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Breeding population of Peregrine Falcon *(Falco peregrinus)* in Lazio, Central Italy: 1983–2017

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Abstract In 1983–1984 the nesting population of Peregrine Falcon *(Falco peregrinus)* in Lazio was estimated to 25–30 pairs located mainly in the limestone massifs of the Southern Anti-Apennines and the Ponziane Islands. The monitoring carried out in the following years showed a steady increase in population size and range. In 2014–2017, the breeding population was 166–193 pairs distributed over most of the regional territory. In four regional macro-geographic areas characterized by different morphologies, lithological and landscape typologies, the density was calculated by NND method, which varied from a minimum of 0.90 to a maximum of 1.77 pairs/100 km^2; average distance between sites from 3848.18 m to 6526.87 m. The urban population of Rome increased from the first nest found in 2001 to 15 currently breeding pairs; the first artificial nest was discovered in 2001 on the building, currently 14 are known. At present in Lazio 16 nests are located in quarries. In the years 2008, 2014, 2015 and 2016, the fledging rate registered was 2.26 (SD = 0.94; bp = 153).

Keywords: monitoring, estimate size, habitat selection, density, fledging rate

Összefoglalás A vándorsólyom *(Falco peregrinus)* költő populációjának méretét csak 25–30 párra becsülték 1983–1984-ben, melyek főleg az Anti-Appenninek Ponziane-szigeteinek (Dél-Lazio) mészkő masszívumain költöttek. Az ezt követő időszak rendszeres felmérései mind a populáció méretében, mind elterjedésében növekedést mutattak. A 2014–2017-es években már 166–193 párra becsülték az állományt, mely a teljes régióban elterjedté vált. Geomorfológiai, kőzettani és tipológiai szempontból elkülöníthető makro-geográfiai területeken a legközelebbi szomszéd távolság (NND) becslésével 0,9 és 1,77 pár/100 km^2 nagyságúra tehető a költő populáció sűrűsége. Az átlagos territóriumok közötti távolság 3848,18 és 6526,87 méter között változott. A Rómában fészkelő városi populáció mérete az első, 2001-ben megfigyelt fészek óta jelenleg 15 párból áll. Az átlagos kirepülési siker a 2008, 2014, 2015 és 2016 év adatait felhasználva 2,26 (SD = 0,94; bp = 153) fiókának adódott.

Kulcsszavak: monitoring, habitat szelekció, denzitás, kirepülési ráta

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Introduction

In the last thirty years in Italy, the Peregrine Falcon *(Falco peregrinus)* had increasing population size and a substantial expansion of its distribution range (Nardelli *et al*. 2015) as well as in Europe (BirdLife International 2015, 2017). In the early ’90s the population was estimated to 470–524 pairs, of which about half were distributed in Sicily and Sardinia, and the rest in the Italian Peninsula (Fasce & Fasce 1992). A decade later, 826-1048 pairs were recorded, doubling the population size and highlighting a strong expansion on the Apennines, the Alps and the Prealps (Allavena & Brunelli 2003). The most recent estimates, from non-systematic surveys throughout the country, point out a growing population of 1100–1400 pairs with a favourable conservation status (Nardelli *et al*. 2015, Gustin *et al*. 2016).

In Lazio, the breeding population of Peregrine Falcon has been constantly monitored since the early ’80s (SROPU 1987), hence it has been possible to accurately follow the evolution of distribution and population size to date.

In 2014, based on the proposal of the Regional Directorate of Lazio, a monitoring network was set up to survey the nesting populations of Peregrine Falcon together with other cliff-nesting raptors such as Golden Eagle *(Aquila chrysaetos)* and Lanner Falcon *(Falco biarmicus)* (Borlenghi *et al*. 2014).

In this study we summarize and compare the available data on widespread process recorded on Peregrine Falcon in Lazio in the period of 1983–2017. Furthermore, values were related to reproductive success and density are also presented.

Study area and methods

The surveys covered all areas suitable for the Peregrine Falcon in Lazio, a region extended 17,200 km^2 located in Central Italy, bounded by Tyrrhenian Sea in the west and by Apennine Mountains in east.

In this study we summarized and compared data available on the breeding population of Peregrine Falcon collected from five different surveys, 1982–83, 1993–95, 2003, 2008 and 2014–17 (SROPU 1987, Bassi & Brunelli 1995, Brunelli 2004, Aradis *et al*. 2012, Borlenghi *et al*. 2017). The observations have been registered from February to May, in the most favorable period for the detection of the species at the nesting sites. All the identified locations were geo-referenced and stored in a database containing 214 breeding sites. It included all the sites in which the species has nested at least once until 2008 or assumed to alternative site. We considered a territory being occupied if nest or pair in typical behaviour, courtship, brood or young were identified (Newton 1979, Ratcliffe 1993).

We calculated the species densities in four geographic macro-areas (northern and central high hilly landscape, Preapennines and central Apennines, southern Anti-Apennines and southern Apennines) and in seven units (Vicani, Reatini, Simbruini and Lepini Mountains, Rome urban area, hills of Lazio Volcano and Mount of Cairo) included in the last four *(Figure 1)*, using the Nearest Neighbour Distance (NND) method, counting only the active nests in 2014–2017 (n = 158). These macro-areas and units were well separated from each

other by different morphology or by sectors where the species has not been found; the coastal sites and those for which the nearest site was not known were excluded (Ratcliffe 1993).

We tested the correlation between the percentage of area of 17 landscapes identified in Lazio (APAT, 2003) and the percentage of breeding sites of Peregrine Falcon falling in the 17 landscapes by Spearman's coefficient (Rs); similarly we tested the percentage of nesting sites falling in six altitude classes (0–250, 251–500, 501–750, 751–1000, 1001–1250 and >1251 m asl.) and the percentage of regional altitude values subdivided. The latter was extract from a 40×40 m DEM (Digital Elevation Model) layer.

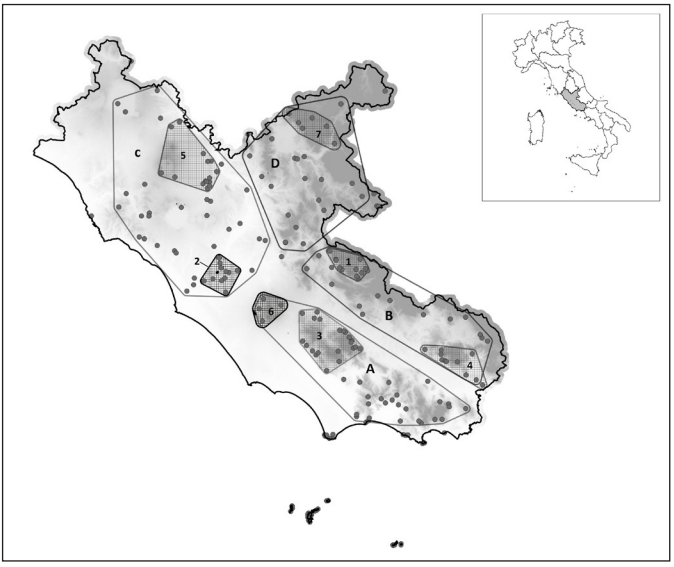

Figure 1. Study area in Lazio, with all the known Peregrine Falcon breeding sites, the four "Macro-geographic areas" and the seven "Landscape units" shown. The orography of region is depicted in shades of grey. See *Table1* for letters and numbers correspondence

1. ábra A vizsgált terület Lazioban, az összes ismert vándorsólyom költőhely, a négy „makro-földrajzi terület" és a hét „tájkép egység" között. A régió tagoltságát szürke árnyalatokkal ábrázoltuk. A betűk és számok jelentését lásd: *Table 1*

In the years 2008, 2014, 2015 and 2016 data on fledging rate were collected (fledged young/pairs) (Cheylan 1981, Ratcliffe 1993).

Results and Discussion

The first detailed data on size and distribution of Peregrine Falcon's breeding population in Lazio can be traced back to the years 1982–1983 when a population of 25–30 breeding pairs was estimated, mainly concentrated in the limestone chains of the southern and central Apennines and the Ponziane Islands (SROPU 1987). After that, the population grew up to 38–45 pairs in the years 1993–95 (Bassi & Brunelli 1995), 58–72 in 2003, with a new colonization of species in the central high hill landscape and north part of Region, with some pairs breeding in urban areas (Brunelli 2004). The estimated trend is shown in *Figure 2*, where the breeding population reaches 92–106 pairs in 2008 (Aradis *et al*. 2012) and 166–193 pairs in 2014–2017 (Borlenghi *et al*. 2017), almost uniformly distributed in all the study area except the north-west sector. In the whole period 1983–2017 the breeding population grew up of 575%, although an underestimate in the first survey (1983) could be possible. Comparing

all the breeding sites in the whole period (n = 214) with 17 regionally recognized landscape types it was detected that more of the half (63.5%) of the breeding population is concentrated in the "carbonatic mountains" (Apennine and Anti-Apennine chains, 46.7%) and "volcanic hilly landscape with planks" (Northern and central high hilly, 16.8%) landscape types; however this distribution does not related to greater extension of the last two types. In fact, there is no statistically significant correlation between the distribution of sites and landscape areas (Rs = 0.022; p = 0.570). Additionally, the species seems to select certain types of landscape beyond their representativeness on the Lazio territory, probably due to their morphology, lithological characteristics and trophic availability (Pezzarossa 2014–15).

The altimetric distribution of the reproductive sites emphasize a strong predominance of the areas up to 500 m a.s.l., where 62.6% of these areas were found. Also in this case, the distribution of the breeding sites in six classes of altitudes and the distribution of altitudes extracted from DEM grids are not statistically correlated (Rs = 0.020; p = 0.803): Peregrine Falcons in Lazio choose certain classes of altitude, mostly coastal and hilly.

In parallel with the increasing number of the breeding pairs, the discovery of nests placed on artificial substrates has become more frequent. In fact, no sites on these substrates were detected before 2001, while currently 30 sites are known (14% of total sites known), of which 14 on buildings (6.5%) and 16 in quarries (7.5%), the latter are mostly inactive. The increase recorded in the city of Rome and its surrounding areas was particularly significant. The first nesting pair was detected in 2002 and 15 pairs were found in 2017, of which 10 in continuous urban fabric, probably due to the huge abundance of wintering and breeding

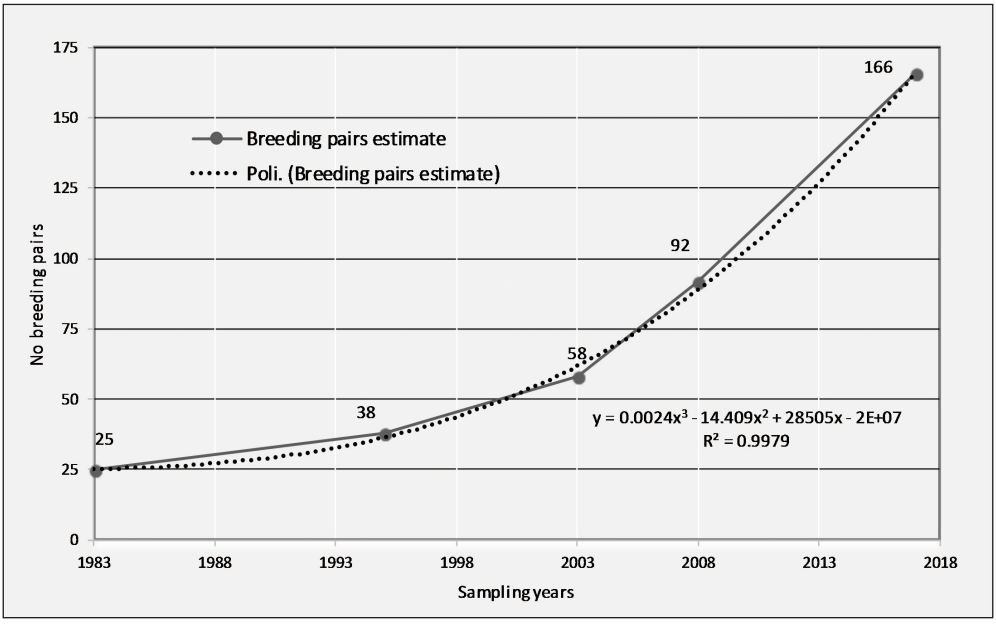

Figure 2. Trends of breeding population of Peregrine Falcon in Lazio in five surveys between 1983–2017 (min number of pairs)

2. ábra A vándorsólyom költőpopulációjának trendjei Lazioban, 5 felmérés során 1983 és 2017 között (párok min. száma)

Table 1. Peregrine Falcon densities in Lazio, subdivided in macro-geographic areas and in seven landscapes units. The table also pointed out the number of pairs, the unit area, the observed mean distance of breeding sites (Nearest Neighbour Distance) and the density value

1. táblázat A vándorsólyom denzitása Lazioban, makrogeográfiai területenként, illetve 7 tájegységben. A táblázat mutatja a párok számát az egységterületet, a költőterületek átlagos távolságát (NND) és a denzitás értékét

Geographical areas	No. pairs	Area km²	NND in m	Density pairs/100 km²
Macro-geographical areas				
A – Sourthern Anti-Apennines	46	2600.33	3848.18	1.77
B – Southern Apennines	33	2208.00	4202.97	1.49
C – Northern and Central high hilly landscape	55	4383.79	4243.26	1.25
D – Preapennines and Central Apennines	24	2680.73	6526.87	0.90
Total density in four macro-areas	158	11872.85	4705.32	1.35
Landscape units				
1 – Simbruini Mountains (Southern Apennines)	9	166.37	3025.20	5.41
2 – Rome urban area (hilly landscape)	10	200.57	3129.19	4.99
3 – Lepini Mountains (Southern Anti-Apennines)	18	520.58	2900.31	3.46
4 – Mount of Cairo (Southern Apennines)	10	299.25	4001.08	3.34
5 – Vicani Mountains (hilly landscape)	16	544.82	2875.57	2.94
6 – Hills of Lazio Volcano (Southern Anti-Apennines)	4	167.48	5982.00	2.39
7 – Reatini Mountains (Central Apennines)	6	267.58	5727.74	2.24

population of Starlings *(Sturnus vulgaris)* and Feral Pigeons *(Columba livia domestica)* (Cignini & Zapparoli 1996, Cignini 1998, Cecere *et al.* 2005).

Furthermore, *Table 1* shows the Peregrine Falcon densities in Lazio in four macro-geographic areas and in seven sub-geographic units. The densities of macro-geographic areas are similar to other Italian study areas, with values between 1.76 to 1.16 pairs/100 km² (Magrini *et al*. 2001, Pandolfi *et al*. 2004, Rizzoli *et al*. 2005, Brambilla *et al*. 2006, Mascara 2012), although lower values have been recorded as well as for example in the Western Alps between 0.55–0.56 pairs/100 km² (Bionda & Bordignon 2006, Beraudo & Toffoli 2009). Overall the macro-area densities show greater values from north-west to south-east and lower from coast toward the Apennines. A similar trend of densities at the level of the sub-units can also be detected *(Table 1)*, but all the values in these cases are higher due essentially to NND calculation method. In particular the density values of two areas it is necessary to underline: Simbruini Mountains and the city of Rome, both with the highest densities 5.41 and 4.99 pairs/100 km², respectively, probably due to the high availability of suitable sites for nesting and, in the case of Rome, also to the huge availability of trophic resources. It is known that particular favorable conditions for the species can increase more density values, such as comparison with Lake District (NW England) with 8.5 pairs/ 100 km² (Ratcliffe 1993).

Between 2008–2016, we have also collected data on reproductive success. We found 2.26 (SD = 0.94) young reared successfully by pair (bp = 153), consistent with other data available in Italy (cf. Brunelli 2007). In 2008 we registered the highest value of young/pair, 2.82 (SD = 0.94, bp = 22), with two pairs composed by five fledged young, a rather occasional event for this species (Ratcliffe 1993).

The considerable increase in the size and distribution of Peregrine Falcon in Lazio, as well as the values found in densities and reproductive success, would seem to depict the species in a favorable status of conservation.

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