top of the pole, measuring 6.5 ± 1.7 cm in depth and 19.2 ± 1.6 cm in diameter (Figure 2-4), at a height of 2.3 ± 0.7 m from the upper tidal limit. The distance of these nest sites from the nearest marsh island was on average 53 ± 58 m. In 46% of cases, adjacent marsh islands hosted substrates suitable for nest construction, such as sandy areas, bivalve shell mounds, and windrows, all of them being higher than the surrounding saltmarsh ground.

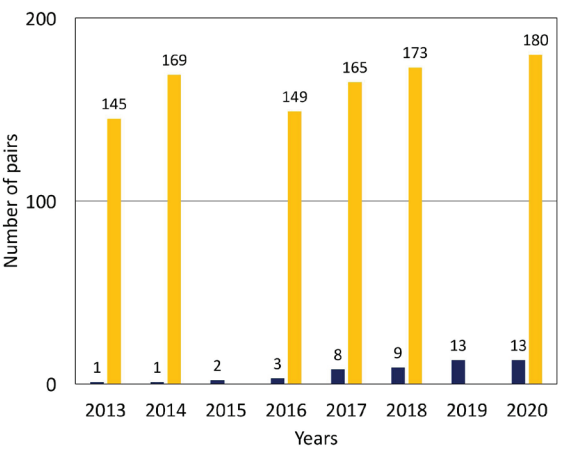

Figure 1. Number of Oystercatcher pairs nesting on pole tops (black bars) in comparison to the total population in the Lagoon of Venice in 2013-2020 (brown bars).

DISCUSSION

The main result of our work is the observation that Oystercatchers are increasingly adopting the pole tops as nesting sites in the Lagoon of Venice. This choice allowed a high hatching success, higher than

Figure 2. Drone view of an Oystercatcher clutch laid on a cup formed by rotten wood on a pole top. Lagoon of Venice, April 2017.

Figure 3. Oystercatcher incubating on a cup formed by erosion on a pole top. Lagoon of Venice. Photo: L. Sattin.

Figure 4. Typical Oystercatcher nest located on a pole top in the Lagoon of Venice.

previously reported for the northern Adriatic populations (Rusticali et al. 1999). This is particularly true for the population inhabiting the Lagoon of Venice, where flooding has been the overriding cause of breeding failure in the previous three decades (Valle et al. 1998 and *pers*. *obs*). It is plausible to hypothesise that this behaviour by Oystercatchers is an adaptive response to the increased frequency of extreme high tides in this period. The adoption of pole topes allowed the use of areas of the Lagoon otherwise unsuitable for nesting for Oystercatchers, i.e. marsh islands without high areas or bivalve shell mounds or windrows, albeit with abundant feeding areas. In the Lagoon of Venice, it is unlikely that pole tops were adopted by individuals born on pole tops in other sites along the Atlantic coast of Europe, because of the clear separation of the two populations and the reasonable attribution of Venetian breeders to the subspecies *longipes*, which has an Eastern distribution (Rusticali et al. 2002). More likely, this behaviour might have originated in the Lagoon from a few pairs, spreading then rapidly to other birds, as observed for the adoption of dredge islands as nesting sites (Valle & Scarton 1998), according to behaviour patterns widely described in the literature. Individuality is very important for the development of new behaviours in birds and, in turn, social conformity drives how individuals will adjust their behaviour in groups both at an intra- and interspecific level (Herbert-Read et al. 2013).

Since the whole population of the Lagoon of Venice expanded over the last ten years, and due to the known nesting site fidelity of the species in other areas (Van de Pol et al. 2006), it is tempting to assume that birds using poles are new breeder in the Lagoon and had never nested on dredge islands, saltmarsh sites or other sites before. In the Wadden Sea, an increase in the mean elevation of nest sites in the population of Oystercatchers was not due to individuals moving from previously used nesting sites, but to the settlement in higher sites, presumably safer from floods, of birds which had never nested before; in this sense, the species did not seem to show a phenotypic plasticity (Bailey et al. 2019).

In the Lagoon of Venice, the Oystercatcher nested in 1996 after about seventy years of absence (last previous records: saltmarshes in the northern lagoon, Ninni 1938). Dredge islands were the first sites to be occupied and saltmarsh islets started to be used only ten years later, despite the occurrence of tens of dredge islands still free of nesting pairs and apparently suitable (Valle & Scarton 1998). Next, oystercatchers started using pole tops and a few other elevated sites such as concrete platforms (*pers*. *obs*.). The Eurasian Oystercatcher is known for its flexibility in selecting breeding habitats, which may be sandy shores, pebble beaches, river mouths, and arable farmlands (Hockey et al. 2020). In addition, this species is reported using a wide variety of sites for nest location, including roofs, fence post tops, tree stumps, broken walls, and shallow hollows in trees to the point of colonising the roofs of inner-city houses (Paton et al. 1973; Reynolds et al. 2019, Fernández Cañero et al. 2010, see Duncan et al. 2001 for a review).

Unfortunately, we were unable to collect systematic data on fledging success, since chicks leave the nest shortly after hatching and swim to the nearest marsh islet, which is usually 10-20 m away (pers. obs.). Freshly hatched chicks are ready to swim for 50 m and more to reach nearby marsh islets, which are highly vegetated and thus offer the possibility of hiding (Fig. 5). Nevertheless, the greater the distance the chicks must swim in open waters, the greater their chance of being preyed upon by Yellow-legged Gulls *Larus michahellis*.

Figure 5. Freshly hatched chicks (note the egg tooth) swimming to reach marsh islets nearby, which are highly vegetated thus offering the possibility of hiding.

Nesting on pole tops could greatly increase the visibility of incubating Oystercatchers by Yellow-legged Gulls, their main nest predator in the Lagoon of Venice. Once gulls have learned that Oystercatchers are breeding on the *bricole*, they might be very selective and effective in predating these nests. This predatory behaviour can spread quickly in the gull population. Recently, Yellow-legged Gulls have quickly learnt to steal hot dogs and similar foods from the hands of tourists in Venice and this behaviour has quickly spread to the Venetian population with a rapidly increasing number of events (Coccon et al. 2022 and *pers*. *obs*). Nevertheless, the *bricole's* poles selected by Oystercatchers for breeding so far have always been far from Yellow-legged Gull colonies and it is known that Oystercatchers can effectively defend their brood from isolated Yellow-legged Gulls far from their colonies (Rusticali et al. 1999). It is also reasonable that this eventual disadvantage would be largely offset by the advantage of a lower risk of nest loss from tidal flooding.

Sea level rise is considered a critical threat to the survival of waterbird species nesting near water and just above sea level in various parts of the world. The Lagoon of Venice has the highest tidal range in the Mediterranean, about 1 m, sometimes higher due to meteorological factors (storm surges) (Zoccarato & Da Lio 2021). Salt marshes become flooded when tides exceed about 0.5 m, and their vegetation is submerged when the tides are higher than about 0.8 m (all the levels refer to the local datum). In the wetlands of the northwestern Adriatic coastline, this phenomenon has not only led to severe limitations in the reproductive success of Sandwich Terns (Valle & Scarton 2023), but also to the mere settlement of other species such as the Slender-billed Gull on the barrier islands of the Po delta (Valle et al. 2023). Sea level rise caused an abrupt decrease of Oystercatchers on the Po Delta barrier islands in the last decade because of the frequent flooding (pers. obs.), along with the abovementioned anthropic pressure (Rusticali et al. 1999). The impact of sea level rise is shared by other congener species of the Eurasian Oystercatcher. In Florida, extreme high tides are considered responsible for the numerical decline of the American Oystercatchers *Haematopus palliatus* in the wintering grounds (Griffin et al. 2023) and their reduced nesting success (Vitale et al. 2022).

The adaptive behaviour described in the Lagoon of Venice by this study is a good omen for the species at least in the short term. On the one hand, the good availability of pole tops suitable for nesting in the Lagoon allows breeding in areas otherwise unsuitable for nesting, due to the lack of sites safe from flooding. On the other hand, as a management strategy, the placement of artificial nests on pole tops is feasible and could be an easy and cheap way for the conservation of the breeding population of Oystercatchers in the Lagoon of Venice in the years to come, as the occurrence of extreme events will probably worsen.

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