

Long-term monitoring of the Peregrine Falcon *Falco peregrinus* nesting in the Furlo Gorge State Nature Reserve (Marches, central Italy)

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Abstract - The present study shows the results of the long-term monitoring of the Peregrine Falcon *Falco peregrinus* nesting in the Furlo Gorge State Nature Reserve located in the Marches region (central Italy). Monitoring took place between 1997-2022, when a minimum of 1 and a maximum of 3 breeding pairs nested within the protected area. During the study period, we identified 11 nesting sites used by the Peregrine Falcons that were located on cliffs with ledges and small niches, placed at an average height of 416 m (± 89 m) a.s.l. Over the study period, the breeding pairs laid a total of 69 eggs, with an annual mean of 2.34 per pair, raising a total of 61 chicks of which 57 fledged successfully. Breeding attempts always occurred in March (with a pronounced peak in the second week) and incubation period lasted on average 32 ± 1.60 days. During the 23 years of monitoring, the productivity rate was of 1.32 (n fledglings/n pairs), with a chick mortality of only 2.44% and a fledging success of 2.47 (fledglings/pairs with juveniles). This study highlights the Furlo Gorge as the second most important monitored breeding area for the Peregrine Falcon in the Marches region being the first one the Regional Park Gola della Rossa e di Frasassi (AN).

Keywords: Breeding biology, *Falco peregrinus*, Furlo Gorge, Marches, Nesting sites, Peregrine Falcon, Raptors

INTRODUCTION

The Peregrine Falcon *Falco peregrinus* nests in all regions of Italy, with the greatest uninterrupted presence in central and southern regions. The current distribution, when compared to that of the early 1980s, shows an expansion of its range in some areas, including on the Adriatic coast (Brichetti & Fracasso 2020). It is estimated that the current Italian breeding popu-

lation comprises between 1,789-2,078 pairs, with these numbers on the increase in all regions (Brunelli & Gustin 2021). The monitoring of the Peregrine Falcon population in the Marches region began in the 1970s (Perna et al. 2007) when the regional population reached 80-90 breeding pairs (Brunelli & Gustin 2021). Although its number has increased slightly in the last twenty years (Perna et al. 2007), the popula-

tion size would have grown further if we were to also consider the nine municipalities in the upper Marecchia Valley of the Marche region (known for hosting Peregrine Falcon breeding pairs) that instead were included in the neighbouring Emilia Romagna region (Brunelli & Gustin 2021, Pantalone et al. 2022).

At a regional level the species is considered to be sedentary-nesting, a regular migrant and an irregular winterer (Giacchini 2003), with an identical phenology in the province of Pesaro-Urbino (Pantalone et al. 2022) where individuals from northern areas can be found in the wintering period (Pandolfi & Giacchini 1995, Brunelli & Gustin 2021). In the Urbino Mountains the species has certainly been breeding since the 16th century giving rise to a flourishing falconry market (Felici 1982, Pandolfi & Zanazzaro 1993). In 1988 the species was reported to be nesting in the Metauro basin (Poggiani & Dionisi 1988) and currently, in the province of Pesaro Urbino, the Peregrine Falcon has certainly seen a discrete increase in its population. Indeed, in 1995 it counted only 6-8 pairs (Pandolfi & Giacchini 1995) while nowadays nesting sites are known to be spread throughout the mountain ridge and also along the coast (Giacchini 2019).

The best-known breeding site at a provincial level is represented by the 'Gola del Furlo' State Nature Reserve and this study aims to provide a contribution to the knowledge of breeding biology of the Peregrine Falcon in this protected area and in central Italy, over a significant time span (1997-2022) by monitoring the pairs present and their reproductive success, as well as characterising the individual nests used.

MATERIALS AND METHODS

Species and study area

With regard to the Peregrine Falcon in the province of Pesaro Urbino, in addition to the nominal subspecies (Baccetti et al. 2020), the presence of the ssp. *calidus* (vagrant) and particularly of the ssp. *brookei* (Giacchini 2019), has also been observed. The latter is considered a sedentary-nesting and regular migrant (Pantalone et al. 2022). However, the provincial territory is located on the clinal area of central-northern

Italy, where this sub-species and the nominal species overlap and merge (Brunelli & Gustin 2021). Over the course of the present study, all pairs observed in the Furlo Gorge presented morphological and phenotypic traits typical of ssp. *brookei* (Giacchini 2019).

The study area is sparsely inhabited and characterised by an extensive rocky gorge, on the Candigliano river (176 m a.s.l.), which divides Monte Paganuccio (976 m a.s.l.) from Monte Pietralata (888 m a.s.l.) (Provincia di Pesaro-Urbino 2014). At the beginning of the study, the study area was a Site of Community Importance (SCI); "IT5310016 Gola del Furlo" (according to the Habitats Directive 92/43/EEC), extending over 3.059 ha and included within the Special Protection Area (SPA) "IT5310029 Furlo" (according to the Birds Directive 79/409/EEC, replaced by Directive 2009/147/EC), with an extension of 4.945 ha (Fig. 1). In 2001, the 'Gola del Furlo' State Nature Reserve was established (protected area extending over 3.607 ha) and it included the territories of the municipalities of Acqualagna, Cagli, Fermignano, Fossombrone and Urbino (all in the province of Pesaro-Urbino). The protected territory is divided into two areas: zone A (fully protected) and zone B. The latter is, in turn, divided into two sub-zones, one of significant and the other of considerable naturalistic value (Province of Pesaro-Urbino 2014, Giacchini 2019).

The "Gola del Furlo" Reserve is characterised by overhanging limestone walls with various habitat types, distributed between 150 and 976 m a.s.l. The rocky environment is the richest and most important habitat in terms of vegetation, and includes deciduous holm-oak woodland (extending from the slopes up to 700 m a.s.l.) with Manna Ash *Fraxinus ornus*, European hop-hornbeam *Ostrya carpinifolia*, Downy Oak *Quercus pubescens* and Montpellier Maple *Acer monspessulanum* (Biondi et al. 2007b). At the forest level, in the Furlo Gorge, in addition to the two main formations mesophilous woods and beech forest (below the summit of Monte Paganuccio, above 700 m a.s.l.), there are also coniferous woods. The shrub woodlands and summit grasslands (an essential part of the Furlo landscape) are important hunt-

ing grounds for the Peregrine Falcon. The latter is particularly widespread in the Paganuccio which is characterised by flat areas (Biondi 2007a, 2007b) where numerous species of passerines use to nest (Giacchini 2019).

In terms of climate, the territory of the Furlo Gorge falls within the sub-Mediterranean bioclimatic plan. Average spring temperatures in the hilly areas reach

12-14° C, while in the same period the summit grasslands of Mount Paganuccio reach average values of 8-10° C. Similarly, in summer, maximum temperature values of 22-24° C and minimum values of 18-20° C are recorded in the hills and on Monte Paganuccio, respectively. In winter Monte Paganuccio and Pietralata are only slightly colder (3-4° C) than the hilly areas (4-6° C) (Biondi 2007b, Giacchini 2019).

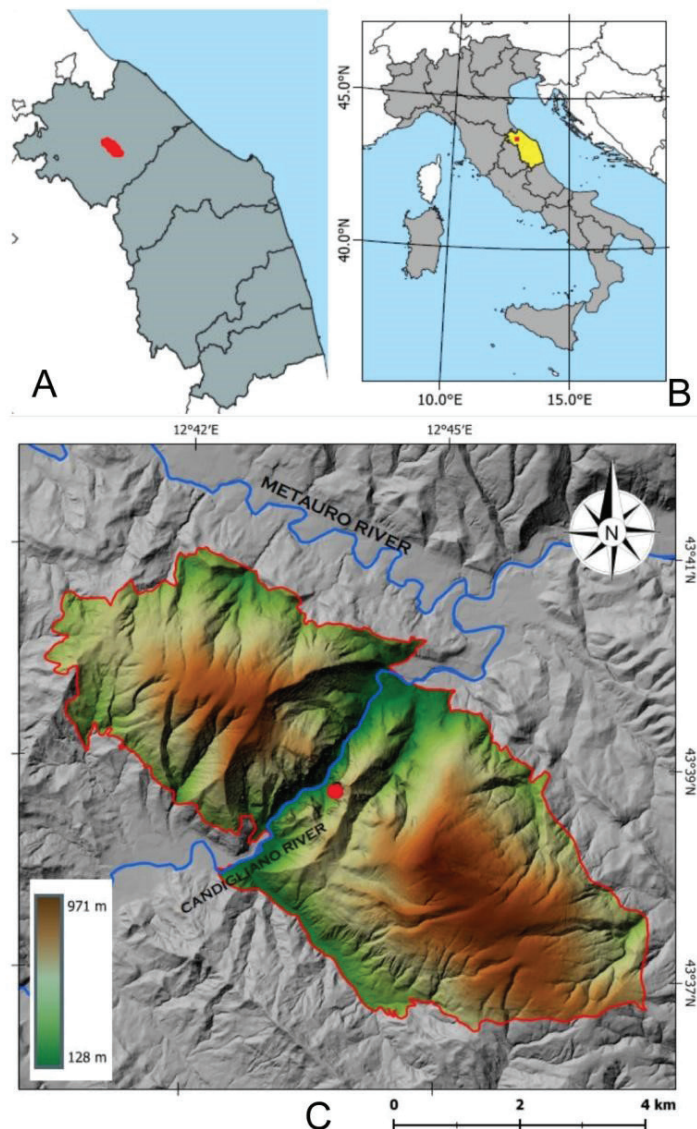


Figure 1. Study area and national framework of the Furlo Gorge reserve. The red dot indicates the location of the historical nest of the Golden Eagle *Aquila chrysaetos*, used as a reference for the location of the Peregrine Falcon nesting areas.

Monitoring of the nesting site

The data presented here were collected by means of non-standardised surveys, consisting of weekly (in many periods daily) continuous observations, throughout the year, from 1997 to 2022. About 3.200 days and over 15.000 hours were dedicated to the observations, which were carried out in all areas of the Furlo Gorge suitable for the nesting of the Peregrine Falcon. Stakeouts were used on facing walls, at a suitable distance and in places that allowed good camouflage, in order to avoid disturbing the species. For the observation, 8x42 and 10x42 binoculars were used, as well as spotting scopes with 20-60x80 magnifications, and using digiscoping. The Google Earth Pro programme was used to measure the height of the nesting sites from sea level (a.s.l.) and from the valley floor, with three-dimensional processing applied to the rock faces and ledges (3-5 m tolerance). Qualitative data describing the different microhabitat characteristics of the nesting sites were also recorded. Furthermore, the study area was divided in sub-areas taking as a central reference the historical nest of a pair of Golden Eagles *Aquila chrysaetos* (Giaccini 2019), whose immediate vicinity is scarcely frequented by Peregrine Falcons. Hence we divided the “Furlo Gorge” into three zones: the eastern sector of the gorge, the western sector and the sector outside the gorge. Each of the three different sectors are the territory of a different pair, with a maximum of three pairs monitored per year.

Different components of reproductive success, mortality rate, sex determination of chicks and prey items

Overall reproductive success was calculated as the ratio between the number of eggs laid and the number of years in which laying took place (eggs laid/years of laying). Fledging success was obtained by dividing the total number of individuals fledged in the study period by the number of pairs with juveniles in that same time frame (fledglings/pairs with nestlings). The percentage of chicks hatched and of successful fledglings were calculated in proportion to the number of laid

eggs multiplying by 100 (Whitlock & Schluter 2014). Chick mortality was calculated dividing the number of dead chicks by the total number of all chicks multiplied by 100 (Whitlock & Schluter 2014). Productivity in the “Furlo Gorge”, is the number of fledged birds in the study period divided by the total number of monitored breeding attempts (fledglings /breeding attempts).

Finally, it was possible to determine the sex of the chicks on the basis of the reversed sexual size dimorphism highly marked in the Peregrine Falcon. Indeed, female Peregrine Falcons are 40-50% larger than males (Scholz 1993, Ferguson-Less & Christie 2001, Forsman 2016, Mills et al. 2019, Schoenjahn et al. 2020). This difference in size is detectable when using the two parents as a means of comparison and is observable prior to fledging, when nestlings are between 35 and 40 days old (Olsen 1995, Hurley et al. 2007). Furthermore, sexual dimorphism continues to be detectable in the days immediately following fledging, when the young still remain in close proximity to the nest.

Although it was not possible to carry out a systematic monitoring of the diet, we recorded qualitative data identifying some prey items delivered to the nests during the chick-rearing stage. Finally, it should be noted that the observed falcons were not ringed therefore we did not know whether breeding mates of each pair were always the same individuals or whether and when they changed.

Constraints in nest content observation

The inaccessible and hidden location of some nests hamper our ability to determine the exact date of first laying and hatching in some years. Indeed, only the nesting sites A2 and A3 located in the reserve, enabled visual observation of their content. This difficulty was compounded by the closure of the road that crosses the Furlo Gorge between 2013 and 2016. This rendered observations in the eastern sector impossible and allowed only the western sector to be monitored (in which no egg laying took place in those years). Furthermore, the closure of an area of the re-

serve in 2019 and 2020, did not allow us to carry out the survey in the sector outside the gorge. These issues affected our dataset which lacks information on the laying date of a pair for a period of 4 years and of a second pair for 2 years.

RESULTS

Nests characteristics

We recorded 11 nesting sites used by the three breeding pairs of Peregrine Falcons (which did not necessarily nest every year) during the study period 1997-2022. Six of these nests were in the eastern sector of the gorge (nests A1, B1, C1, D1, E1 and F1), three were in the western sector (A2, B2 and C2) and two were in the area outside the gorge (A3 and B3). The nests in the eastern sector were used by historical pairs, those in the western sector by pairs that settled in 2006 and those outside the gorge by pairs that took possession of the area in 2017.

All nesting sites identified during this study are north-west facing, excluding a single site located on the northern cliff of the eastern sector, which faces east

and is the oldest nest in this study (A1). The nest sites were classified into three typologies: 36% (N=4) were located on terraces, wide rocky shelves on cliff walls (Fig. 2), 36% (N=4) were located on ledges, small flat protrusions on steep walls, and 27% (N=3) were located in niches, small recesses in the rock face (Tab. 1). An important observation concerns the presence of vegetation such as Holm Oak *Quercus ilex* trees near three nests (A2, C2 and B3). The pendulous branches of the tree seemed to protect the nest from harsh weather, direct sun illumination and heat. The average height of nesting site locations was 416 ± 89 m a.s.l. or 107 ± 55 m when considering the height from the valley floor below the walls used for nesting. The most frequently used nest site (D1) was used 6 times. This nest site was also used for several consecutive years (2006-2010) (Fig. 3). However, in some years falcons did not attempt to breed as in 1999 (the only pair in the protected area), or in 2010, 2011 (although mating was observed), 2012-2017 and 2019, always regarding only one of the pairs present.



Figure 2. Example of food delivery to the chicks (nest B1) in the Furlo Gorge, with a Common Starling *Sturnus vulgaris* as prey (taken in 2022).

Table 1. Microhabitat characteristics and height of Peregrine Falcon nesting sites in the Furlo Gorge recorded in the period 1997-2022

Nest/sector	Nesting site characteristics	Exposure	Height a.s.l. (m)	Height from the valley floor (m)
A1	Wide niche with ledge base	East	528	198
B1	Ledge	North-West	509	155
C1	Ledge	North-West	513	159
D1	Small terrace	North-West	430	76
E1	Ledge	North-West	490	136
F1	Niche	North-West	450	96
A2	Ledge with <i>Quercus ilex</i>	North-West	398	143
B2	Small terrace	North-West	335	80
C2	Small terrace with <i>Quercus ilex</i>	North-West	315	60
A3	Small terrace partly recessed into the wall	North-West	279	15
B3	Niche with <i>Quercus ilex</i>	North-West	330	66

Breeding phenology

In spite of the above-mentioned issues encountered during ten years of monitoring, 27 depositions were dated, all of which occurred exclusively in March (Fig. 4). The analysis showed that in 44.4% of cases the first egg was laid in the second week of March while 33.3% in the third week, 18.5% in the fourth week and only in 1 case (3.7%) in the first week. The earliest laying date was the 2nd of March (2019) and the latest was the 31st of March (2017). The mean number of laid eggs was 2.3 ± 0.9 (range 1-4). On average incubation lasted 32.0 ± 1.6 days (range: 28-35d, N=23). During the study period, the hatching date was recorded for 20 breeding attempts allowing to determine the duration of the mean chick-rearing stage that was of 39.8 d (\pm SD=2.4; range: 34-43 d; N=20). It was only in 2022, when the three breeding pairs managed to get the maximum fledgling success.

Three prey species were identified during chick-rearing: the Common Woodpigeon *Columba palumbus*, the Feral Pigeon *Columba livia domestica* and the Starling *Sturnus vulgaris* (Fig. 2). In addition, prey included small and medium-sized passerines such as the Golden Oriole *Oriolus oriolus*, and in one case, a predation attempt on Common Swift *Apus apus* was recorded.

Components of reproductive success

During the study period, a total of 69 eggs were laid with a hatching failure of 2.9% (N=2 eggs). 8.7% (N=6) of the eggs were either abandoned during hatching or damaged. The annual rate of laid eggs was 3.63 (N= 69 eggs/19 years), while the total number of chicks hatched was 61 (88.4% of laid eggs) and of these the total number of fledglings was 57 (82.6%, n. fledglings/laid eggs). Over a 23 year-long study period, the productivity of the pairs was 1.32 chicks, with a fledging rate of 2.47, (Tab. 2).

Furthermore, chick mortality was 2.44% (only 4 chicks died before fledging). During the period 2017-2022, thanks to the improved optical technology available, it was also possible to determine the sex of the 26 fledged chicks, of which 65% (N=17) were males and 35% (N=9) were females.

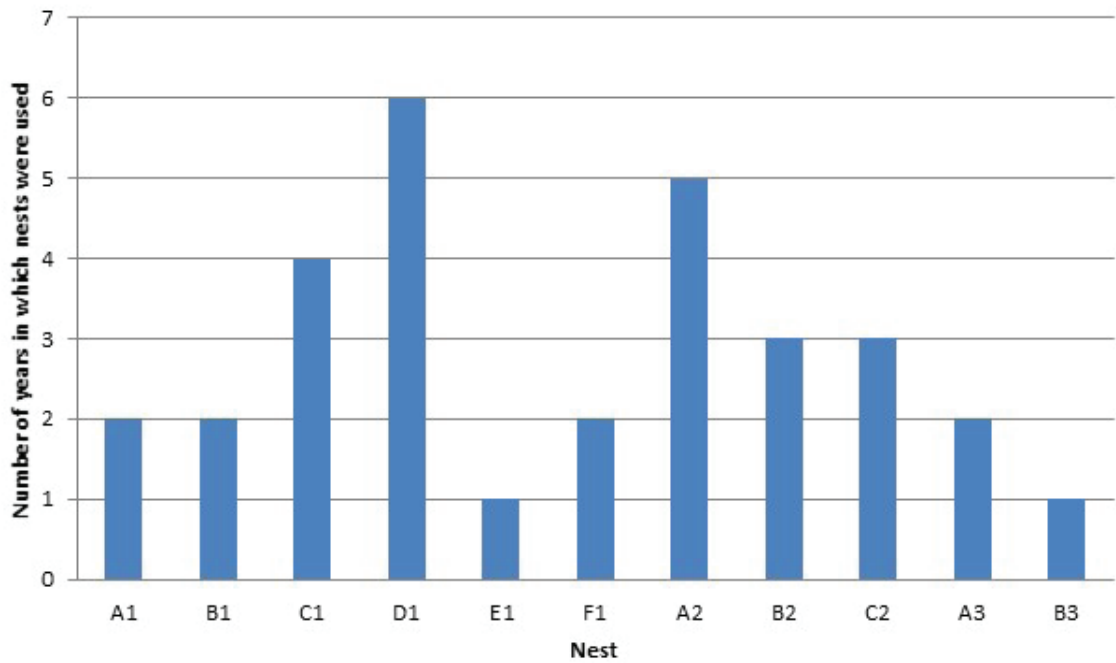


Figure 3. Number of years in which each nest site was occupied by a Peregrine Falcon pair in Furlo Gorge during the period 1997 -2022 (breeding pairs 1-3; breeding attempt =31).

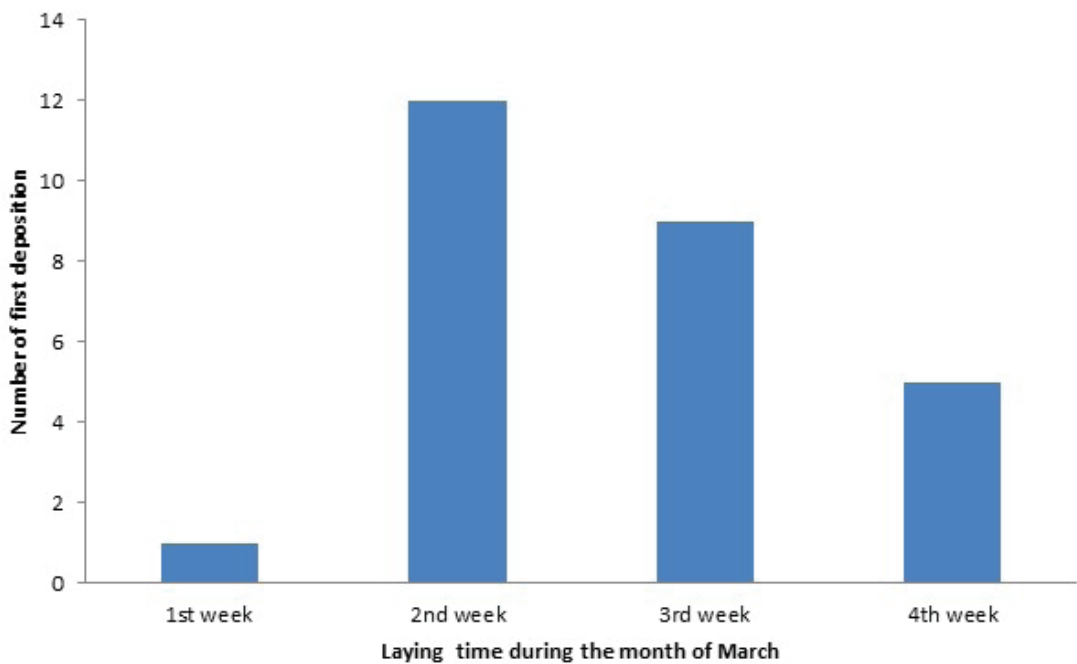


Figure 4. Distribution of Peregrine Falcons laying date within the month of March for the period 1997-2022. (Pairs number 1-3; Depositions number =27).

Table 2. Breeding performance of Peregrine Falcon during the period 1997-2022 in the Furlo Gorge.

Year	Eastern sector pairs		Western sector pairs		Sector outside the gorge pairs		Annual total number	
	Eggs	Fledglings	Eggs	Fledglings	Eggs	Fledglings	Eggs	Fledglings
1997	4	4					4	4
1998	3	0					3	0
1999	No nesting	0					0	0
2000	2	1					2	1
2001	3	3					3	3
2002	3	3					3	3
2003	No nesting	0					0	0
2004	2	0					2	0
2005	4	4					4	4
2006	No nesting	0	2	2			2	2
2007	No nesting	0	4	4			4	4
2008	No nesting	0	4	4			4	4
2009	No nesting	0	3	2			3	2
2010	No nesting	0	2	2			2	2
2011	No nesting	0	2	2			2	2
2012	No nesting	0	No nesting	0			0	0
2013	?*	?*	No nesting	0			0	0
2014	?*	?*	No nesting	0			0	0
2015	?*	?*	No nesting	0			0	0
2016	?*	?*	No nesting	0			0	0
2017	2	2	No nesting	0	1	1	3	3
2018	4	4	1	1	No nesting	0	5	5
2019	No nesting	0	3	0	?*	?*	3	0
2020	3	2	3	3	?*	?*	6	5
2021	No nesting	0	2	2	2	2	4	4
2022	3	3	3	3	4	3	10	9
Total mean	1.50	1.18	1.70	1.47	1.75	1.50		
Total							69	57

* (2013-2016 ban on access to the eastern sector for cars and pedestrians)

** (2019-2020 ban on access to the nesting area outside the Furlo Gorge).

“?” Data not available

Table 3. Comparison of Peregrine Falcon breeding performance between the present study and breeding pairs in other Italian provinces and regions.

Province e regioni	Years	Number of pairs	Productivity rate	Fledging success	References
Furlo Gorge	1997-2022	1-3	1.32	2.47	Current study
Regional Park "Gola della Rossa e di Frasassi"	1999-2001	5	No data	2.3	Angelini et al. 2003
Regional Park "Gola della Rossa e di Frasassi"	2007-2019	7-8	1.79	1.93	Brunelli & Gustin 2021
Rimini Province	No data	No data	1.75	2,47	"
Ravenna Province	No data	No data	2.07	2.50	"
Forlì Province	No data	No data	1.67	2.14~2.67	"
Umbria Region	No data	No data	No data	2.41	"
Tuscany Region	No data	No data	No data	2.62	"
Lazio Region	No data	No data	No data	2.09 ~ 2.82	"
Campania Region	No data	No data	2.2	No data	"
Sicily Recion	No data	No data	1.87	2.45	"
Valle d'Aosta Region	No data	No data	2.33	2.80	"

DISCUSSION

The present study brings the Gola del Furlo State Nature Reserve, with its three nesting pairs of Peregrine Falcon, to be the second area in the Marche region with information on the nesting of the species over a significant period of time (1997-2022), following the "Gola della Rossa e di Frasassi" Regional Park (AN), where continuous monitoring began in 1986 (Brunelli & Gustin 2021). The current study confirms the species' preference for using overhanging rocky walls with ledges and small niches for nesting in the natural environment (Brichetti & Fracasso 2003, 2020), with a predilection for sites that offer shade and shelter from the heat, likely provided by the presence of vegetation cover consisting of pendulous Holm Oak trees. Similarly, this research confirms the great fidelity of the pairs to the same nesting site, as it was not uncommon for them to reuse them for more than 10-20 years (Caula & Beraudo 2014). This study also made it possible to calculate the average height of the nests in the Furlo Gorge, which was 416 m a.s.l. and 107 m from the valley floor.

The laying data recorded at the Furlo Gorge peaked between the second and third weeks of March. This

period overlaps substantially with the laying period observed for the species in other areas within the Marche region (Brunelli & Gustin 2021) and in Italy (Brichetti & Fracasso 2020). The observed nesting failure of a second or third pair over a ten-year period, could be due to a partial overlap of their relatively small territories resulting in a growing competition for prey resources, with a consequent reduction in reproductive numbers (Giacchini 2019).

The mean number of laid eggs in our study sites (2.76 eggs) is also consistent with range of 2-4 laid eggs recorded for the species at national scale. Similarly, the average duration of incubation (32 days) as well as the chick-rearing period of 39.8 days are comparable to the periods of 28-33 days and 35-42 days respectively known for other populations in Italy (Cauli & Genero 2017). Our field observations seem to confirm the participation of both partners to the incubation duties with the female investing more compared to the male. With regard to the species' reproductive success during the period of the present study (Tab. 2), pair productivity was 1.32 chicks, with a fledging rate of 2.47, while the mortality rate was 2.44% (N=4 dead chicks). In the latter case, an

entire brood of 3 chicks died in 2019, possibly due to continuous cold and rain; conditions that often compromise reproduction (Anctil et al. 2014). Conversely, the Peregrine Falcon chick hatching rate was 2.47 for the Gola del Furlo, higher than rates recorded in the "Gola della Rossa e di Frasassi" Regional Park, both when there were 5 breeding pairs in the latter as well as in the period 2007-2019 when there were 7-8 (see Tab. 3). If, on the other hand, we also take other neighbouring provinces as a reference, the result is similar to that of Rimini and Ravenna, while if we consider regional data, the fledging success is slightly higher than that of neighbouring Umbria, but lower than that of Tuscany and Lazio (see Tab. 3). In the Urbino reserve, the level of productivity during the study period was 1.32, lower than that of the already mentioned Ancona regional park in the years 2007-2019 (Brunelli & Gustin 2021), which, however, has had eight breeding pairs since 2015. In this context, the result of the Furlo Gorge is also lower than that of the nearby provinces of Rimini and Ravenna, and is comparable with the few regions that have data on this subject (Tab. 3), such as Campania, Sicily and Valle d'Aosta (Brunelli & Gustin 2021).

During the study period, qualitative observations were also made on the prey delivered to the chicks, confirming Columbiformes (Fraissinet & De Rosa 2010) as the main prey group constituting the basic diet of Peregrine Falcon nestlings (Ranazzi & De Giacomo 2005).

Some of the most interesting data concerning the Peregrine Falcon in the Gola del Furlo relates to density which, in the period 1971-2002, ranged between 0.17~1.75 pairs per 100 Km² in Italy (Magrini et al. 2007), with 1.25 pairs/100 Km² in the Umbria-Marches Apennines (Magrini & Gambaro 1997). Consequently, it is of interest that there are now as many as three pairs of Peregrine Falcons nesting in an area as small as the one considered in this study, which additionally seems to have food resources suitable for bird of prey (Wood Pigeon, one of the six dominant species in the Furlo Gorge, Gustin et al. 2005).

Further the uniqueness of this breeding site for the Peregrine Falcon is highlighted by the reduced distance between the nests especially if we considered those two inside the gorge and therefore between two different pairs. Nests were separated by 1,400 m within the gorge, and just 800 m if the space separating the nesting sites in the eastern sector of the gorge and those outside it is considered. These are two of the shortest distances recorded for the Peregrine Falcon in inland Italian and Europe (Angelini et al. 2003).

The settlement of a third pair in the study area is most likely related to the establishment of the Gola del Furlo State Nature Reserve in 2001, which has led to an increased level of controls as well as to a reduction of disturbance to the species. This fact highlights the importance of protecting and managing areas to preserve biodiversity.

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