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From a regional reintroduction project to a country-wide conservation approach: scaling up results to promote Osprey conservation in Italy

Andrea Sforzi[1,*], Giampiero Sammuri[2], Flavio Monti[1,3]

[1] *Maremma Natural History Museum - Strada Corsini 5, 58100 Grosseto, Italy*
[2] *Federparchi - Via Nazionale 230, 00184 Rome, Italy*
[3] *Department of Physical Sciences, Earth and Environment, University of Siena - Via Mattioli 4, 53100 Siena, Italy*
* *Corresponding author: direzione@museonaturalemaremma.it*

The Osprey *Pandion haliaetus* is a cosmopolitan raptor species that has evolved specialized physical characteristics and exhibits unique behaviour to assist in catching prey, consisting of live epipelagic fish only (Poole 2019). Despite its high specialization as a piscivore, it is an opportunistic forager that can feed in both freshwater and marine environments (Zwarts *et al*. 2009). Although most exclusively tree-nester in the vicinity of rivers and lakes in northern parts of Palearctic range, the Osprey chooses rocky cliffs or coastal wetlands for nesting in the Mediterranean area. The breeding season begins between February and April (according to the latitude of breeding areas): on average three eggs are laid, which hatch in May. Chicks fledge at the end of June or early July and migrate between August and October (Poole 1989).

During the 19th and early 20th centuries, the Osprey faced heavy direct persecution in many European countries that led to severe population declines (Poole 1989, Saurola 2005). Years of human persecution and egg-collection, together with a strong exploitation of coastal areas, have gradually brought to extinction this raptor as a breeding species in many countries including Italy, in the late '60ies (Brichetti & Fracasso 2003). Historical data prove that in the first half of the XX century Ospreys were nesting in Sardinia, Sicily and in the Tuscan Archipelago (Montecristo Island; Arrigoni degli Oddi 1929). More specifically, the last established nesting records date back to 1968 for Sicily (Egadi Islands) and 1968-1969 for Sardinia (Baunei coast) (Massa 1973, Thibault & Patrimonio 1992, Brichetti & Fracasso 2003). Since that time, and for over 40 years, the species was only recorded as migrant and/or wintering, with few cases of immature individuals observed during summer (Spina & Volponi 2008).

Osprey is a particularly protected species in Italy since 1977: registered in Appendix 1 of the ' Birds' Directive (2009/147/CE), listed in Annex 2 of the Berne Convention, included in Annex 2 of the Bonn Convention on the Conservation of Migratory Species (species in unfavorable conservation status, which requires the adoption of appropriate measures), included in Annex 2 of the Washington Convention on International Trade in Wildlife Species and wild flora threatened with extinction (CITES - species threatened with extinction, trade is prohibited inside and outside the European Union).

As a part of an international strategy aiming at the recovery of historical Osprey breeding sites, several reintroduction projects were carried out and/or are currently ongoing in different Mediterranean countries (e.g. Muriel *et al*. 2006, CIBIO 2011). Such reintroduction projects are also contributing to favour the connectivity between different release sites. During their dispersal, juvenile ospreys may in fact visit surrounding areas, so contributing to the success of the actions undertaken at local and regional scale. In this context, in 2004 the Parc Naturel Régional de Corse (FR) and the Maremma Regional Park (IT) started a common project to re-establish a nesting osprey population in Central Italy and to secure the future of the Corsican population (Sforzi 2004). During the first phase (2004-2005) 12 artificial nests (i.e., wooden platform on poles) were built along the Ombrone river banks, on the rocky cliffs North of Talamone village, within the Maremma Regional Park (MRP) and at four different sites in the extensive coastal wetland system of southern Tuscany (Monti *et al*. 2019). Nests were aimed at attracting migrating and/or dispersing individuals and encouraging their permanence during the breeding period. The following phase of the project be-

gan in 2006, with the first translocations of 5 to 6 weeks-old chicks collected from natural nests in western Corsica (Monti *et al*. 2014). The technique adopted (hacking) involves the release of chicks from donor populations (in our case only from Corsica) after a permanence period in a hacking tower, with cages normally suspended few meters above the ground level (Dennis & Dixon 2001). Due to the highly philopatric behaviour of the Ospreys, this technique will guide them back to the release area for nesting once the sexual maturity is reached (Triay & Siverio 2008). Between 2006 and 2010, 6 to 8 Corsican chicks were released every year, for a total of 33 individuals translocated (and 32 released). All birds were ringed with both a Euring and a coloured PVC-ring. All chicks were also equipped with a VHF transmitter, with the aim to monitor their local movements immediately after release and during the post-fledging dependence period (Monti *et al*. 2012). The constant evaluation of any reintroduction programme is extremely important for planning management and conservation strategies aimed at reducing post-fledging mortality and, ultimately, influence the successful establishment of adults over time (Armstrong & Seddon 2008). The settlement of the first breeding pair constitutes in this context an important milestone for the establishment of a new viable population and for the attraction of other individuals in the area.

In 2011, after >40 years from local extinction, Osprey started to breed again in Italy, in the same place where the reintroduction took place, in the Maremma Regional Park. The breeding pair was constituted of a male released in 2006 and a wild (unringed) female of unknown geographical origin, attracted on the nest by the presence of the territorial male. The pair settled on an artificial nest located in a marsh, 600 m far from the hacking site. In that year, 2 chicks were raised and successfully fledged. From 2013 onwards, all wild born juveniles plus 4 adults were captured and fitted with backpack-mounted 24-g solar-powered GPS/GSM devices (model Duck-4, Ecotone, Gdynia, Poland) or, alternatively with Ornitrack 25 units (Ornitela, Vilnius, LT). In 2014, a second pair settled and bred in the Diaccia Botrona Nature Reserve (a wetland located ca. 15 km North from the hacking site): the pair was made up of one of the two wild chicks born in the Maremma Regional park in 2011 and a female released in 2010 (hence of Corsican origins), the last year of translocation. In 2015, a third pair (both unringed adults, neither part of the translocated stock, nor offspring of the two breeding pairs of the project) joined the population and reproduced in the Diaccia Botrona Nature Reserve. In 2018, a fourth pair (an unringed male and a female ringed as a *pullus* by our team in Corsica in 2013), bred on an artificial nest, in the WWF Orbetello Nature Reserve (a coastal lagoon about 25 km in line of sight Southward from the hacking site). According to GPS-GSM data, this female reproduced for the first time at the age of 5 years. In 2019, a fifth pair settled in the Orti-Bottagone WWF Nature Reserve (a coastal wetland at 48 km in line of sight Northward from the hacking site, in the province of Livorno). This latter pair was made of an unringed male and a female born in 2016 (thus, breeding at 3 years old) in the Diaccia Botrona NR (Fig. 2).

It is known that the species exhibits semi-coloniality in some local populations and that the floaters tend to select vacant nest-sites preferably located in close proximity of already existing couples (Bretagnolle & Thibault 1993, Bretagnolle *et al*. 2008). Our data confirm the fundamental role of local established individuals for the attraction of floaters in dispersal from other populations and for giving information about the process of recruitment in a new established population. In synthesis, from the beginning of the project, the number of known pairs has progressively increased. Overall, 23 reproductive events were recorded, 64 eggs were laid, 45 of them hatched (70.31%) and 41 young successfully fledged between 2011 and 2019 (Figs. 1-2). Sex ratio of the chicks was biased in favour of males (65.6%). These data represent a first step towards a self-sustaining population. GPS-GSM transmitters allowed us to collect important spatial data, useful for conservation (e.g. migratory movements, wintering places, location and possible causes of mortality; Monti *et al*. 2018a). Overall, we recorded a high mortality (ca. 30%) of juveniles during their first year of life, especially during the first winter. Most of the mortality cases were associated to both direct and indirect human activities (Monti *et al*. 2018a). This suggests that in long-living raptors that reach sexual maturity at two years old and may need more than 5 years before became breeders, the process of recruitment in the breeding population might become a matter of concern. As a direct consequence, the population growth rate is normally slow and its range expansion requires a long time (Netwon 2003). Similarly, the reintroduction project of the Bearded vulture *Gypaetus barbatus* in the Italian Alps started in 1986, took 11 years before the first successful breeding in the wild occurred (in 1997) and other 9 years (in 2006) to reach 9 breeding pairs and a self-sustaining, viable population (Schaub *et al*. 2009).

Levering results at the national level

Despite the original objective of the Italian Osprey reintroduction project (i.e. re-establishing a fully self-sustainable breeding population inter-connected with the nearby Corsican breeding population) is not yet fully achieved, current achievements allow to foresee a gradual increase in the number of breeding pairs in Central Italy in the com-

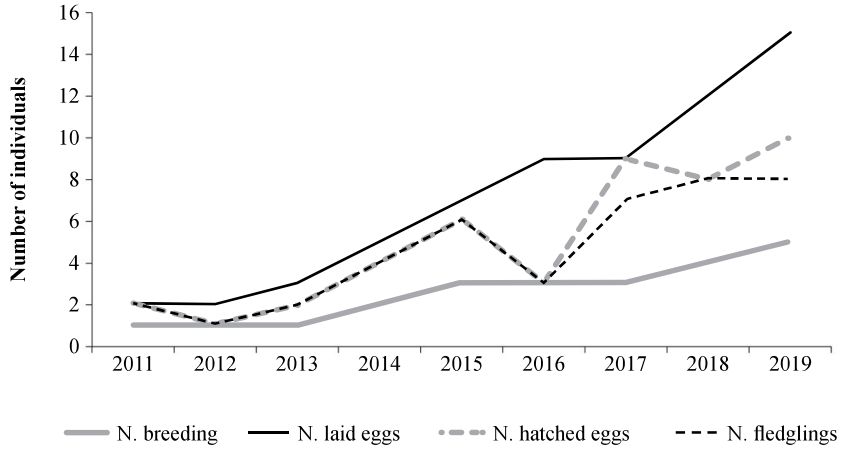

Figure 1. Trend of main demographic parameters of the osprey breeding population in Italy since 2011. Dashed line indicates the number of breeding events per year; black line represents the number of laid eggs per year, dotted line and point-dashed line are for the number of hatched eggs and the number of chicks fledged per year, respectively. Data are the cumulative figures of breeding pair parameters.

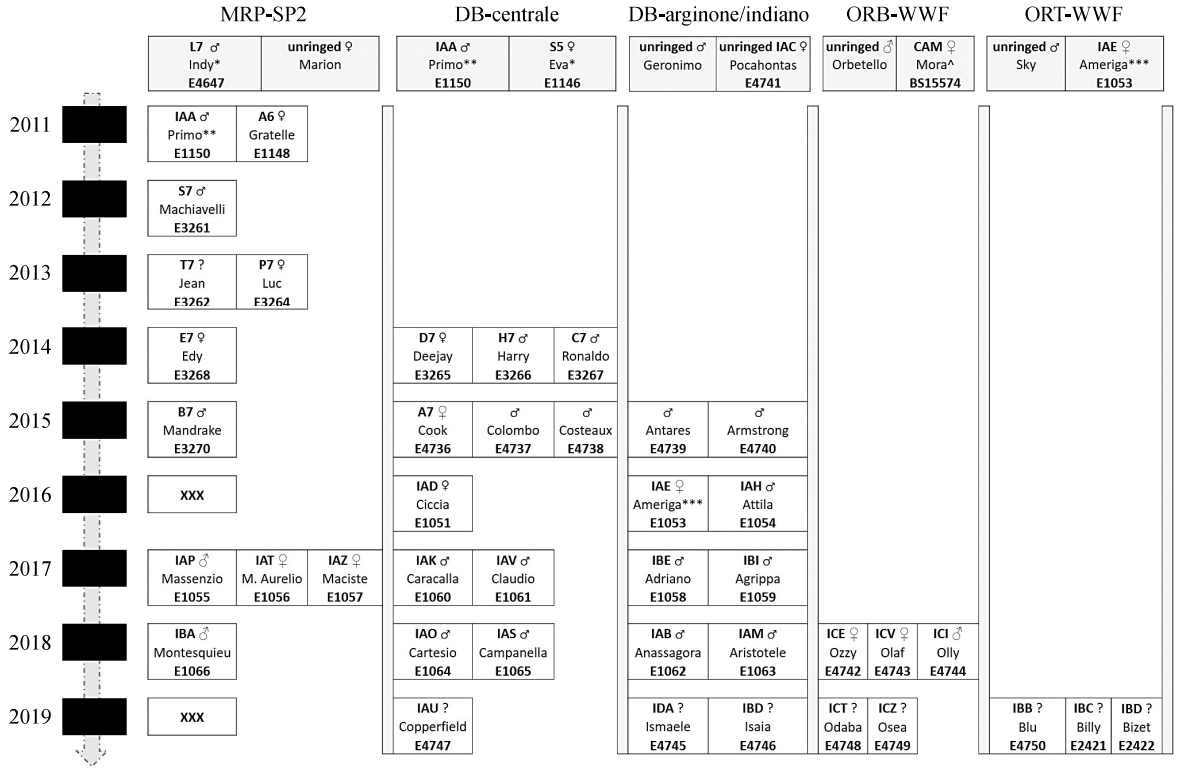

Figura 2. Family trees of the five breeding pairs between 2011 and 2019. In the grey and white boxes both the breeding adults and the fledged young are reported, respectively. The symbol ♂ is for male and ♀ for female. In bold the pvc-ring code (and/or the IAB Euring code). Names of the birds are also reported. Unringed birds of unknown origin are indicated with "unringed" (the bird IAC was originally unringed and then captured for ringing). The symbol * indicates birds that were translocated from Corsica between 2006 and 2010 in the framework of the reintroduction project. The symbol ** marks a juvenile individual born in 2011 that turned into a breeding adult in 2014. The symbol *** marks a juvenile individual born in 2016 that turned into a breeding adult in 2019. The symbol ^ is for a wild Corsican female who started to reproduce in Italy in 2018, while XXX represents a failed breeding event (eggs laid but not hatched). The symbol ? indicates that the sex of the bird was not determined or not available at the time of writing. MRP is for Maremma Regional Park, DB for Diaccia Botrona Natural Reserve, ORB for WWF Orbetello Nature Reserve and ORT for WWF Orti-Bottagone Nature Reserve. The grey arrow on the left represents the temporal line.

ing years. Our project currently envisages an active collaboration between various bodies: the Tuscan Archipelago National Park, the Tuscan Regional Government, the Maremma Regional Park, the Migliarino, San Rossore and Massaciuccoli Regional Park, the WWF Nature Reserves service and the Istituto Nazionale per la Protezione e la Ricerca Ambientale (ISPRA).

The seven islands included in the Tuscany Archipelago National Park are located in the midway between Corsica and Tuscany, thus playing an important role as 'stepping-stones', potentially facilitating connections between the two populations. As a consequence, these islands may play a crucial role for the future expansion of the species in the region (Monti *et al*. 2014). For this reason, between 2015 and 2019, a total of 9 artificial nests have been built in the area (2 located in Pianosa island, 4 in Montecristo island and 3 in Capraia island), with the aim to foster the colonization process and improve the connectivity between the Corsican and the Tuscan populations. The final aim of these conservation actions is to re-create a self-sustaining population, interlinking the two areas.

However, to secure a constant growth rate and long-term viability of the developing Italian Osprey population, management actions should not be geographically restricted only to coastal Tuscany. Remarkably, the studies we carried out on the dispersal and migratory movements of young Ospreys in Italy (Monti *et al*. 2018a) allow us to prove that the potential wintering sites include, at a different extent, all the areas that fell within the known historical range of the species (e.g. Sardinia, Sicily and northern Apulia), together with other relevant areas of central, southern and northern Italy). Therefore, all these areas play an essential role for the conservation of the species. Furthermore, we are actively collaborating with other realities in different Italian regions to perform coordinated conservation actions.

Since the beginning of our project, a growing number of Ospreys have been observed wintering in Tuscany, Sardinia and surrounding areas. This fact could be interpreted as a possible direct consequence of the increasing number of individuals that spent their time in the area and the major offer in terms of artificial nesting platforms, both outputs of our project activities. It is well known, in fact (Poole 1989) that the presence of resident Ospreys and nesting platforms facilitate the attraction of other individuals, potentially extending their permanence in a specific place. In some cases, we were asked to provide guidance for the building up of new nesting platforms in neighbouring areas, not included in our project area (e.g. Oristano coastal lakes and Lake Omodeo in Sardinia; Lesina Lake in northern Apulia). Along with these activities, other spontaneous local initiatives have been developed, bringing to the construction of further artificial nests (e.g. Porto Conte Regional Park and Alghero province, in Sardinia), hence multiplying the potential attractive effect of central-southern Italian territories. In some areas of past presence of breeding Ospreys, such as Sardinia, the regular presence of ospreys in winter has brought to hypothesise a further reintroduction project to establish a local breeding population (Fozzi *et al*. 2017). However, in the framework of our project, we were able to perform some genetic and geographical analyses on ospreys samples coming from Central Mediterranean (Italy, Corsica, Balearic Islands, Morocco) and compare these results with populations from northern Europe, as well as other areas (Monti *et al*. 2018b). The main finding proved that the Mediterranean osprey population are genetically distinguishable from the rest of Europe, and their migratory behaviour is quite different from that of populations living in other parts of Europe (Monti *et al*. 2018a, 2018b). The main implications of these finding are that the need of a reintroduction project should be carefully evaluated before starting (giving priority to other conservation actions, aimed at facilitating the natural recolonization of the species); in the case of a positive evaluation, the source population should be genetically and geographically close to the area of possible reintroduction (e.g. IUCN 2013).

In order to secure coordinated actions built on the features of the establishing Italian Osprey population, we advise that any future initiative concerning Osprey conservation in Italy be shared among working groups, taking advantage from the experience our group matured during over fifteen years of activity. The future of the Central Mediterranean Osprey population lays in the degree of openness and collaboration we will be able to achieve.

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