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Editorial

Italy at a turning point in its ecological research world (or not ?)

Something big is shaking up the Italian ecological research world. Aiming to foster the recovery from the economic crisis of the pandemic years, the European Union allocated an incredible amount of € 750 billion (MEF 2022) in favour of Italy. This is the main capital of the National Recovery and Resilience Plan (NRRP). Indeed, this astonishing incentive is a great news and represents an unprecedented opportunity to foster the modernization and advancement of our Country. A consistent part of this incentive is going to finance directly or indirectly both basic and applied research, including, of course, those in ecology and ornithology.

As scientists, we are used to being sceptical. So far, some doubts and worries must be raised on whether this money is effectively on the way to revolutionising Italian research, but at the same time, if possible, we must assume a positive attitude to contribute to optimising this process. Moreover, we must be conscious of the great responsibility that we are assuming spending this credit, indebting the future generations for the decades to come.

At least two of the different 'Missions' in which the NRRP is structured are of close interest to the community of researchers and conservationists that work in environmental and ecological fields: the so-called 'energetic ecological transition', and the direct contributions to research development.

Mission 2 of the NRRP is devoted to the ecological transition of Italy. In 2018, Italy had 5,600 wind farms, summing up a total capacity of 10,3 GW (Giannì & Benedetti 2019). But the energy production is at least planned to double by 2030. By this year, Italy must fulfil the legally binding objectives of the 'Fit for 55' EU plan (EU council 2022), thus reducing 55% of its greenhouse gas emissions. In practice, tens of thousands of wind turbines are about to populate our lands and, especially, our seas. It is beyond the aims of this Editorial to discuss whether this energetic strategy is or is not viable. I just want to stress that scientists are indeed worried about how the wide diffusion of wind farms may have deleterious consequences on biodiversity, with birds and bats among the most affected organisms (e.g. Serrano et al. 2020). I think that, as scientists, we should at least demand that professional ornithologists and zoologists are assigned to the proper roles as environmental impact evaluators. We should thus expect that the importance of our role will rise in the years to come.

These circumstances may help answer the question that many young people ask when they have to choose their academic careers. *'If I will be a field biologist, can I find a job?'*. My answer is always that *'The world really needs people like you!'*. And that's absolutely true. Not simply Italy, but the World urges field biologists, ornithologists, environmental experts and people that really understand what *biodiversity* is! These people are our only chance to successfully face the unprecedented challenges posed by climate change, energetic crisis, and ecological hecatomb. However, despite this urgency being obvious to me as well as to some other million people out there (e.g. 'Fridays for Future'), I always have to admit with young students that *'it's not easy to find a position with this specialization'*. Again, that's the (frustrating) truth.

Can the NRRP be the opportunity to change this?

Let's restrict the field of interest to research-related careers. Mission 4 of the NRRP promises to open 6,000 (yes, six thousand!) new PhD positions in the next months (MEF 2022) since the whole money must be spent within 2026. Of course, this sounds great: a revolution for the Italian academy! As a good sceptical scientist, however, I see here at least two orders of problems. First, the salary question. A PhD in Italy earns a monthly gross salary of € 1,353 (D.M. 247, 23-02-2022). This is often below the living costs of major cities. Not only can't you plan to have a family, but you could probably neither pay a flat rental with your income. Indeed, this a pressing problem well beyond Italy, as stressed in a recent Nature editorial (Nature 611:8, 2 Nov 2022). Wouldn't it be better to open fewer but better-paid positions? Second, what is occurring later on, after the PhD? Only a minor fraction of PhD graduates find employment in academia, in Italy. Most of them have no other option than to turn to non-academic jobs, a phenomenon called *segmentation* (Marini 2022). This is not necessarily bad: we live in a knowledge-based society which favours continuous growth in the mean education level, where PhD-holding people use their skills beyond academia (Hnatkova et al. 2022). But the point is whether the Italian research system is prepared to take profit from these new doctors and improve itself. At the current conditions, I would say not. The number of post-doc positions is risible compared to those of the PhDs, creating a bottleneck.

Potentially, NRRP may broaden this bottleneck. The most relevant case is the new-born National Biodiversity Future Centre (https://www.nbfc.it), entirely financed by NRRP. An ambitious infrastructure, coordinated by the National Research Council (CNR) and involving several universities, aimed to revolutionise the quality of biodiversity-related research in Italy. As mentioned above, this sounds wonderful. Literally, hundreds of post-doc and research positions are opening daily to fulfil the sudden need for biodiversity researchers in Italy. A few days ago, the University of Palermo opened in a single rush a call for 136 research positions (UNIPA 2022), almost unbelievable! Unfortunately, I'm not sure this will be an happy-ending story. Primarily, Italy has a structural, long-lasting and major debility in accepting foreign qualifications. Not only holders of extra-European degrees but even those that obtained their MSc or PhD in EU countries have to pass through a winding, time- consuming and costly procedure to get their degree recognised in Italy, frequently failing on the road. A problem that (as for PhDs) sums up to the low salary perceived by post-docs in Italy (mostly ranging from € 1,420 to € 1,650), especially when compared with those of other neighbouring countries (up to € 6,500 in Switzerland!). For these reasons, Italy is fatally poorly attractive to both foreign talents and talented Italians who graduated abroad! These problems are radicated in the Italian system and older than most of us can remember.

Sticking to the current NRRP, the MAIN criticism is that 100% of the new research positions are conceived to be *non*-permanent. One may argue that this was unavoidable. But that's not true. Somebody, at some point in the chain that organized the NRRP funds, decided that the creation of permanent positions was not a priority. Somebody that was in Italy. Indeed, other EU countries had radically different approaches. In Spain, as an example, the national correspondent to Italian NRRP include (objective C17. I4., 'New scientific Careers') early stabilisation of research personnel as a primary target and announced the introduction of a tenure track career model (MCINN 2022). We could have done the same in Italy too. Maintaining for long years researchers in non-permanent positions is not only a wicked but also a dumb strategy. Researchers with permanent positions feel better (Castellacci & Viñas-Bardolet 2021), produce more (e.g. Lafuente & Berbegal-Mirabent 2019; Cirillo & Ricci 2022) and, moreover, work to attract new funds and projects. Hiring permanent researchers today means funding basic research (and of higher quality!) for the years to come. On the contrary, creating hundreds of temporary positions today will produce frustration and a stock of super-trained but; soon unemployed, researchers. This is a drama that we must expose as scientists, pressuring politics to significantly increase the proportion of permanent personnel of our research system, while making it more attractive to foreign talents. In this sense, the deep 'architecture' of the NRRP looks like a lost opportunity.

Even so, I want to see the cup as being half full. Hundreds, probably thousands, of researchers out there are conscious of all the abovementioned problems and will work during and beyond these 'NRRP years' keeping in mind that we are facing an unprecedented opportunity, possibly representing a turning point for our research system.

I can firmly state that this is happening at least in the field that I better know, ornithology. I'm proud to announce here that many of us are involved in organising the next Italian Ornithological Congress (https://www.cio2023varese.it/en/home/), which will see its XXI edition in September 2023. For the first time, the conference will be entirely bi-lingual, aiming to strengthen the connections of the Italian ornithological community with the EU ones. We have already received contributions from at least five more countries. A great success for a national conference! Up to the 31st of March, there is time to submit your abstract, we are looking forward to receiving your contribution as well.

If politics would pay more attention to the voice of researchers, I'm sure that we could still make the most out of these NRRP funds. We have a few years to do so, starting… yesterday. So, back to work, having in mind that we want a world in which eventually revise the recommendation to pupils and state a warm '*Of course, study as a field biologist and get your PhD, is a promising career!*'

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Diet and foraging ecology of the Hoopoe *Upupa epops* in a Mediterranean area of Central Italy

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Abstract - During the breeding season, the Hoopoe *Upupa epops* inhabits traditional and diversified rural habitats with high availability of bare ground and short grass areas where it forages. Only a few studies addressed the breeding diet of this species. Most of them were conducted in the intensively cultivated plains of southern Switzerland, where *Gryllotalpa gryllotalpa* represents the most common prey. In contrast, limited information is available for Mediterranean habitats. To fill this knowledge gap, we investigated the foraging behaviour of the species in a Mediterranean heterogeneous agricultural area in Central Italy during the 2020-2021 breeding seasons. 1123 prey items brought to the nest by adults were identified using camera traps positioned near four natural nests. Insect larvae constitute 84% of the diet, of which 61% are represented by *Cicada orni* nymphs. The importance of cicadas in the Hoopoe diet has been never described in the literature before. *C. orni* seems to substitute *G. gryllotalpa* in the more arid and hard soil of Mediterranean areas. The observed provisioning rate to clutches showed a maximum daily mean of over 14 prey per hour. To investigate Hoopoe foraging microhabitat selection, six different microhabitat variables were measured at 64 1 m^2 plots located at an equal number of foraging and random control points, by using a grid of 100 squares (10x10 cm each). Habitat selection analysis indicates that short herbaceous sward and low herbaceous cover are the fundamental factors driving foraging microhabitat selection. Our study contributed to enhancing the limited knowledge of the Hoopoe diet and foraging ecology in Mediterranean habitats and demonstrates, for the first time, the importance of *Cicada orni* nymphs in the diet of the species in this biogeographical region.

Keywords: nestling diet, trophic ecology, *Cicada orni*, provisioning rate, foraging habitat selection.
Short title: Hoopoe foraging ecology

INTRODUCTION

In Italy, the Hoopoe *Upupa epops* is a regular breeder, migrant and sometimes winterer species (Bricchetti & Fracasso 2015, Baccetti et al. 2020). Landscapes modelled by low-intensive and traditional anthropogenic activities (i.e. extensive animal husbandry and low-intensive agriculture) are often favoured by Hoopoes (Martín-Vivaldi et al. 2016). In fact, during the breeding period, Hoopoes favour open countryside with scattered trees such as pastures, parkland, fruit orchards, heathland, olive groves or vineyards (Krištín & Kirwan 2020). The species avoids closed forests, especially coniferous ones, and favours landscape and local habitat heterogeneity (Barbaro et al. 2007, Schaub et al. 2010). Old traditional olive groves are important nesting habitats for the species in the

Mediterranean, as the thick trunks of these trees are plenty of cavities (Martín-Vivaldi et al. 2016). Indeed, this species strongly depend on suitably sized cavities for nesting (Martín-Vivaldi et al. 2016), although it was reported to have great versatility in using different types of holes, whether in trees, buildings, walls, heaps of stones, and nest boxes. Bare or sparsely vegetated land such as grasslands, forest clearings, field margins, or roadsides presenting short and sparse herbaceous swards are the preferred foraging places (Barbaro et al. 2007, Tagmann-Ioset & Arlettaz 2007, Schaub et al. 2010). This bird species mostly forages on large terrestrial insects (Krištín 2001). Prey items are captured with the long beak after being located under the ground or stones (Cramp 1985, Krištín 2001). Most of the few studies on the nestling diet of this species were carried out in the cultivated plains of Switzerland (Fournier & Arlettaz 2001, Schaad 2002, Duplain et al. 2015, Guillod et al. 2016) where Mole cricket (*Gryllotalpa gryllotalpa*) represents the main prey in term of biomass provided to nestlings. In contrast, in the Veronese Prealps and the Euganean Hills (N Italy) and south-western France, the Lepidopteran *Thaumetopoea pityocampa* pupae are the main prey items in pine plantations (Battisti 1986, Battisti et al. 2000, Barbaro et al. 2007); observations of predation on this insect were also recorded in Spain (Stefanescu 1997).

The Hoopoe has experienced a long-term decline, especially in central and eastern Europe, including northern Switzerland (Arlettaz et al. 2010b, Barbaro 2020) as well as Italy where its decline has been considered moderate in the last 20 years (Rete Rurale Nazionale & Lipu 2021). The main threats to the species are represented by agricultural intensification and urbanization, which trigger widespread habitat loss (Barbaro 2020). The removal of old rotting trees in farmland causes the loss of suitable nesting sites (Arlettaz et al. 2010a) and the use of insecticides could even lead to local extinctions if invertebrate prey strongly reduces (Martín-Vivaldi et al. 2016). Climate change may lead to lower reproductive success, especially during cold and rainy springs (Arlettaz et al. 2010a). The population fluctuations attributed to climate change seem to be more pronounced in Middle Europe than in Mediterranean populations (Cramp 1985).

Considering the limited information about the Hoopoe diet and foraging ecology in southern Europe, and the likely conservation relevance of this information, we decided to address these topics in the Mediterranean biogeographical region, working in a heterogeneous rural landscape of Central Italy. Specifically, we investigated two aspects: i) the nestling diet and the adult provisioning rate to nestlings, which were assessed working on natural nests; and ii) the foraging microhabitat selection of provisioning adults.

MATERIALS AND METHODS

Study area

The study was performed in Castel di Guido, near Rome (Central Italy), within the National Natural Reserve of the Roman Coast, 21-86 m above sea level (Fig. 1). Castel di Guido Farm is managed by Rome Municipality since 1978 and produces mainly cereals but also bovine dairy products and meat. Animals are raised both in enclosures and in the wild (Pizzuti Piccoli et al. 2019). The area is bioclimatically part of the transitional Mediterranean region (Blasi 1994). The study area is characterized by a great diversity of vegetation communities and extends for 1966 ha. According to the data provided by the Farm in 1999, 17% of the area (366 ha) is occupied by crops of durum wheat, corn, barley, olive groves, and alfa-alfa, 22% by natural forests (430 ha) with oak prevalence, 22% by pastures, 28% by pine plantations and reforestation areas, and the remaining part of the territory is occupied by roads, rural buildings, stables, irrigation channels, and other artificial infrastructures (Filesi 2001, Bartolucci & De Lorenzis 2004). The land cover of the study area remained quite stable in the last decades.

Nest survey

During the breeding seasons 2020-2021 (between

April and August), to study the nestling diet and provisioning rate, natural nests were searched within the study area. Adult movements toward suitable sites, such as tree rows, olives groves, isolated mature trees and agricultural buildings were investigated through direct observations using binoculars and telescopes. To increase nesting site availability and therein the survey sample, in early 2020, 22 wood handmade nest boxes were installed on trees or rural buildings within two meters of height, near farmhouses, tree rows or crops, and open areas such as pastures (Fig. 1). The entrance hole of the nest boxes was 6.5 cm and the internal space was 18 x 20 x 45 cm.

Nestling diet and provisioning rate

Camera traps with motion sensors were placed in front of the entrance of four natural nests. The cameras have been set to produce ten-second-long movies with 1920x1080 (Full HD 1080p) resolution and a motion detection interval of 15 seconds. Cameras were active from mid-May to mid-July 2020-2021. This video material was used to taxonomically identify the prey supplied to the chicks from the first days of life to the last days before the flight and to determine their relative frequency. Prey has been identified mainly at the Order and sometimes Family level, descending in some cases to hierarchical levels less inclusive when the video quality allowed it.

To determine the nestling diet, 9,172 videos were processed. 1,123 were selected for prey identification while movies in which the prey was not easily visible in the parent beak were discarded (87.76%). The video material was collected during 69 different days covering two years and relative to all the nests.

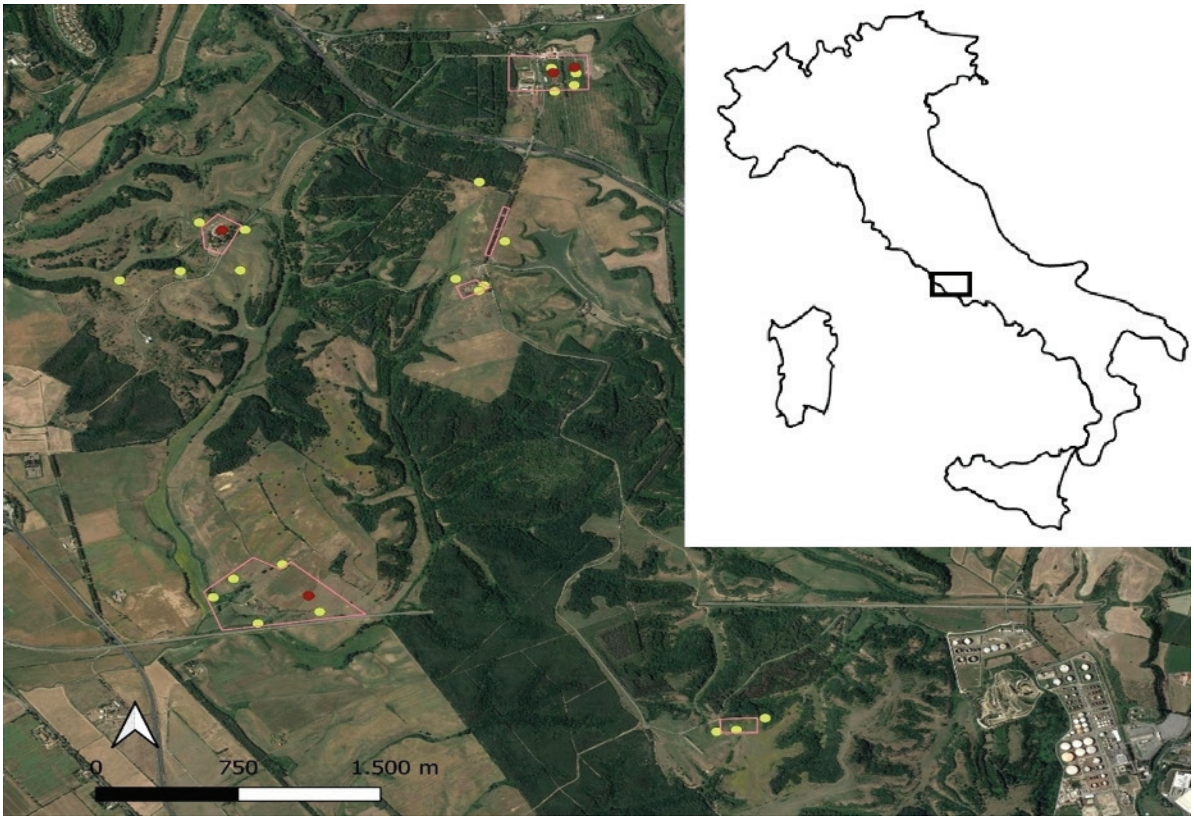

Figure 1. Location of the study area and position of Hoopoe *Upupa epops* natural and artificial breeding sites within the study area. In the inset is shown the location of the study area (rectangle) in Italy. Red points in the main map represent natural breeding sites, yellow points nest boxes, and pink polygons the areas within which foraging plots were located. Base map: orthophoto © 2020 Google.

Furthermore, through the videos recorded by the camera traps, it was also possible to estimate the provisioning rate (i.e., the number of prey items brought to the nest in an hour). Considering that the Hoopoe carries only one prey at a time to the nest, each movie of an adult carrying a prey (identifiable or not) to the nest was counted as one prey. The estimation of the provisioning rate was measured at three nests (N1, N2, N3) until the last chick flew, starting in N1 from the third day since the deposition of the first egg, or the 11th (N2) and 13th (N3) day of age of the first chick. The video material to estimate the provisioning rate was collected during 81 different days covering the two years of the study and relative to the three nests.

Foraging microhabitat selection

To investigate foraging microhabitat selection, six microhabitat variables were measured at 32 1 m^2 plots placed on the ground where the Hoopoes were seen foraging during the breeding period (from March to August 2021). These plots were mostly located around active nests and at several other potentially suitable areas (Fig. 1). We chose the microhabitat variables according to a comprehensive study on the Hoopoe habitat selection (Barbaro et al. 2007) and hypothesized which were the microhabitat characteristics that could influence the prey density and their accessibility in our study area. The microhabitat variables measured within the plots were: (1) bare soil percentage cover, (2) herbaceous vegetation height, (3) biological debris (dead wood, leaves and other organic material) percentage cover, (4) herbaceous vegetation percentage cover, (5) tree and shrub vegetation percentage cover, and (6) pebble percentage cover. The percentage cover of each variable was measured with the help of a grid consisting of 100 squares (10x10 cm each) centred at the point where the adult extracted prey or probed the soil with its beak. In addition, the same variables were measured at an equal number of control plots of equal size, selected 25 m away from each foraging point, in a randomly chosen direction. Microhabitat selection analysis was performed using Generalized Linear Models (GLM) with a binomial error distribution and a logit link. The plot type (1: foraging; 0: control) was entered into the model as a binomial response variable. We used Pearson's correlation coefficient (R *cor.test* function) to assess predictor correlation and reduce multicollinearity issues. Bare soil and biological debris cover resulted to be significantly negatively correlated with herbaceous vegetation height and cover (Tab. 3) and were thus removed from the statistical analysis to avoid multicollinearity issues. Model selection was conducted using a stepwise approach using the AIC through the R function *stepAIC* in the *MASS* package (Venables & Ripley 2002). All the analyses were performed using R version 4.1.2 (R Development Core Team 2021).

RESULTS

Four different natural Hoopoe nests were found during the two study years (Fig. 1). Two nests were found in tree cavities located within one meter from the ground and two were in root splits at the ground level. Only one successful brood per nest was raised during each season. On average, nestlings fledged within 30 days of age. None of the 22 installed nest boxes was occupied by the Hoopoe, while they were occupied by Starlings *Sturnus vulgaris* (13.6%) and Great Tits *Parus major* (4.5%), as well as by several Hymenoptera species.

Nestling diet and provisioning rate

The nestling diet consisted of Insecta (93.7%), Arachnida (3.9%), Clitellata (0.3%), Malacostraca (0.2%), Chilopoda (0.1%), Reptilia (0.1%), and unidentified prey (1.7%). The larvae constituted a large part of the prey items (84.2%) and they were mainly represented by *Cicada orni* (61.4%). The Cicada's nymph number ranges from a minimum of 2.25% in an early brood that ended at the beginning of June, when the natural availability of these nymphs is low, to a maximum of 88.7% in a brood concluded at the end of the same month. The remaining larvae (22.8%) were Lepidoptera, Diptera, Coleoptera, and other unidentified insects. The insects preyed upon in the imago phase were Coleoptera (8.2%) and Orthoptera (1.2%), with only one Mole cricket detected. All the Arachnida were spiders. 15.5% of Insect larvae were not identified at a lower taxonomic level due to low video quality. Table 1 summarizes the data collected on the four reproductive sites for the breeding seasons 2020-2021.

The average provisioning rate during incubation was 5.4 prey/h (minimum 3.7 on the first and ninth incubation days; maximum 8.3 on the eleventh day). Food provisioning average frequency was 6.35 prey/h in N1 (minimum 0.9 at day 30 of age; maximum 13.1 at day 9), 9 prey/h in N2 (minimum 0.3 at day 30 of age; maximum 14.4 at day 15), and 8.33 prey/h in N3 (minimum 0.1 at day 30 of age; maximum 13.2 at day 19). To grow a brood of five chicks (of which three fledged), we estimated a total of 3047 prey items were brought to the nest in thirty-one days (N1), with a maximum of 197 prey/day (N1), 216 (N2), and 198 (N3). In N2 and N3, it was not possible to obtain data on the provisioning rate for the full period of incubation and chick growth, because of technical problems with the camera traps (Fig. 2).

Table 1. Hoopoe nestling diet in Castel di Guido (Rome, Italy). We reported the absolute number (N) and relative percentage (%) of prey items provided to nestlings. Data refer to 69 different sampling days at four nests during the breeding seasons 2020-2021.

Taxon	N	%
Hemiptera		
Cicada orni (nymphs)	689	61.4
Unidentified Insect larvae	174	15.5
Lepidoptera (larvae)	34	3.0
Coleoptera (imago)	92	8.2
Coleoptera (larvae)	21	1.9
Scarabaeidae (larvae)	5	0.4
Diptera (larvae)	5	0.4
Tipulidae (larvae)	17	1.6
Orthoptera	14	1.2
Gryllotalpa gryllotalpa	1	0.1
Araneae	44	3.9
Clitellata	4	0.3
Malacostraca	2	0.2
Chilopoda	1	0.1
Lacertilia	1	0.1
Unidentified prey	19	1.7
Total prey	1123	100

Foraging microhabitat selection

Foraging plots were characterized by a shorter herbaceous sward, a lower herbaceous vegetation cover and absence of trees and shrubs, and a higher cover of bare ground, pebbles, and biological debris compared to random plots (Tab. 2).

Herbaceous vegetation height and cover were the only statistically significant variables according to the parsimonious binomial GLM (Tab. 4). The other variables were excluded from the backward stepwise selection or resulted to be non-significant (Tab. 4).

DISCUSSION

Our work represents the first study on the Hoopoe diet in a heterogeneous agricultural Mediterranean landscape during the breeding season and the results indicate that *C. orni* is a very important food resource in this habitat, comparable to the Mole cricket in the Swiss intensive agroecosystems, where it represents the main prey provided to nestlings in term of biomass (Fournier & Arlettaz 2001). Our results showed that over 61% of the nestling diet consisted of nymphs

Table 2. Microhabitat variable mean values ± SD at foraging and control plots.

Microhabitat variables	Foraging plot	Control plot
Bare soil cover (%)	36 ± 25	5.4 ± 11
Herbaceous vegetation height (cm)	6.64 ± 3.55	57.0 ± 46.4
Biological debris cover (%)	29 ± 35	16 ± 27
Herbaceous vegetation cover (%)	35 ± 28	73 ± 34
Tree and shrub vegetation cover (%)	0 ± 0	6 ± 21
Pebble cover (%)	7 ± 16	0.3 ± 1

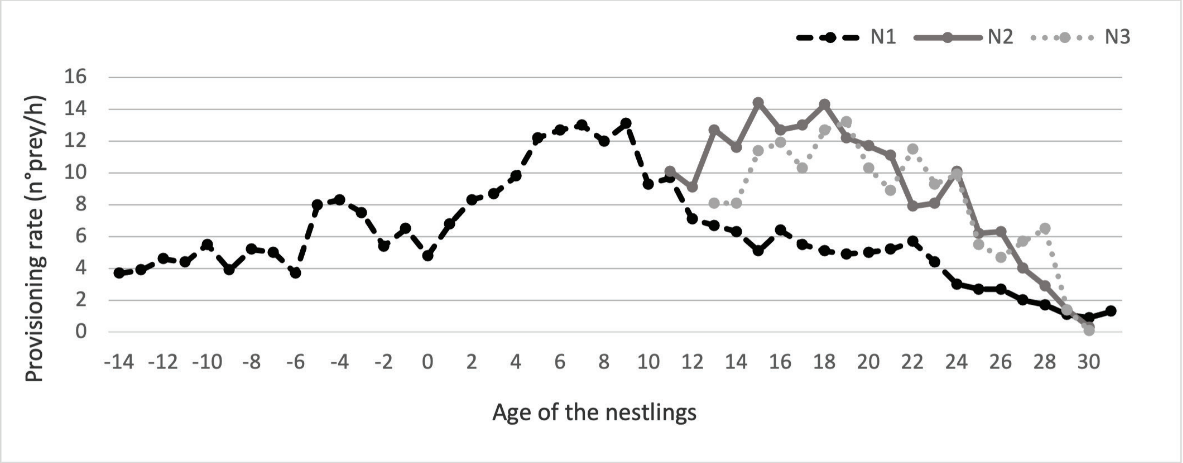

Figure 2. Provisioning rate (n°prey/h) at three Hoopoe nests during the breeding season in Castel di Guido (Rome, Italy). On the x-axis, the day 0 corresponds to the hatching of the first egg. Different lines represent different nests.

Table 3. Correlation table of the six micro-habitat variables measured in the field. Pearson Correlation Coefficient is reported and the significance of the correlation between paired samples is reported as follows: *** P < 0.001, ** P < 0.01, * P < 0.05.

	Bare soil cover	Herbaceous vegetation height	Biological debris cover	Herbaceous vegetation cover	Tree and shrub vegetation cover	Pebble cover
Bare soil cover		-0.48**	-0.22	-0.43***	-0.17	0.28*
Herbaceous vegetation height			-0.31*	0.45***	0.37**	-0.15
Biological debris cover				-0.69***	-0.07	-0.19
Herbaceous vegetation cover					-0.24*	0.00
Tree and shrub vegetation cover						-0.07

Table 4. Microhabitat foraging habitat selection of breeding Hoopoe in Castel di Guido (Rome, Italy). Summary of the parsimonious best binomial GLM obtained with a backward stepwise procedure. ** P < 0.01, * P < 0.05, ns = not significant.

	Estimate	Standard error	z-value	P-value
Intercept	7.117	2.503	2.843	**
Herbaceous vegetation height	-0.588	0.226	-2.599	**
Herbaceous vegetation cover	-5.266	2.240	-2.351	*
Pebble cover	1.917	3.138	0.611	ns

of *C. orni*, which has not been listed in literature until now as a preferential Hoopoe prey. We observed the Hoopoe actively searching on the ground for tunnels that the *Cicada* nymphs dug to emerge, and once found, inserted their long bill into the galleries to extract them. The nymphs of this insect begin to be prevalent in the nestling diet in the first days of June, when they start raising from the underground and become available for Hoopoes. Before cicadas become available in the environment, we observed that the other groups of terrestrial larvae (Lepidoptera, Coleoptera and Diptera) are dominant in the diet of the chicks. Conversely, Mole crickets are irrelevant in our study area as food provided to nestlings, probably because the soil is quite hard and dry, and therefore less suitable for this insect, which prefers moist and soft soils where it is facilitated in digging tunnels (Hertl & Brandenburg 2007). Indeed, as previously suggested by Fournier & Arlettaz (2001), our study confirms that the Hoopoe is mainly specialized in hunting Insect larvae (over 84% of their diet).

Several previous studies indicate that Hoopoe feeds on below-ground pupae of the pine processionary moth (*Thaumetopoea pityocampa*) and it could also represent the dominant prey species provisioned to chicks in landscapes where open habitats are intermixed with pine forests (Battisti 1986, Battisti et al. 2000, Barbaro et al. 2007). Notably, in the intensively managed maritime pine plantation forest of southwestern France, the Hoopoe breeding success is linked to the *Thaumetopoea pityocampa* abundance (Barbaro et al. 2007). In our sample, we have not recorded any pupae of pine processionary moth; this could be due to the relative distance of the sampled nests from most of the pine forests since the Hoopoe does not usually move too much from the nest to forage (Barbaro et al. 2007).

All the works carried out to date on the Hoopoe foraging biology demonstrate that in landscapes and regions where Mole cricket are rare or absent, other ground-dwelling prey of likely similar energy content may become dominant in nestling diet: *Thaumetopoea pityocampa* near pine plantations (Battisti et al. 2000) or *C. orni* in the Mediterranean extensive rural areas (this study), suggesting that the Hoopoe can be quite adaptable in term of prey preference depending on local context and resulting prey availability. Further research should assess if *C. orni* is an important food resource also in other Mediterranean habitats and should investigate the relationship between provided *Cicada* biomass and breeding success.

In birds, foraging habitat selection results from an interaction between food abundance and accessibility, mediated by vegetation structure (Morris et al. 2001). Our foraging microhabitat selection analysis showed that the herbaceous vegetation height and cover are the only influential variable for the species. In particular, as grass height and cover increase, the likelihood that this bird chooses an area to feed decreases. However, as shown by the preliminary correlation analysis performed, when the herbaceous vegetation cover decrease, the bare ground increase (along with the organic debris). Therefore, it could be assumed that the bare ground also affects the choice of microhabitat, as demonstrated in the study of Tagmann-Ioset & Arlettaz (2007). Indeed, Hoopoes avoid sites characterized by extensive high vegetation cover, preferring open areas with bare soil alternated with scattered patches of sparse grass, probably because this mosaic provides a greater amount and diversity of prey compared to areas completely bare or completely vegetated (Schaub et al. 2010). Grass, especially if high, is however negatively selected as it constitutes an obstacle in probing the soil or otherwise making the below-ground insects less accessible; particularly, as vegetation height increases, prey location signals are likely less detectable (Butler & Gillings 2004). At the same time, sparse vegetation may decrease the predation risk (Whittingham & Evans 2004), because elements such as tall or dense vegetation could hinder predator perception and thus delay an escape response from peril (Devereux et al. 2006).

With regard to the complete lack of nest box occupation in our study area, we hypothesized that it depends on the high heterogeneity and complexity of the landscape, which presumably offers enough natural breeding sites, even if increased nest box density may increase the Hoopoe population (Arlettaz et al. 2010a). This data could prove that the nest box installation in extensive rural areas may be much less important than in more intensive cultivable environments, where there is a lack of nesting cavities (Arlettaz et al. 2010a). Another complementary hypothesis is that the nest boxes colonization by Hoopoes may take longer than one year, even if this is not sufficiently documented in the literature. However, in the WWF oasis of Macchiagrande, approximately 10 Km from our study area, Hoopoes occupied nest boxes only in the second year since installation (Baldi & Sorace 1996).

Low-intensive anthropogenic activity, which includes mechanical removal of grass along crops or country houses, creation of dirt roads and dry-stone walls, extensive animal husbandry, and herbaceous firebreaks maintained low by cutting or grazing, in traditional cultural landscape (well exemplified by our study area) can contribute to create and maintain suitable environmental conditions for this decreasing species, which requires a microscale mosaic of different habitats to forage (Barbaro et al. 2007). We think that this evidence should be accounted for when designing conservation plans aimed at this species, or others with similar ecological needs (Schaub et al. 2010), also considering the strong context-dependent foraging habitat needs of insectivorous bird species in different regions (Assandri et al. 2022).

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GPS-tracking reveals annual variation in home-range and sedentary behaviour in Common Kestrels breeding in central Italy

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Abstract - We studied the movements of Common Kestrels *Falco tinnunculus* in central Italy by GPS-tracking 10 individuals between 2019 and 2021. Our aim was to investigate the extent of movements during the breeding and non-breeding seasons. In the breeding season the mean home-range size increased from incubation (1.11 km^2) to the chick-rearing period (3.35 km^2), and the average home-range for the entire study period was 3.68 km^2. In winter, all tagged individuals remained within a few hundred meters of their nesting area, revealing for the first time a non-migratory behaviour for the species. In conclusion, our study provides novel data on the movement ecology of Kestrels during both the breeding and non-breeding seasons, and documented the resident behaviour of Kestrels in central Italy.

Keywords: home-range; GPS tracking, Kestrel; raptor migration; nest boxes; power lines.

INTRODUCTION

Research on movement ecology of birds provides important insights into species' responses to landscape structures or to environmental changes (e.g. Nathan et al. 2008; Fleming et al. 2014). Historically, collection of this type of data has been not only time consuming but also logistically challenging. In the last few decades, advances in technology, such as high-resolution GPS tracking, has enabled to collect remotely large datasets about activity of birds, opening new horizons for the study of home ranges, space use, or migratory behaviour (Tomkiewicz et al. 2010). GPS data may provide robust data to better describe changes in movements from the breeding to the non-reproductive season or to support the occurrence of both obligate migratory birds and resident birds over the whole distribution of particular bird species. For example, many birds of prey belonging to the genus *Falco* are described as partial migrants, but GPS data are not always available to strengthen direct field observations or data obtained from ringed birds (Miller et al. 2012).

The Common Kestrel *Falco tinnunculus* Linnaeus, 1758 (thereafter Kestrel), which is a small-size open-land bird of prey widespread across Europe, Africa, and Asia, has been described as partial migrant by several authors (e.g. Holte et al. 2016). The Kestrel is well-distributed in many environments, including grasslands, farmlands, and cities (Village 1990). Kestrels feed on a large variety of prey species with a wide latitudinal variation in diet composition (Costantini & Dell'Omo 2020). Kestrels breeding in the northern parts of their distribution mainly hunt on small mammals like voles (Yalden & Yalden 1985), which are abundant during spring and summer but not in winter. To face this seasonal decrease in prey and the harsh winter conditions, Kestrels of northern Europe are obligate migrants (Snow 1968; Newton & Dale 1996). In central or southern regions of Europe, Kestrels are partial migrants, meaning they can migrate, or even be resident, because of better climatic and food conditions (Adriaensen et al. 1998; Dhondt et al. 1997; Riegert & Fuchs 2011). Ringing programs across Europe, the main sources of data available about migratory behaviour (Adriaensen et al. 1997, The Eurasian African Bird Migration Atlas 2022), support the notion that the migratory strategy of this species varies in relation to latitude, being strongly influenced by prey abundance and weather conditions (Richardson 1990). In contrast to open-land environments, Kestrels tend to be resident in cities, probably because of the constant availability of avian prey (passerines) throughout the year (Kettel et al. 2018). However, even in cities, many studies conducted in Northern Europe highlight that Kestrels may show migratory habits (Riegert & Fuchs 2011; Sumasgutner et al. 2014), revealing that high latitudes can influence the migratory behaviour.

As compared to northern populations, there are limited systematic data on the migratory behaviour and movements of Kestrels in southern Europe. Moreover, data on movements of Kestrels have been collected with methods that present inherent limitations (e.g. visual observations: Village 1990; Brichetti & Fracasso 2003; VHF transmitters: Cunningham 2013; Riegert & Fuchs 2011; ringing programs: Adriaensen et al. 1997). In particular, the migratory behaviour has been investigated with data collected from recoveries of ringed birds (e.g. Sumrada & Hanzel 2012; Holte et al. 2016; Huchler et al. 2020), a technique that suffers unavoidable bias that may hinder interpretation. Small GPS devices represent an additional tool to record the movements of birds with precision. Within the kestrel species, GPS-data loggers have been successfully used on Lesser Kestrels *Falco naumanni* (Pliego et al. 2017, Cecere et al. 2020). Small VHF transmitters have been deployed on common Kestrels (Riegert et al. 2007), but so far to the best of our knowledge, there are no tracking studies on this species using GPS tags.

Here we report the first GPS-tracking study on Common Kestrels in central Italy, which lies in the southern part of its European range. The aim of this study was to reveal circannual movements of Kestrels, to define home-range and to investigate the migratory behaviour of the species. We further analyzed the daily flying effort, by measuring the daily distances travelled per day in relation to sex and period of the year. Finally, we also described the space arrangement in which intraspecific interactions might occur, by comparing the home-ranges of neighboring breeding birds and measuring their overlap.

MATERIALS AND METHODS

Study population and GPS tracking

The Kestrels GPS-tracked in this study belong to a population breeding in nest boxes placed on high voltage power lines (Terna S.p.a., Rome, Italy) inside and outside the city of Rome, Italy. In 2019-2020 ten breeding individuals (seven females and three males) were captured to deploy small solar-powered GPS tags (GiPSy-Remote, Technosmart Europe, Rome, Italy). Tags weighed 3.5 g, which is 1.6% of the average bird's body mass (range: 1.5-1.9%), and thus lies within the recommended limits for tagging of wild birds (Casper 2009). Females were captured at their nest boxes during the early incubation period (i.e. after laying was completed and birds were regularly sitting on the eggs) using remotely triggered traps. Males were trapped when delivering food to the female inside the nest. There was no need to recapture the individuals since data could be downloaded via radio link up to a distance of 500 m using an automated base station placed in the vicinity of the nest.

All devices were deployed using a backpack Teflon harness crossed on the sternum (Rodriguez et al. 2012). The GPS were set to sample from 6:00 A.M. to 7:00 P.M. (local time), to avoid taking points during the night and draining the instruments battery. The instruments registered 1 fix/30 minutes from April to June, and 1 fix/120 minutes thereafter. The interval between fixes was increased to save battery during winter. Kestrel behaviour was sometimes an issue for solar recharging, as they perched most of their time with the solar panel not well exposed to the sun (Hernandez-Pliego et al. 2015). Moreover, during the breeding season females spent most of their time inside the nest, preventing solar recharge. Therefore, battery requirements forced us to decrease the sampling frequency in some cases, up to 1 fix/120 minutes, the settings of the GPS could be in fact remotely modified using the automated base station.

To investigate changes of the home-range size during the year, the study was divided in two seasons: the breeding season from April to September because in our study region egg laying starts in April and hatching continues until the end of June (Costantini et al. 2009; Costantini & Dell'Omo 2020), and the post-fledging dependence period is highly variable (even longer than one month), meaning that chicks from late breeders can potentially remain in the breeding area until late September (Costantini & Dell'Omo 2020); the non-breeding season between October and March. In addition, the reproductive season was further divided in three periods according to the reproductive ecology of the species (Costantini & Dell'Omo 2020): 1) incubation-brooding, from laying of the first egg to one week after hatching, during which the female spends most of their time inside the nest; 2) chick-rearing, from the first week after hatching to the second week after fledging (ca. 45 days after hatching) during which both parents hunt and provide food to the offspring; to be conservative we chose a post-fledging period of 15 days because it is approximately the period during which young Kestrels learn how to hover and hunt (e.g. Bustamente et al. 1994; Boileau & Bretagnolle 2014); 3) post-reproductive period, during which fledglings are more independent from their parents, even if they can still be seen in the breeding area. Some individuals have been tracked for more than a year, allowing us to analyze multi-year tracking home ranges.

Home range

Home range (HR) was calculated for each individual and for each period by using the 95% autocorrelated kernel density estimate (AKDE) following Fleming et al. (2015). Briefly, different continuous-time movement models were calculated from GPS data from each individual, then the model with lowest AICc was used to produce an AKDE (R package ctmm v. 0.6.1, Fleming and Calabrese 2021). All AKDEs were projected on a planar coordinate system (WGS 84 – UTM zone 33N) to measure areas. To investigate possible differences in HR depending on period, AKDE areas were regressed against period and number of sampling days using a linear mixed-effects model with bird identity (ID) included as a random factor. Whether to include sex as a factor was decided through AICc-based model selection. Differences between factor levels were tested post-hoc (R function glth, package multcomp v. 1.4.19). To account for high variability in sampling periods, only AKDEs estimated from at least 5 days of GPS tracking were considered in the model. We calculated the General Overlap Index (GOI, Ferrarini et al. 2021) between HRs of the individuals belonging to the same pair (four individuals in total), to gather information on HR overlap change during the breeding season and throughout the year. We also calculated the GOI for the four individuals which were tracked for two years, to compare HR from one year to the other. To compare our results with those of previous studies, we calculated also the 95% KDE using normal scale bandwidth (package ks v. 1.11.7).

Daily distance travelled

Estimation of daily distance travelled (DD) might depend on how frequently GPS fixes were taken. We verified that the most common time lag between fixes was 30 minutes and filtered our subset to only use data with a temporal resolution of 30 minutes, leaving 63% of the raw data set (7,467 points). Then, distance between fixes was calculated for each individual (R function deg.dist, package fossil v. 0.4.0) and averaged over days. Similarly, to AKDE area, DD was regressed against period, sex, number of sampling days, and day of year using a GLMM with a Gamma distribution and log link, and with year and bird ID as random factors. We expected an increase in foraging effort during chick rearing, therefore we included day of year as both a linear and a quadratic term. Assumptions of normality and equal variances were met for both home range and DD models. After fitting the linear mixed effects models, residual plots were checked to confirm these assumptions. All analyses were conducted with R version 4.0.3.

RESULTS

One male Kestrel lost the device shortly after the application; therefore, GPS data were gathered from nine individuals (seven females and two males). Overall, we considered 11,910 fixes (1,323 mean per ID, ranging from 73 to 6,710). Of the nine tagged individuals, we could monitor only six beyond the incubation period (four females and the two males). One couple abandoned the nest because eggs were predated ; we no longer received data from the female's device, probably because she did not return within the download range of the base station. Devices of two other females stopped to send data during chick rearing but both females successfully raised their chicks until fledging.

Home range

Mean home range area, for the entire study period, as calculated by AKDE, was 3.68 km^2 (range 0.11-19.71 km^2). This analysis does not consider home range of bird 1007, which exhibited a unique behaviour by performing a 20 km trip from her nest on three separate occasions during the post-reproductive period. This exclusion did not affect the linear mixed-effects model since bird 1007 was only tracked for 4 days during this period, and therefore was excluded by the GLMM model. Full information on AKDE area, sampling days and total number of GPS fixes can be found in Tab. 1. The LMM including sex as a factor showed a better fitting with our data (ΔAICc of model excluding sex = 24), although neither sex nor number of sampling days were found to have a significant effect on AKDE area. Period, instead, was significantly associated with AKDE: Kestrels had smaller home ranges during incubation with respect to all other periods ($Z = -3.12$, $p < 0.01$; Tab. 2).

HR were estimated during the non-breeding season for the four individuals which were tracked between October and March. The home-range mean size during winter was 0.749 km^2 (range 0.493 – 1.21 km^2). No long-distance movements (> 20 km from nest area) from the breeding area were registered during the study period, especially during winter, except for irregular daily movements.

Although these results are purely descriptive since they refer to only four individuals belonging to two couples, we found a tendency within each couple to exhibit a higher GOI during incubation (Tab. 3).

Finally, we also calculated the 95% kernel density estimate (KDE) per individual, without distinguishing between periods, using normal scale bandwidth (R package ks v. 1.11.7), that shows a mean home range size of 1.5 km^2.

Daily distance travelled

Kestrels travelled shorter distances per day during incubation (est = -0.71, SE = 0.17, $t = -4.15$, $p < 0.01$), and longer during the post-reproductive period (est = 0.34, SE = 0.08, $t = -1.46$, $p < 0.01$). We found a

Table 1. Home range size by individual (ID) and breeding phase. Only home ranges estimated from at least 5 sampling days were used in the LMM model of AKDE area regressed against breeding period, sex, and sampling days with bird ID as a random factor. AKDE models correspond to the following: IID identically and independently distributed Gaussian model; OU Ornstein-Uhlenbeck model; OUf/OUF Ornstein-Uhlenbeck model restricted to a finite home range; letters 'i' or 'a' in the model specifications stand for isotropic or anisotropic.

ID	Sex	Period	AKDE95 (km^2)	Sampling days	Tot fixes	AKDE model
1001	Female	Incubation	19.71	3	73	OU a
1002	Female	All data	0.59	257	985	IID a
		Incubation	0.02	9	97	OU a
		Rearing	1.00	23	132	IID i
		Post-breeding	0.58	225	756	IID a
1003	Female	Incubation	0.11	11	161	OU a
1004	Female	All data	1.52	210	1061	OUF a
		Incubation	0.42	16	201	OU a
		Rearing	2.05	35	292	OU a
		Post-breeding	1.18	159	568	IID a
1005	Female	All data	1.22	45	528	OUf a
		Incubation	0.49	9	142	OU a
		Rearing	1.58	27	323	OUf a
		Post-breeding	1.08	9	63	IID a
1006	Male	All data	1.43	407	6710	OU a
		Incubation	1.23	11	252	OU a
		Rearing	1.45	30	595	OU a
		Post-breeding	1.74	227	2293	OU a
1007	Female	All data	5,438.24	30	487	OUF a
		Incubation	*	1	1	
		Rearing	0.009	25	429	IID a
		Post-breeding	57.28	4	57	OUf a
1008	Male	All data	1.53	160	1642	OUF i
		Incubation	1.52	20	513	OU a
		Rearing	1.67	30	619	OU a
		Post-breeding	1.24	110	510	IID a
1010	Female	Incubation	3.35	19	263	OUF a

(*) AKDE of bird 1007 was not calculated during incubation because of lack of data. Note that the bird 1007 has an extremely wide home range, due to overestimation of the AKDE. The bird 1007, in fact, made several excursions outside the home range that increased its extension. The home range calculated with 95% KDE is 0.17 km^2, which is a more plausible value.

Table 2. Summary of LMM model of AKDE area against breeding period, sex, and number of sampling days.

	Value	SE	t-value	p-value
Intercept	1,521,853.0	529,657.0	1.50	0.18
Period = Chick rearing	731,234.5	234,080.3	3.12	<0.01
Period = Post-breeding	-540,275.5	370,117.2	0.48	0.63
Sex = Male	350,684.9	1,002,336.0	0.35	0.74
N. sampling days	111,418.9	179,849.3	0.62	0.54

Table 3. General Overlap Index (% GOI) of male and female HR within the same couple during the reproductive periods.

Period	Couple 1004-1006	Couple 1005-1008
Incubation	59.0%	74.3%
Chick rearing	39.5%	71%
Post breeding	51.7%	66%

negative association with squared day of the year (est = -0.09, SE = 0.02, t = -2.24, $p < 0.01$), indicating a non-linear relationship between DD and period of the year. Males tended to fly longer distances per day than females (est = 1.26, SE = 0.43, t = 2.96, $p < 0.01$), although with greater variation among individuals. The model summary is reported in Tab. 4.

Multi-year tracking

Females 1002 and 1004, and males 1006 and 1008 were monitored for two years. Although device performance deteriorated with time, and the number of fixes was lower, it is clear that each of the four individuals occupied the same home-range area (Fig. 1) and the same nest for breeding, and none of them showed migratory behaviour. Finally, the reoccupation of the same area is also confirmed by the GOI calculated between years: 93% for 1002, 63% for 1004, 98% for 1006, and 100% for 1008.

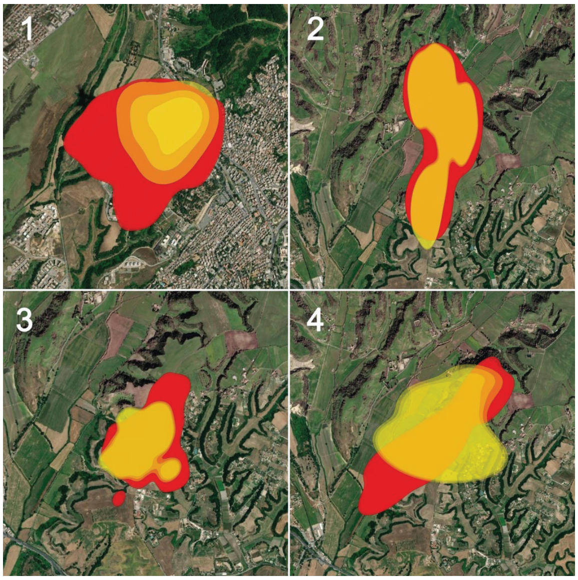

Figure 1. Multi-year tracking of individuals followed for multiple breeding seasons. AKDE home - ranges are provided per year: in red the first year of monitoring, in yellow the following year. 1: years 2019 (red) and 2020 (yellow) of the 1008 (male). 2: years 2020 (red) and 2021(yellow) of 1006 (male). 3: years 2019 (red) and 2020 (yellow) of 1002 (female). 4: years 2019 (red) and 2020 (yellow) of 1004 (female).

DISCUSSION

Home range

Common Kestrels breeding in the area of Rome had an average home range, calculated by AKDE, of 3.68 km^2, which is approximately twice the estimate (1.5 km^2) obtained using the classic KDE method. Our AKDE estimate of the home range also differs from estimates of previous studies (e.g., Cunningham 2013; Village 1990), which relied on the KDE method, a common issue when comparing traditional KDE to AKDE.

The results of our work also show that males have a larger home-range than females during the reproductive season, which is in agreement with prior work based on direct observations (Tolonen & Korpimaki 1995). Females dramatically increased their home-range from incubation to chick-rearing period, as expected owing to their larger contribution to incubation as compared to males (Fig. 2). Prior work showed that variation of the home range of Kestrels is mainly determined by the brood's food requirements and by prey abundance (Casagrande et al. 2008) but can also depend on competition among neighbouring breeding individuals (Riegert et al. 2007).

The overlap of home ranges between partners was highest at the beginning of the breeding season. During incubation, females spent most of their time in the nest-box and movements, which were also restricted around the nest, were wholly included in the partner's larger home-range. The lowest overlap if considering the average between the couples (41.3%) occurred during the post-reproduction period, suggesting an increased trophic competition or an expansion of hunting territories (Village 1982).

Daily displacement

Like home range area, daily travelled distance increased from incubation to the chick-rearing period as well, as previously suggested for other Kestrel populations (Tolonen & Korpimaki 1994, Ramellini et

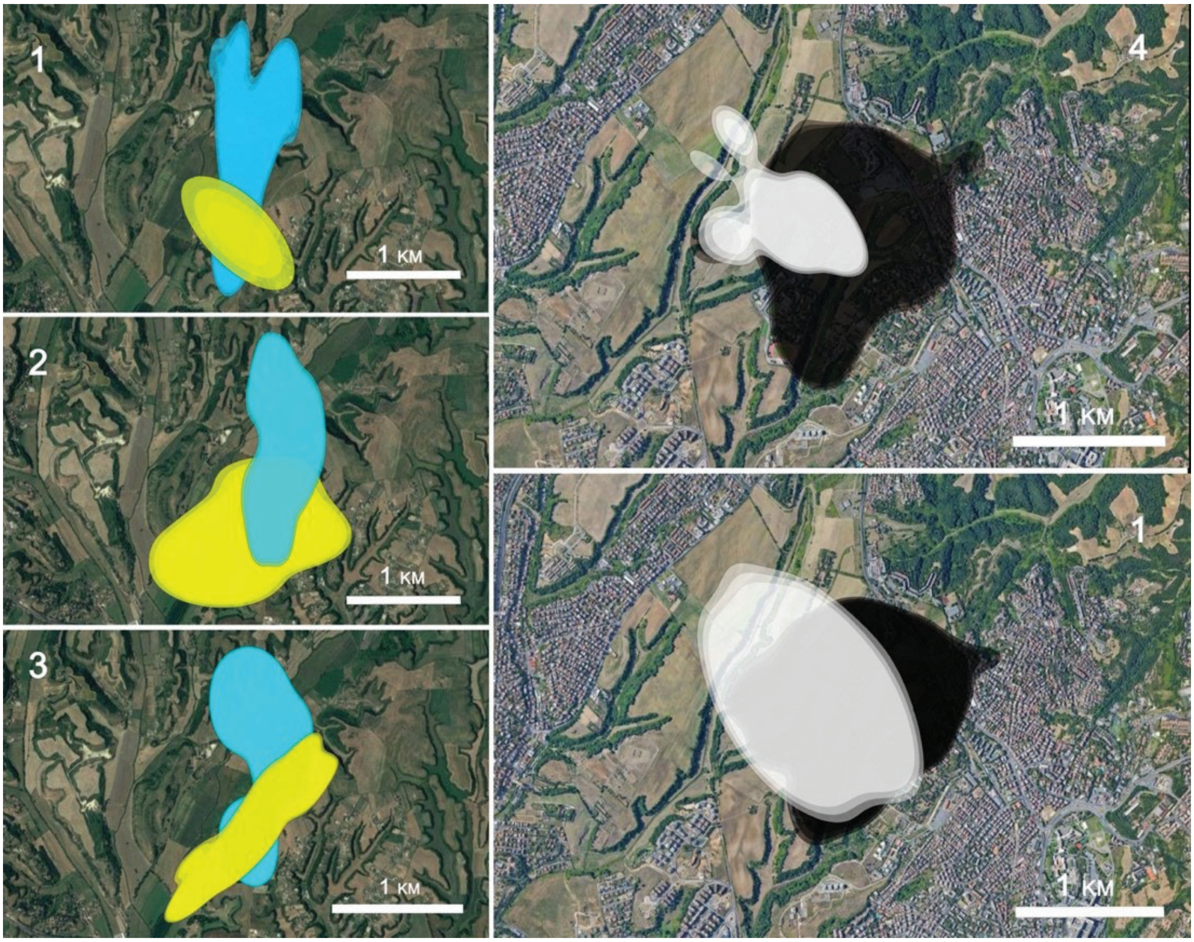

Figure 2. On the left: changes in overlap between male and female of the same couple. AKDE home - ranges of the couple 1004 (female, yellow) and 1006 (male, blue) from May 2019 to July 2021. 1: incubation period, 2 rearing-chick period, 3 post-reproduction period. On the right: overlap between male (1008) and female (1005) of the same couple, measured by AKDE home-ranges (white female, black male). 1 - Incubation period. 2 - Rearing-chick period.

al. 2022).

In winter, due to bad weather conditions and to a shift toward perch-hunting behaviour (e.g. Masman et al. 1988b) we expected reduced flight activity. This was the case in general, however, we also recorded a few events of extended daily displacements, with rapid flights up to 20 km from the breeding area and return within the day. This type of event was also observed during the late chick-rearing period in one individual, and seemed not to be related with foraging activity but more with an impulse to explore the surroundings. Further work is needed to clarify the meaning of this behaviour.

Migration and wintering area

Our data show that the four individuals that we could track for two consecutive winters (October-March) remained in the vicinity of the breeding site. Although these data are limited to a small number of individuals, they represent the first direct evidence of non-migratory behaviour of the Kestrels in the Mediterranean region, demonstrated with GPS instruments. In fact, return data of ringed individuals, which are abundant in central Europe and have helped to depict the winter movements of the species across countries (Costantini & Dell'Omo 2020), are almost missing for our study region, regardless of the fact that more than 6,500 Kestrels have been ringed in Italy since 2000 within the EURING framework (data analysis in preparation). One factor that could lead to a resident behaviour is the proximity to the city of Rome as previously suggested for other European cities (Huchler et al. 2020), as it might guarantee milder winter conditions and larger availability of prey. However, there is debate about whether cities are optimal environments for Common Kestrels, as results are contrasting (e.g. Sumasgutner et al. 2014; Kettel et al. 2018; Costantini & Dell'Omo 2020). This topic deserves further investigation.

In conclusion, the results of our multi-year GPS tracking show that the size of the home ranges, the overlap between partners, and the daily displacement of individuals vary in relation with the season. Our data also show that movements are performed in a very restricted area throughout the whole year, suggesting the occurrence of a non-migratory behaviour of Kestrels in our study area.

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Table 4. Summary of GLMM model of daily displacement against day of year, breeding period, sex, and number of sampling days.

	Value	SE	z-value	p-value
Intercept	3.99	0.62	6.49	<0.01
Day of year	-0.01	0.06	-0.14	0.89
Day of year ^{2}	-0.09	0.02	-3.71	<0.01
Period = Chick rearing	0.71	0.17	4.09	<0.01
Period = Post-breeding	1.05	0.17	6.22	<0.01
Sex = Male	1.26	0.43	2.96	<0.01
N. sampling days	-0.73	0.20	-3.67	<0.01

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Habitat selection, density and breeding of Great Spotted Woodpecker *Dendrocopos major* in a protected natural area in northern Italy

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Abstract - Woodpeckers have a strong affinity to forests and woodlands, even though they can also occur in man-made environments such as tree plantations, where they assume the role of keystone species thanks to their ability to create cavities, used as nests or refuges by other animals. However, it remains unclear how the spreading of man-made environments influences the occurrence and distribution of local populations. This study aimed to investigate the macrohabitat and microhabitat selection of the Great Spotted Woodpecker during the breeding season in a protected area in northern Italy, focusing on plantations and woodland habitats. We additionally provided some data on breeding biology and estimated the density in this area. As macrohabitat characteristics, we compared the cover of woodlands (three types: oak, black locust, and willow woodlands) and tree plantations (two types: poplar plantations and reforestations). To define the microhabitat selection, we compared environmental variables around nesting sites and around an equal number of random locations in their proximity. The Great Spotted Woodpecker selected oak and black locust woodlands, but also reforestation and poplar plantations. The results of the microhabitat analysis showed that for breeding, Great Spotted Woodpeckers require food resources, but also a rather dense arboreal vegetation and large trees. We estimated a density of 7.61 ind./km^2 ± 1,13 (ES), indicating a good state of conservation. In conclusion, the Great Spotted Woodpecker occurs in both natural woodlands, where it also selects the non-native black locust, and tree plantations, despite the latter possibly being used only for foraging. Even though it is a generalist species, the woodpecker may play an important role as ecosystem engineer in both tree plantations and black locust woodlands, due to the scarcity of natural cavity in these habitats. To favour the presence of the species it is advisable to (1) increase the surface of tree vegetation of any type, (2) favour the maintenance of mature trees, (3) avoid silvicultural interventions during the breeding season (late January-late July).

Keywords: Woodpecker, cavity nester, poplar plantations, black locust, silviculture.

INTRODUCTION

Woodpeckers have a strong affinity to forests and woodlands and are considered the most demanding group among European forest birds in terms of ecological requirements (Angelstam & Mikusiński 1994, Mikusiński et al. 2001). They are very susceptible to habitat changes; most woodpecker species depend on dead wood for foraging and digging cavities (Mikusiński et al. 2001). Furthermore, woodpeckers' ability to dig holes in wood leads them to play a key role for numerous other animals, which can exploit these cavities as nests or shelters (Johnsson et al. 1993, Martin & Eadie 1999, Gorman 2004, Drever et al. 2008). For this reason, they can be considered important keystone species (Johnsson et al. 1993, Angelstam & Mikusiński 1994, Remm et al. 2006). Indeed, in a habitat where natural cavities are a limiting resource, the secondary nesters depend on the primary ones that produce cavities (Martin & Eadie 1999, Virkkala 2006). The usefulness of these sites should not be underestimated, in fact, in some locations, such as in intensely managed forests and in arboriculture, the scarce presence of suitable sites for the nesting of the woodpeckers, limits the density of other species nesting in cavities (Gorman 2004). The strong interdependencies among the members of the cavity-nesting bird community have led some authors to propose the concept of a "network of nests", analogous to food webs (Martin & Eadie 1999).

One of the most important European primary-cavity nesters is the Great Spotted Woodpecker *Dendrocopos major* (Linnaeus, 1758). It is the most abundant, the most widespread and the largest generalist among the European woodpeckers (Scherzinger 2001, Michalek & Miettinen 2003, Ćiković et al. 2008). Its vast range includes most of Europe, the north-west of Africa, the mid-latitudes of western and eastern Asia and further east it is also widespread in the north-tropical areas of Myanmar and Indochina (Cramp 1985, del Hoyo et al. 2000). This species inhabits most of the wooded environments between the sea level and the upper limit of woodlands, avoiding treeless environments. It prefers forests due to the presence of dry wood and mature plants used to feed and to dig holes as night shelters and nests; however, it can successfully occupy artificial and man-made environments (e.g. parks, gardens, tree plantations) (Cramp 1985, Brichetti & Fracasso 2020). It is potentially present from the Arctic taiga to the Mediterranean scrub, as well as in central European temperate forests, in alpine forests, and in other wooded habitats with trees large enough to host cavities (Cramp 1985). Despite being the most omnivorous of European woodpeckers, insects (both wood-dwelling and surface-living) are its main food sources in all season (Cramp 1985, Gorman 2004). The Great Spotted Woodpecker is a monogamous species even if the pairs usually only last for one breeding season. The nests are excavated annually by both sexes in spring and consist of cavities in the trunks of living or dead trees and a wide variety of tree species (Gorman 2004, Matsuoka 2008). In general, the population trend in Europe appears to be decreasing (BirdLife International 2021), but with a European population estimated at around 17,200,000-27,300,000 individuals, the conditions for classification within one of the threat categories are not met. The main threats are the fragmentation of the nesting and feeding habitat, the removal of dry or perishable trunks and the use of pesticides (Keller et al. 2020, BirdLife International 2021). In Italy it is a sedentary and breeding species, with higher densities in the northern regions and in Sardinia, as well as in the altitudinal range below 2000 m (Fornasari et al. 2010), with range gaps in Tuscany, Puglia and Sicily (Brichetti & Fracasso 2020). The Italian population is estimated to be composed of 70,000-150,000 pairs (Brichetti & Fracasso 2020) and is classified as Least Concern (Gustin et al. 2019). In fact, Italian populations show a good state of conservation, thanks to the remarkable ecological plasticity and the tolerance to anthropogenic disturbance on a large part of the national territory (Fornasari et al. 2010, Brichetti & Fracasso 2020).

This study was aimed to investigate the status and ecology of the Great Spotted Woodpecker during the breeding season in an area of the Ticino Valley Regional Park, in northern Italy. Specifically, the study was designed with three aims: (i) to analyze the habitat selection at two levels (macrohabitat and microhabitat) across woodlands and tree plantations, (ii) to provide data on the breeding biology of the species in this area, and (iii) to obtain an estimate of the density of the species. In this area, the species is a sedentary breeder (500-700 breeding pairs are estimated; Casale 2015), well distributed, except for more urbanized areas or agricultural environments with little or no presence of tree elements (Casale 2015).

This study is important firstly to understand better the role of both woodlands, also composed of non-native tree species, and tree plantations on the ecology of this species. Indeed, both these habitats are generally associated with low bird diversity (Laiolo et al. 2003, Hanzelka & Reif 2015, FAO 2020), even though they are used by the Great Spotted Woodpecker (Chiatante et al. 2019b, Porro et al. 2021). However, it is unclear how strong the selection for these habitats is, and it is important to quantify the effect of anthropogenic disturbance on its population viability. As a matter of fact, it was suggested that tree plantations could act as ecological traps: although they might appear to be suitable natural woodlands for woodpeckers, they can be associated with low nesting success and a high predation rate (Camprodon et al. 2015, Porro et al. 2021). Furthermore, in areas with many small non-native trees and tree plantations such as the one here in consideration there is a lack of natural tree cavities (Lindenmayer & Franklin 2002, Hartley 2002, Remm & Lõhmus 2011). Therefore, the role of the Great Spotted Woodpecker as ecosystem engineer could be essential for the conservation of secondary-cavity nesters and other forest species that rely on the holes excavated by it (Hardin et al. 2021, Catalina-Allueva & Martín 2021).

MATERIALS AND METHODS

Study area

The present study was carried out in Lombardy (Northern Italy), in an area of 1652 ha located in the western Po Plain, specifically in the Ticino Valley Regional Park (Fig. 1). This area represents the Special Area of Conservation (SAC) IT2080014 “Boschi Siro Negri e Moriano” and the southern portion of the SAC IT2080002 “Basso corso e sponde del Ticino”, and it is included in the Special Protected Area SPA IT2080301 “Boschi del Ticino”. The study area is crossed from NW to SE by the Ticino River, which originates in the Alps and flows into the Po River. The climate in this area is temperate-humid continental type, characterized by hot and sultry summers (mean temperatures between 25°C and 30°C) and cold winters (mean temperatures between -1°C and + 5°C). Natural vegetation covers 38.5% of the study area, corresponding mainly to meso-hygrophilous deciduous forests (19.9%) and riparian forests (12.2%), with a rich and well-structured undergrown. The dominant tree species are oaks *Quercus robur*, poplars *Populus alba*, *P. nigra*, *P. canescens*, the elm *Ulmus minor*, and willows *Salix alba* and *Salix fragilis*. Also, very abundant are non-native species, such as the black locust *Robinia pseudoacacia*, the tree of heaven *Ailanthus altissima* and the American maple *Acer negundo*. Arable lands occupied 40.8% of the study area and tree plantations is also well represented, occupying 13.3% of the study area, and dominated by traditional poplar plantations. The Ticino River and other water bodies represent 15.0% of the study area, whereas roads and built-up areas occupies 2.0% of the study area.

Fieldwork and data collection

Occurrence and abundances of Great Spotted Woodpecker

During the breeding period, we counted the Great Spotted Woodpecker with the linear transects method (Bibby et al. 2000). From February to May 2021, we walked 16 transects corresponding to paths and unpaved roads of the study area (Fig. 1), once a month, for a total of 36.5 km per month, along which every individual seen (using a binocular 10×40) or detected due to its song/call was recorded. To obtain a representative sample of the environment investigated, a stratified sampling design was planned (Krebs 1999, Sutherland 2006). In particular, the covers of each land use type in a 100 m buffer around transects (the distance at which the detection

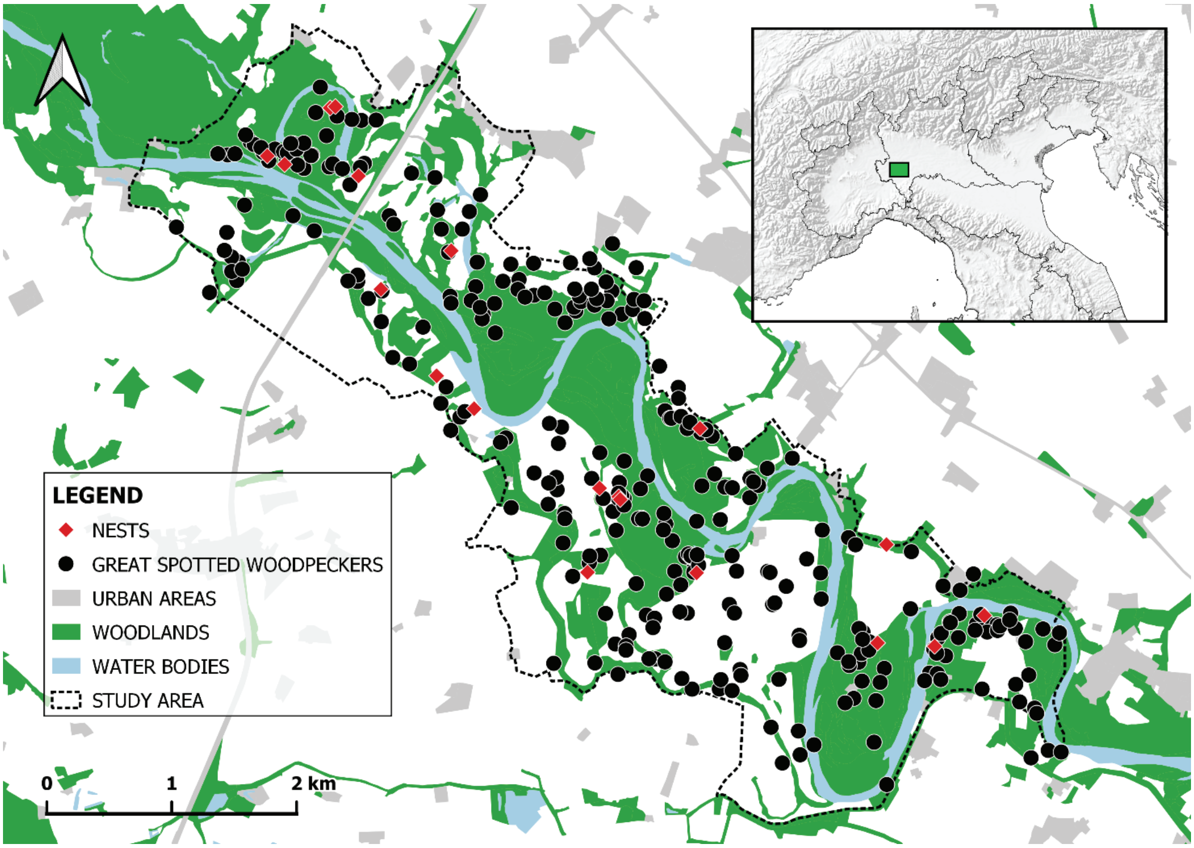

Figure 1. Study area surveyed to investigate the habitat selection and density of the Great Spotted Woodpecker in northern Italy. Observations and nests of the Great Spotted Woodpecker are shown.

probability is higher; see Results, paragraph "Abundance and Density") is proportional to those of the whole study area. Counts were conducted in the morning between dawn and 12 a.m., avoiding windy and rainy days. The data collected, including the distance and direction of each contact, were noted and subsequently entered in a Microsoft Excel spreadsheet (Microsoft Corporation 2016).

Breeding: nest search, tree and cavity variables

Starting from the first week of May to the first week of June we searched for woodpecker nests walking the 16 transects previously described and some of the wooded areas adjacent to them. The seeking of cavities was conducted mainly in the morning, walking at a slow pace to visually inspect almost all trees, carefully checking snags and alive broken trees, since strongly selected for nest excavation by the Great Spotted Woodpecker (Olsson et al. 1992, Wiktander et al. 1992, Gorman 2004, Smith 2007). In addition, the begging call of the nestlings was exploited, since it can be heard even from a distance (Ferguson-Lees et al. 2011, Ćiković et al. 2014, Porro et al. 2021). Rainy days and strong winds were avoided. When an active nest was found, the following data were collected: (1) the nest coordinates, (2) the species of the tree, (3) the integrity of the tree (possible levels: alive, alive and decaying, dead, dead and broken), (4) the diameter of the trunk (DBH, diameter at breast height), (5) the height of the tree, (6) the height of the nest, (7) the orientation of the nest. A tree was considered decaying if at least one large dead branch was present. The height of the tree and the nest was calculated through trigonometric principles (van

Laar & Akça 2007) after we measured distance from eye level to tree crown and to tree top by a laser rangefinder (Leica Rangemaster 900; Leica, Solms, Germany). In the absence of obstacles and if the nest was at a height of less than about 12 m, the internal cavity was inspected with the help of a handcrafted pole-mounted camera system, consisting of a small infrared camera (SQ11 Mini DV, China) and a telescopic pole 8 m long (Porro et al. 2021). In this case, the (8) number of eggs/juveniles in the nest was counted.

Environmental variables

Macrohabitat

To assess the habitat selection of the Great Spotted Woodpecker in the study area, we explored the effect of the percent cover of both woodland types, i.e. oak woodland (dominated by *Quercus robur*), black locust woodland (dominated by *Robinia pseudoacacia*), and willow woodland (dominated by *Salix alba*) and tree plantations (poplar plantations and reforestations). The values of the environmental variables were obtained with the support of the QGIS 3.14.16 software using a land use map ad hoc built by us. Specifically, combining information from the regional land use map DUSAF 6.0 (ERSAF 2021), the regional forest map "Carta dei tipi forestali reali della Lombardia" (ERSAF 2012), and Google Satellite imageries (Map data ©2021 Google) from the QGIS plugin QuickMapServices (NextGIS 2019), we digitalized all polygons composing the land use map of the study area. Then, we attributed the land use type to each polygon with a visual check during the study period.

Nest site selection

During the period between the second week of June and the last week of July, microhabitat data were collected. In particular, the environmental variables were measured in a plot with a radius of 10 m (0.03 ha) around the nests and around points (in equal number with respect to the nests) randomly located within a radius of 50 m from the nest (Barrientos 2010) and at a minimum distance of 20 m from them (Kosiñski & Winiecki 2004, Pasinelli 2007, Hebda et al. 2017). Specifically, in each plot (nest or random), 18 variables were measured (Tab. 1) (Porro et al. 2021). Among them, we counted the number of trees with entrance and emergence holes of saproxylic beetles larvae in the wood in the first 2 m above ground, as an indirect measure of insect prey abundance (Nappi et al. 2003). Among trees, we considered only trees with the diameter of tree trunk at breast height (DBH) ≥ 18 cm because 18 cm is considered the minimum size of a tree suitable to dig a nest (Smith 1997). For the analysis, we also separately considered trees with DBH > 50 cm as this size range was the most frequent nesting substrates selected to dig nests (Kosiński et al. 2006, Touihri et al. 2015).

Data analysis

Habitat selection: macrohabitat

The habitat selection at a macroscale was investigated applying a use versus availability approach (Manly et al. 2002), calculating the covers of macrohabitat within both the presence and the availability cells of the Great Spotted Woodpecker. These cells were obtained by overlapping on the study area a grid with cell size equal to that of the home-range of the species. In particular, the home-range of the Great Spotted Woodpecker has an average size of 10 ha (del Hoyo et al. 2000) and for this reason a grid with cells of 316 m per side was generated (Chiatante et al. 2019b).

We computed an exploratory analysis verifying the existence of significant differences between the covers of land use types between presence and availability cells through both the non-parametric Mann-Whitney U test and the Kruskal-Wallis test (Legendre & Legendre 1998). Then, we investigated the habitat suitability through binary logistic regression analysis (Manly et al. 2002, Boyce et al. 2002). We used a presence-availability approach basing on the assumption that the certainty of the presence of the species, obtained during the data collection phase, cannot be matched by an equal

Table 1. Variables used to investigate the microhabitat selection of the Great Spotted Woodpecker in northern Italy. All measures were related only to trees with DBH > 18 cm

Variable	Description
Tree cover	Estimated visual coverage of the tree crowns (%)
Shrubs cover	Estimated visual coverage of shrub vegetation (%)
Dead wood	Abundance of dead wood on the ground (four levels: 1 absent or very rare, 2 rare, 3 abundant, 4 very abundant)
Tree species	Number of trees of each species
Tree diversity	Shannon-Wiener Diversity Index of tree species
Tree vegetative state	vegetative state of each tree (four classes: alive, more alive than dead, more dead than alive, dead)
N. whole trees	number of whole trees
N. broken trees	number of broken trees
Tree DBH	average DBH of trees (cm)
Tree DBH > 50 cm	average DBH of trees with DBH > 50 cm (cm)
N. tree DBH > 18	number of trees with DBH > 18 cm
N. tree DBH > 50	number of trees with DBH > 50 cm
N. dead tree DBH > 18	number of dead trees with DBH > 18 cm
N. dead tree DBH > 50	number of dead trees with DBH > 50 cm
N. tree with ivy	number of trees with ivy
N. tree with ivy DBH > 18	number of trees with ivy with DBH > 18 cm
N. tree with ivy DBH > 50	number of trees with ivy with DBH > 50 cm
N. tree with beetles' holes	number of trees with holes of saproxylic beetles

certainty of its absence, even if the area has been subject to data collection (Boyce et al. 2002, Johnson et al. 2006). Therefore, the dependent variable was binary (1 = presence, 0 = availability) whereas as independent variables we used the coverage of the land use type inside cells previously described. The variables included in the models were selected through an Information Theoretic Approach, and in particular we used the multimodel inference using the second-order Akaike's Information Criterion (AICc) as an evaluation parameter (Burnham & Anderson 2002). This is a quantitative selection method based on maximum likelihood and on the number of parameters, in which low values indicate better adherence to the distribution of the collected data (Burnham & Anderson 2002). Then, using data dredging, all the models with independent variables were formulated and for each of them the AICc was calculated (Burnham & Anderson 2002). Therefore, we selected as the best models with ΔAICc<2, as they are attributed with greater information (Burnham & Anderson 2002); for each of them we calculated also the Akaike's weight wi. Based on the set of best models, we have carried out the model averaging, calculating the partial regression coefficients of each variables and their relative importance (Burnham & Anderson 2002). The absence of collinearity of the variables present in the model set was verified through the Variance Inflation Factor (VIF), using a threshold equal to 3.00 (Fox & Monette 1992, Zuur et al. 2010). The predictive capacity of the average model was tested through the AUC of the ROC curve (Receiver Operating Characteristic) (Pearce & Ferrier 2000, Boyce et al. 2002) and as the value for the estimate of the explained variance, we calculated the explained deviance D^2 (Boyce et al. 2002, Zuur et al. 2007). Finally, based on the models obtained, we created a prediction map of the probability of presence of the species in the entire study area, using a grid with cells of the same size as those used for the formulation of the models. The software R 4.1.1 (R Core Team 2021) and the package MuMIn (Bartoń 2018) were used for the statistical analyses.

Habitat selection: nest site selection

For the analysis of the microhabitat selection of the Great Spotted Woodpecker, we used a comparative approach between the variables measured in the plots around the nests and those collected in the random plots. First, we ran some exploratory analyses with the non-parametric Mann-Whitney U test and the χ^2 test with contingency tables, to verify the existence of significant differences between the variables measured in the plots around the nests and those around the random points. Then, similarly to the macrohabitat selection, we investigated the nest site selection through binary logistic regression analysis, using as dependent variable the nests (1) and the random plots (0) and as independent variables, the environmental characteristics previously described (Tab. 1). The variables were standardized by normalization, that is, each variable had a mean of zero and a standard deviation of one (Zuur et al. 2007). We performed model selection through the Information Theoretic Approach, using data dredging and calculating for each model with a different set of variables the AICc. Considering the small sample size (n = 39, see Results), to reduce bias, we considered only models with a maximum of four predictors, basing on the rule of thumb “one in ten” which states that one predictive variable can be studied for every ten events while keeping the risk of overfitting low (Harrell et al. 1984, Peduzzi et al. 1996). Based on the set of best models (ΔAICc<2), we carried out the model averaging, calculating the partial regression coefficients of each variable and their relative importance. The absence of collinearity of the variables present in the model set was verified through the VIF, the predictive capacity of the average model was tested through the AUC of the ROC curve and we calculated the explained deviance D^2 to estimate the explained variance.

Abundances and density

The abundances of the species along linear transects were calculated through the Kilometric Abundance Index (Bull 1981, Czeszczewik et al. 2013). To verify the existence of significant differences between abundances of each months, we used the non-parametric Kruskal-Wallis test (Legendre & Legendre 1998). The density of Great Spotted Woodpecker was estimated through the distance sampling method (CDS) (Buckland et al. 1993). After a visual inspection of distances distribution, we transformed the distance data into equal intervals of 50 m. Moreover, the probability of detecting a bird depends not only on distance but also on many other factors, such as habitat, weather, period and bird behaviour (Buckland et al. 1993), a circumstance that could exist, at least in part, in this research due to the spatio-temporal variability of our data. Therefore, ignoring all these other factors, besides distances, could cause some bias in the estimate (Beavers & Ramsey 1998, Bas et al. 2008, Anderson et al. 2015). Indeed, a graphical exploratory analysis and the Kruskal Wallis test have shown that the month could bias our estimate because the detection distance changed with it (χ^2 = 22.261, df = 3, P <0.001). For this reason, to obtain the best model, we used multiple covariate distance sampling (MCDS) (Marques et al. 2007), an extension of CDS that allow modelling the detection probability as a function of variables other than distance. Accordingly to these considerations and as advised by Buckland et al. (1993) and by Thomas et al. (2010), in this study the detectability function was calculated using three models: (1) half-normal with cosine-based correction factor, (2) half-normal with Hermite-based correction factor, and (3) hazard-rate with correction factor based on simple polynomials. To select a model among those obtained, we used the second-order Akaike Information Criterion (AICc) and the goodness of fit of the models was assessed by χ2 tests, comparing the frequencies of the observed and expected contacts (Buckland et al. 1993). Finally, we calculated the detection probability and the Effective Strip Width (ESW), i.e. the distance within which the number of individuals not observed is equal to the number of individuals observed beyond (defined as the distance within which the probability of contact individuals is maximum). For each estimate, both the coefficient of variation (CV) and the 95% confidence intervals (CI) were calculated. The analyses were performed using the statistical software R v.4.1.1 (R Core Team 2021) and the package Distance (Miller 2020).

RESULTS

Habitat Selection

Habitat selection: macrohabitat

In the study area, the Great Spotted Woodpecker is present as a sedentary and nesting species. During the breeding season, 299 observations were collected, in particular 106 in February, 80 in March, 72 in April and 41 in May. As can be seen from Fig. 1, the Great Spotted Woodpecker appears well distributed in the study area. The exploratory analysis showed that for all five wooded types were found significant differences between cases of presence and controls (Supplementary Materials, SM Tab. S1). In general, there were significant differences between each wooded type within presence cells (Kruskal-Wallis test, $\chi^2 = 29.049$, df = 4, $P < 0.001$), with the highest cover in woodlands and poplar plantations (SM Tab. S1, SM Fig. S1). The multimodel inference showed that two models best explained the occurrence of the Great Spotted Woodpecker (SM Tab. S2). The average model showed that all the wooded types positively affected the species and that the most important ($\Sigma w_i \geq 0.90$) were reforestations, poplar plantations, oak woodlands and black locust woodlands (Tab. 2, Fig. 2). The estimate of reforestations' effect was slightly higher than those of both oak and black locust woodlands. On the other hand, the importance of willow woodlands was very low. The Variance Inflation Factor (VIF) confirmed the absence of collinearity between the variables in the model set (Tab. 2). The ROC curve showed a good discriminatory capacity of the model, with an AUC equal to 0.809 (P <0.001), and the mean explained deviance was 17.9%. The probability of the presence of the Great Spotted Woodpecker in the study area was 0.51 ± 0.232 (SD), with a minimum of 0 and a maximum of 0.99 (SM Fig. S2).

Habitat selection: nest site selection

During breeding season 2021, we found 19 Great Spotted Woodpecker nests, all in the woodlands (Fig. 1). The exploratory analyses showed that in plots with nest sites occurred a higher abundance of whole trees (U = 110.5, P = 0.042), with an average DBH greater than 18 cm (U = 103.5, P = 0.025) and with saproxylic beetles' holes on the trunk (U = 110.5, P = 0.026) than in control plots. For all other variables, we did not find significant differences between nest and control plots (SM Tab. SM3). The multimodel inference showed that four models best explained the nest site selection of the Great Spotted Woodpecker (SM Tab. S4). The average model, composed of five variables, showed that the most important covariate was the number of trees with saproxylic beetles' holes, which associated positively with presence of the Great Spotted Woodpecker (Tab. 3, Fig. 3). In addition, the number of trees with DBH > 18 cm positively affected the nest site selection; dead wood, tree diversity and number of whole trees, entered the model but did not explain much variation. The VIF confirmed the absence of collinearity between the variables in the model set (Tab. 3). The ROC curve showed a good discriminatory capacity of the model, with an AUC equal to 0.878 (P <0.001), and the mean explained deviance was 30.8%.

Abundances and density

The average Kilometric Abundance Index (KAI), related to the 299 observations collected between February and May, was equal to 2.02 ± 1.68 (SD) individuals per km. The abundance decreased from a maximum of 2.98 in February to a minimum of 1.06

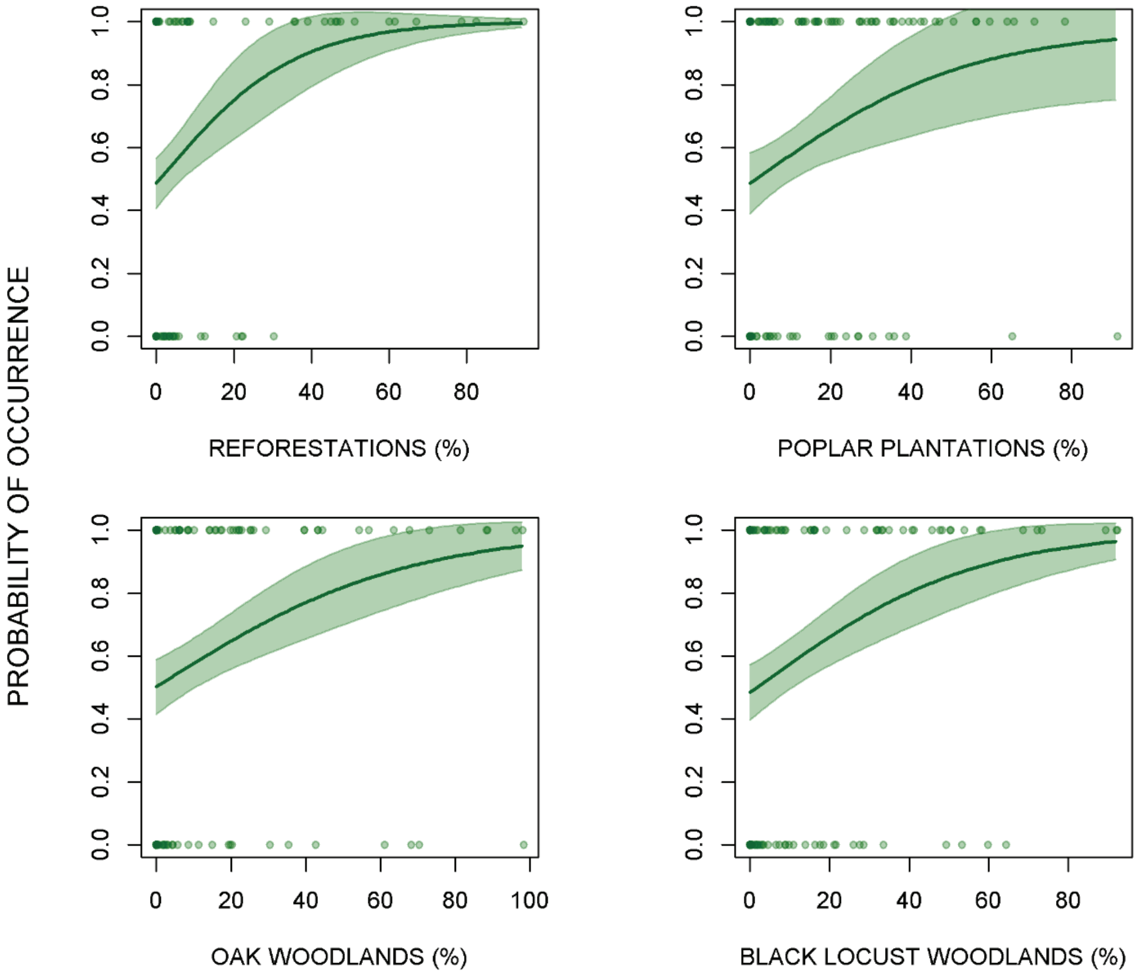

Figure 2. Estimates of the probability of occurrence as a function of increasing coverage of the most important environmental variables (Σwi >0.90) selected in the average binary logistic regression to investigate the occurrence of the Great Spotted Woodpecker in northern Italy.

Table 2. The average logistic regression explaining the occurrence of the Great Spotted Woodpecker in northern Italy. In bold are the most important variables ($\Sigma w_i > 0.90$).

Variable	β	SE	LCI	UCI	Σw_i	VIF
Intercept	-1.003	0.225	-	-	-	-
Reforestations	**0.058**	**0.017**	**0.024**	**0.092**	**1.00**	**1.02**
Poplar plantations	**0.038**	**0.011**	**0.017**	**0.059**	**0.94**	**1.01**
Oak woodlands	**0.030**	**0.009**	**0.012**	**0.048**	**1.00**	**1.08**
Black locust woodlands	**0.036**	**0.010**	**0.017**	**0.056**	**1.00**	**1.06**
Willow woodlands	0.029	0.009	0.011	0.047	0.06	1.08

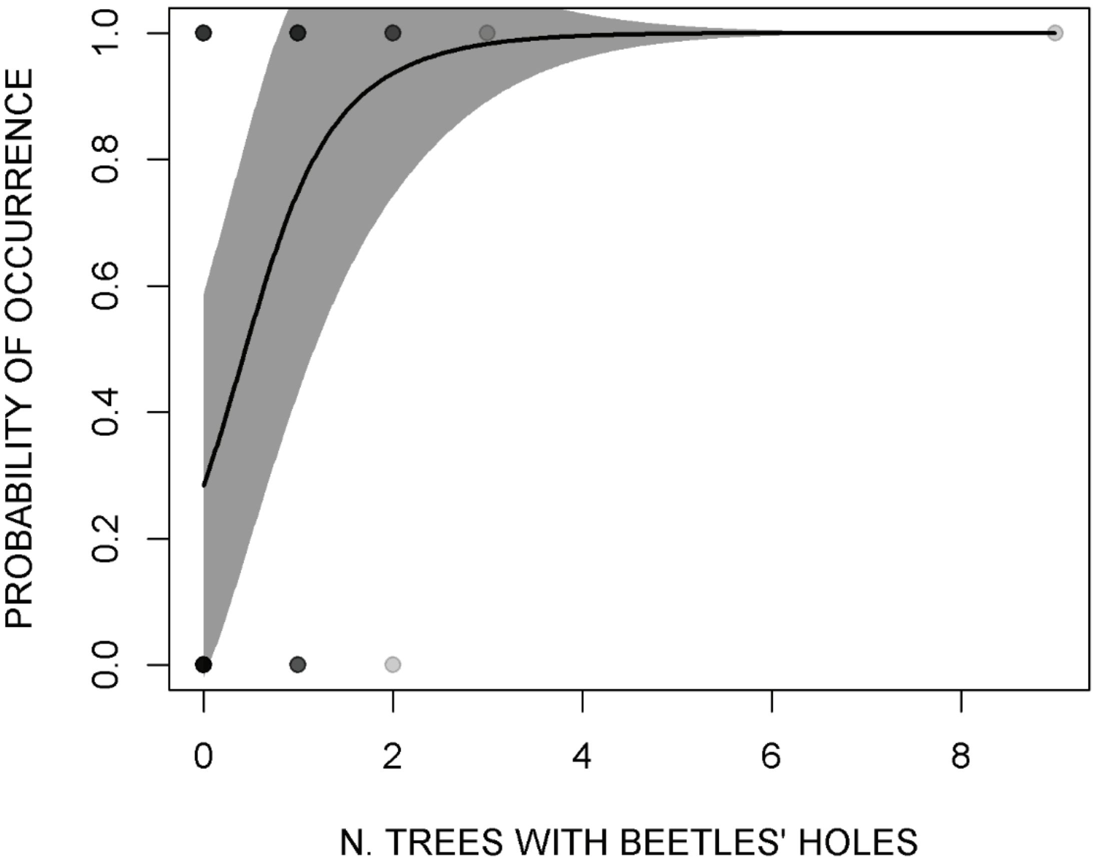

Figure 3. Estimates of the probability of occurrence as a function of increasing number of trees with saproxylic beetles' holes in the average binary logistic regression to investigate the nest-site selection of the Great Spotted Woodpecker in northern Italy.

Table 3. The average logistic regression explaining the nest site selection of the Great Spotted Woodpecker in northern Italy. For the dead wood, the reference level was "Absent or very rare". In bold are the most important variables ($\Sigma w_i > 0.90$).

Variable		β	SE	LCI	UCI	Σw_i	VIF
Intercept		12.947	19.98	-	-	-	-
Dead wood	*rare*	-18.768	23.99	-49.09	48.71	0.64	1.15
	abundant	-18.793	23.99	-49.09	48.71		
	very abundant	-22.116	23.99	-49.12	48.68		
Tree diversity		0.716	0.554	-0.414	1.845	0.24	1.22
N. whole trees		0.842	0.450	-0.071	1.755	0.17	1.18
N. trees with DBH > 18 cm		1.793	0.938	-0.095	3.681	0.83	1.46
N. trees with beetles' holes		**3.301**	**1.665**	**-0.048**	**6.650**	**1.00**	**1.31**

in May (March = 2.11, April = 1.93), with significant differences among months (χ^2 = 9.649; df = 3; P = 0.022).

The densities estimated with the multiple covariates distance sampling (MCDS) were equal to 7.61 ind./km^2 ± 1.13 (SE) (LCI 95% = 5.60, UCI 95% = 10.32, CV = 14.8%). The best model for calculating the detection probability function was the hazard-rate with simple polynomial adjustments (Tab. 4, Fig. 4). The goodness-of-fit of the model was adequate (χ^2 = 4.871, df = 3, P = 0.181). The ESW calculated from the model was 96 m and the average probability of detection was estimated to be 0.31 ± 0.02 (SE).

Breeding

During the breeding season 2021, 19 Great Spotted Woodpecker nests were found between the 7th of May and the 25th of June. The nests were dug mainly

Figure 4. Histogram of the detection function calculated to estimate the density of the Great Spotted Woodpecker in northern Italy. On the y-axis, the detection distance in meters, on the x-axis the detection probability (from 0 to 1).

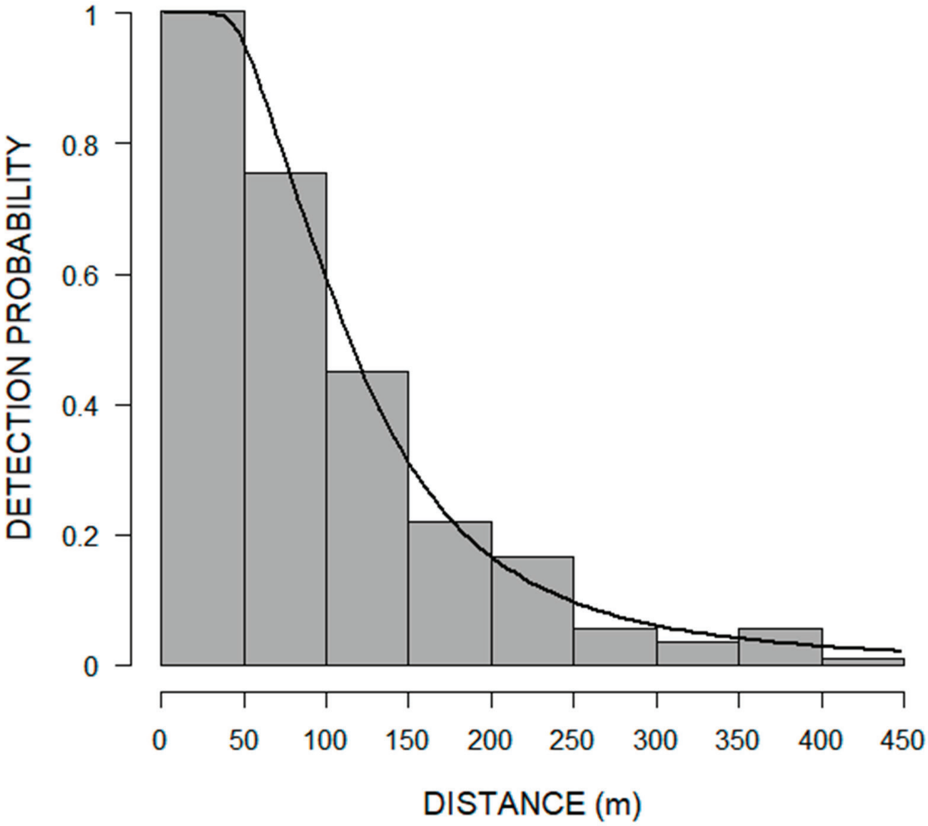

Table 4. Distance sampling models computed to estimate the density of Great Spotted Woodpecker in northern Italy. We showed the function (key + series adjustment), the model used, the AICc and its Δ, and the average estimated detection probability (P_a).

Function	D± SE	CV (%)	AICc	ΔAICc	P_a ± ES
Hazard-rate simple polynomial	7.61 ± 1.13	14.8	963.00	0.00	0.31 ± 0.02
Half-normal Hermite polynomial	7.18± 0.99	13.8	968.60	5.60	0.32 ± 0.01
Half-normal cosine	7.18± 0.99	13.8	968.60	5.60	0.32 ± 0.01

in white poplar (n = 11, 57.9%) and black locust (n = 4, 21.1%), but also in white willow (n = 3, 15.8%) and black poplar (n = 1, 5.3%) on trees with an average height of 17.2 m (± 6.1 SD). The mean diameter of the trees used was 47.3 cm (± 18.7 SD). The nests were at an average height of 9.3 m (± 4.7 SD) and were exposed on average to south, south-west (precisely 193°N ± 96.1 SD). The nest trees were mostly in a rotting state (n = 8, 42%), alive (n = 7, 37%) but also dead (n = 4, 21.1%). Five of the 19 trees were covered with ivy (26.3%). Due to too high nests and obstacles such as vegetation, only 7 out of 19 nests were inspected, in which a total of 21 juveniles were counted (SM Fig. S2). Of these seven nests, three contained 4 juveniles, two contained 3 juveniles, one contained 2 juveniles and one 1 juveniles (mean = 3.0 juv/nest, SD = 1.15).

DISCUSSION

Habitat selection

Habitat selection: macrohabitat

The results of this study allow to define the environmental characteristics that promote the presence of the Great Spotted Woodpecker in an area of the Ticino Valley Park. During the breeding season, the species has a rather homogeneous distribution and essentially inhabits both woodlands and tree plantations, as showed by our analyses and previous research done in this area (Chiatante et al. 2019b, Porro et al. 2021). These results agree with the ecology of this bird, indicated as the most generalist of the European woodpeckers, occurring anywhere where there is tree vegetation (Cramp 1985, Hannsson 1992, Rolstad et al. 1995, Tobalske & Tobalske 1999, Gorman 2004).

Our analyses show that increasing coverage of woodlands and tree plantations positively associated with the presence of the species in our study area. Among forest habitats, oak and black locust woodlands seem to be play an important role for the occurrence of the Great Spotted Woodpecker, whereas willow woodlands, although with a positive effect, only weakly correlated to the presence of the species. Generally, the selection of oak woodlands is found in many studies (Smith 1997, Hebda et al. 2017, Komlós et al. 2021), and can be attributed to a greater foraging activity, thanks to a high presence of seeds and insects as a consequence of the occurrence of large and senescent trees (Török 1990). The only study describing the selection of forest habitats of woodpeckers disagree with our result relating to black locust woodlands and suggest an underutilization of forests composed of non-native and invasive species compared to native oak and willow forests (Ónodi & Csörgö 2014). However, in our case, their positive effect could be linked to the fact that the black locust woodlands are mostly young woods with less crown coverage. It follows that in spring the undergrowth is more developed, leading to a higher density of insects foraged by the woodpecker than in mature woods with a thicker crown coverage (Hansson 1983, Blake & Hoppes 1986). In addition, black locust trees are very prone to the formation of dead wood (McComb & Muller 1983), which is fundamental for the presence of the woodpecker (Gorman 2004, Smith 2007).

Among tree plantations, poplar plantations and especially reforestations are positively associated with the presence of the species. This is likely related to the fact that poplar plantations are more managed than reforestations, which appear more natural. Indeed, poplar plantations are generally ploughed and sprayed to avoid attacks of wood-boring and bark beetles (such as, *Saperda carcharias*; Allegro 1991); in addition, snags and dead wood are generally removed. The link between dead wood and woodpeckers is well known, because most woodpecker species are indeed dependent on dead wood for either nesting, foraging, or both (Roberge et al. 2008, Gutzat & Dormann 2018). Thus, dead wood is often a limiting factor for woodpecker using managed forests, as snags and logs are usually scarce (Virkkala 2006). That is the case for poplar plantations as well, where woodpeckers appear to be positively associated with the presence of at least some standing decaying trees within the stand

(Porro et al. 2021). Nonetheless, the selection for tree plantations could be due to the presence of natural features inside them, such as big elder trees and vegetated edges that provide nesting and foraging sites (Barrientos 2010, Basile et al. 2020). However, tree plantations represent a complementary or supplementary habitats (Dunning et al. 1992, Ekroos et al. 2016), as the density in this environment is lower than that in woodlands (Chiatante et al., 2019a, Porro et al., 2021).

Habitat selection: nest site selection

Our results from the microhabitat selection of the Great Spotted Woodpecker indicated selection for some of the variables measured. Indeed, nesting plots, compared to random plots, have a greater number of trees, which are characterized by a greater presence of holes created by saproxylic beetles and with an average DBH greater than 18 cm. The explanation underlying the higher number of trees in the nesting sites may be related to the woodpecker feeding habits and requirements. In fact, in all seasons both wood-dwelling and surface-living insects are the main food sources of this species (Cramp 1985, Gorman 2004), that are searched mainly on the tree trunk (Török 1990, Gorman 2004). In the study area there are few large trees and the tree trunk diameter is generally low, especially in black locust woodlands (Motta et al. 2009, Tescari 2020), which were selected by the species. Therefore, due to the needs of environments rich in food to rear the offspring, the species may select areas with a greater number of trees where large quantities of food resources are possibly available. Furthermore, nesting in closed forests offers better shelter from aerial predators, as well as from some arboreal predators (Short 1979, Li & Martin 1991, Stenberg 1996); indeed, in the area occurred Eurasian Sparrowhawks *Accipiter nisus*, Northern Goshawk *Accipiter gentilis*, and Pine Martens *Martes martes* (Casale 2015, Balestrieri et al. 2015), which are some of the natural predators of the woodpecker. The high presence of trees with saproxylic beetle's holes is in line with the previous result and probably derives from the feeding habits of the species, based in summer on the larval and adult forms of forest arthropods (Cramp 1985, Osiejuk 1998, Gorman 2004). The selection for habitats rich in saproxylic insects has been observed for many woodpeckers (Török 1990, Nappi et al. 2003, Kosiński et al. 2006, Komlós et al. 2021), and in most of these studies, it appears that it was mainly a consequence of the selection for deadwood. The selection for areas with trees having an average DBH > 18 cm agrees with most of the previous research (Smith 1997, Kosiñski & Winiecki 2004, Pasinelli 2007, Komlós et al. 2021). Indeed, the species selects these trees because are suitable to dig a nest, whereas younger trees - with a DBH < 18 cm - are usually avoided (Kosiñski & Winiecki 2004, Pasinelli 2007, Barrientos 2010). In addition, the younger the trees the smaller the nests, leading to overcrowding which can reduce nest survival (Wiebe & Swift 2001). Furthermore, nests built in small and dead trees are colder during incubation and appear to be energetically more expensive for adults and chicks than warmer nests (Wiebe 2001).

The low number of differences found between nesting and control plots could have several explanations. First, they could be an artefact originating from the small sample size. In most of the microhabitat selection studies regarding this species the number of nesting plots used was bigger than 50 (Smith 1997, Kosiñski & Winiecki 2004, Hebda et al. 2017), while here we found only 19 nests. Another explanation could be that the microhabitats of the woodlands of the study area are structurally almost similar, at least at the spatial scale we worked at (20-50 m), and therefore it is not possible to show a selection. Finally, in other studies carried out in North America, it was found that the vegetation in the immediate proximity of the nesting tree minimally affects the nesting site selection of the woodpeckers (Gutzwiller & Anderson 1987, Adkins Giese & Cuthbert 2003). In fact, since the Great Spotted Woodpecker is a generalist species, it can live in various microhabitats depending on the architecture of the habitat, the distribution of prey and the spatial distribution of competitors.

Abundances and density

The Great Spotted Woodpecker was detected 299 times in the four months of investigation, with a decrease of the abundances over time. This result is explained by the fact that in February and March the woodpecker is very active in establishing nesting territories and in finding a partner and is therefore more detectable. In April and especially in May, however, the adults are engaged in the incubation of the eggs and rearing of the offspring (Gorman 2004, Brichetti & Fracasso 2020) and for this reason they are less detectable.

The estimated density is equal to 7.6 ind./km^2 for this area of the Ticino Valley Regional Park, indicating a good state of conservation of this species. Indeed, Gustin et al. (2016) indicated 5 pairs/km^2 as favourable reference value for Italian populations inhabiting in mature broadleaved and riparian woodlands. This result is comparable to that found by Casale (2015) in the whole Park: 500-700 pairs found in 20.000 hectares of forests, which correspond about 2.5-3.5 pairs/km^2. The density measure of this study seems slightly higher than that found by Porro (2014) for a fragmented area of Lombardy (6.8 ind/km^2) and Woodward et al. (2020) in the southern and coastal area of Great Britain in the period 2007-2009 (4.5-9 ind/km^2). The data is also comparable to the estimates of pairs and territories found by other authors in various European regions. Indeed, in natural forests, in Germany it was estimated a density of 4.5 pairs/km^2 (Scherzinger 1982), in western Poland, Wesołowski and Tomiałojć (1986) identified 6.6 territories/km^2, whereas in Southern Finland were estimated 3.78 pairs/km^2 (Virkkala et al. 1994). Conversely, in a Romanian managed forest were estimated 0.08 pairs/10 ha-1 (Domokos & Cristea 2014). Altogether, the density estimated in this study is higher than that found in other studies related to environments where the distribution of resources is less concentrated or fragmented and vital areas are necessarily larger (McCollin 1993).

Breeding

Despite the small sample of nests found not allowing for an in-depth analysis of the breeding biology of the Great Spotted Woodpecker in this study area, it is possible to make some considerations. The environmental characteristics found appear to be in line with many studies on the nest site selection of the Great Spotted Woodpecker in Europe in similar areas. For example, the average DBH of trees in which the woodpeckers dig nests was 47 cm, matching with results found in Swiss old oak-hornbeam forest managed for centuries as coppice (Pasinelli 2007), in continental forests of Croatia (Ćiković et al. 2014) and in oak woodlands of southern England (Smith 1997). Another example is the result related to a greater number of nests dig on living or rotting trees, which is in agreement with the general ecology of the species (Cramp 1985, Gorman 2004, Ónodi & Csörgö 2014). Furthermore, even the average height of the nests found, equal to 9.3 m, is in line with results found in Croatia (7.8 m; Ćiković et al. 2014) and in Poland (10.0 m; Kosiński et al. 2006).

Finally, we found 3 juveniles per nest, a value similar to that observed in Central Europe (Poland: 2.9-4.1; Mazgajski 2002) even though lower than that observed in other places, such as United Kingdom (3.78; Smith & Smith 2019) and Poland (3.92-4.48; Mazgajski & Rejt 2006, Kosiński & Ksit 2006).

Conclusion

In this study, we investigated which macro- and micro-habitat characteristics are selected by the Great Spotted Woodpecker across natural and man-made wooded environments. Our results indicate that both woodlands and tree plantations are selected. Specifically, oak and black locust woodlands positively associate with the occurrence of the species in our study area, as well as reforestations and traditional poplar plantations. However, despite the species also occurring in tree plantations, such areas possibly represent a complementary or supplementary habitat possibly exploited solely for foraging, as further suggested by the fact that all nests we found were in woodlands. Furthermore, for breeding, rather dense arboreal vegetation and fairly large trees are necessary, useful both for the presence of food resources, such as saproxylic beetles, and for digging the nests.

Finally, the density estimated for the species is similar to that found in other European areas and, considering the characteristics of this territory, indicates a good state of conservation. Nevertheless, this species faces local threats, such as the modification of the nesting and feeding habitat, the removal of dry or perishable trunks and the use of pesticides. To promote the presence of the species it is therefore advisable (i) to increase the surface of mature tree vegetation, keeping in mind the limited contribution of poplar plantations to the species occurrence, (ii) to promote the maintenance of mature trees and remaining natural vegetation in tree plantations, and (iii) avoid silvicultural practices during the breeding season, that is between late January and late July.

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Preliminary acoustic analyses of the structure of Red-billed *Leiothrix Leiothrix lutea* (Scopoli, 1786) song samples from Northern Italy

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Abstract - The authors present an introductory piece of research concerning the acoustic analysis of a set of song samples of Red-billed *Leiothrix Leiothrix lutea* from two regions of Northern Italy (Veneto, Liguria). By using an R package to analyze and find variations in the structure of the species' male songs, the count of the number of sound events detected, and the duration of pause event, show the most significant differences; moreover, the duration of signal events turns out to be different. The limited sample and the current lack of specific studies for comparison do not allow the authors to speculate whether the said variations are attributable to inter-individual variability or geographic isolation and habitat adaption: further research from wider geographic areas is no doubt needed, also using the methods we followed, to make the analysis replicable.

Keywords: acoustic analysis, exotic, Red-billed *Leiothrix Leiothrix lutea*, song, Northern Italy.

INTRODUCTION

The Red-billed Leiothrix *Leiothrix lutea* (Scopoli, 1786) is a polytypic species, distributed throughout a wide area ranging from southwestern Asia to southern China and northwestern India; it is naturalized in Japan, the Hawaiian Islands, Spain and France (Puglisi et al.2009). In Italy, the Red-billed Leiothrix is regarded as a resident bird (Baccetti et al. 2021), a naturalized breeding species whose populations belong to the subspecies *L. l. calypigia* (Brichetti & Fracasso 2010). It can be considered as such because its presence in the Italian peninsula consists of at least three self-sustaining populations (Verducci 2009). Its current distribution throughout Italy includes various populations scattered from Liguria in the Northwest (the region where some escaped birds formed the first breeding groups around the 1980s: Spanò et al. 2000), to Tuscany (Verducci 2009) and Lazio (Puglisi et al. 2011) in Central Italy. Fragmented populations are also known in the Veneto, Friuli-Venezia Giulia and in the Marche. Most of these settlements are believed to have originated around the 1990s or shortly before.

In neighboring Mediterranean France, the bird is widespread in the region of Nice (Belaud 2009) as well as the southwestern part of the country (Béarn: Basly 2007) and, further west, in the Iberian Peninsula (Pereira et al. 2019).In Italy, its breeding habitat consists of woodland with dense shrub undergrowth (Tuscany: Verducci, 2009), uncultivated and abandoned crops with shrubland, and pine and holm oak thickets (Liguria: Spanò et al. 2000); in the Northeast (Veneto: Piva, 2019), the Red-billed Leiothrix preferably settles in fresh woods of chestnut and hornbeam, especially if close to streams.

To date, no analytical data is available on the species' song structure and the state of research on Red-billed Leiothrix vocalizations in Italy is poorly known. Although the species is described in some detail by Ramellini (2017), it is not yet sufficiently investigated; the Red-billed Leiothrix, whose song is generically defined as variable in structure (Collar et al*.* 2017), is considered a bird featuring a repertoire of high inter-individual variability (Farina et al. 2013).Three types of song have been described, which are of different duration or with quieter and subdued tones (Collar et al*.* 2017). It is a bird that can acoustically interact with different species in the community (Ramellini 2017) and enter into competition, probably impacting on the Eurasian Blackcap in eastern Liguria (Farina et al. 2013) and on the Common Nightingale in Veneto (Piva 2019).

Our work aimed to verify and analyze differences and kinds of variation in the structure of song samples along the Red-billed Leiothrix distribution range.

MATERIALS AND METHODS

During 2018 and 2020 we collected some recordings of songs performed by individuals from seven different sites in two regions of Northern Italy, fairly distant geographically (Veneto and Liguria, nearly 250 km apart), for which quality recordings were available.

In Veneto, where the species has been widespread since about 2000 (Brichetti & Fracasso 2010), recordings were obtained in two different sites, the (Piva 2019) and the Chiampo valley, a pre-alpine valley on the edge of the Lessini mountains, about 45 km apart.

In Liguria two areas were selected: one located in the eastern part of the region, along the Riviera di Levante with three sites, Mezzanego, Castiglione Chiavarese (Genoa) and Deiva Marina (La Spezia). Here a first dissemination center was reported in 1980s (Spanò et al., 2000) and the species' density was known to be so high (Baghino et al. 2013) that it turns out to be acoustically dominant in the local bird community (Farina et al. 2013). The other area lies 115 km away, in western Liguria, specifically in the westernmost part of the province of Savona. Here the Red-billed Leiothrix is known to have been present since the 2000s and is also able to perform some migratory movements (Chiusi 2011) in the region where the species' breeding range appears to be, if not separated, at least still discontinuous to date (Baghino & Fasano 2017).

We acquired song samples referable to the Type I song as it was described in Collar et al. (2017): a rather rapid and fluty warble of up to 15 notes, recalling the Eurasian Blackcap (*Sylvia atricapilla*). We collected the recordings from 15 April to 20 May, before the egg-laying phase of the species (Brichetti & Fracasso 2010) when the singing activity is most intense.

In all areas, 96kHz/24-bit digital stereo recorders (Sony PCM-M10, Zoom H1) coupled with parabolic microphones (Dodotronic Hi-Sound stereo) were used on sunny/non-rainy days with light wind (wind speed < 0.3 m s^{-1}) and in absence of appreciable background noise. The audio files were recorded at a 48kHz/24bit sample rate in WAV format to achieve high sound quality and they were run by an audio analysis and editing software (Adobe Audition 7.01). Fourteen files contain multiple songs of the same individual, while two files include multiple songs of two different individuals. The songs analyzed were individually selected from the recordings obtained with parabolic microphones.

We also carried out deeper analyses of the male song through the open-source program RStudio (RStudio, Inc., 250 Northen Ave., Boston, MA 02210 844-448-1212) featuring a set of integrated tools designed to interact with an R environment for syntax highlighting, while taking advantage in particular of the added-in Seewave package (Sueur et al. 2008), considered the most suitable for our case study.

For each song (*.WAV file) we computed the duration of syllable periods, of pause periods between syllables, and their ratio (function: timer; Fig.1 and Fig. 2). We set an amplitude threshold of 15% applied on the Hilbert envelope with no time threshold and power factor. In order to smooth the time wave, and thus remove the residual noise, we also set msmooth, that is preferable for short (<60 s) sounds (Sueur 2018). The window length was a set of 512 samples without overlap. We analyzed the male songs considering three parameters: i) "s" as the duration of signal syllable (s) in seconds, ii) "p" as the duration of pause event among syllables in seconds (s) and iii) "n" as the count of the number of syllables detected.

To determine the distribution of all three parameters, we performed a Shapiro-Wilk test which did not show evidence of non-normality (parameter "s": W = 0.958, *P* = 0.068; "p": W = 0.976, *P* = 0.071; "n": W = 0.988, *P* = 0.570). Based on this outcome, we decided to use a parametric test. We calculated the mean and standard deviation of each parameter by site; furthermore, an analysis of variance (one-way ANOVA) was carried out to compare the difference between sites.

To analyze and find variations in the structure of species song we examined a batch of 100 songs. The duration of recordings is between 2 seconds and 7 seconds, with most samples coming from sites in the Veneto (*N* = 63) and Liguria (*N* = 37), of which 23 are from the eastern part of the region and 14 from the western part): in this species, the frequency of the male song ranges from 1500 to 3800 Hz (Farina et al. 2013).

In order to test the reliability of the sample obtained using the timer () function, we carried out the manual measure of a subsample (*N*=27) of songs. For each parameter considered (s, p, n) the difference in average of the two samples was tested by a paired t-Test. The results (parameter s: *t* = -1.622, *df* = 52, *P* = 0.110; parameter p: *t* = 0.413, *df* = 52, *P*= 0.681; parameter n: *t* = 0.278, *df* = 52, *P*= 0.781) allowed to accept the null hypothesis for each parameter, and therefore to consider the sample obtained with the timer () function as valid.

RESULTS

The summaries of results obtained from the analysis of song samples (minimum, maximum, mean, and standard deviation) by parameter were: "s" (min=0.01, max=0.17, mean 0.075±0.02), "p" (min=0.05, max=0.23, mean 0.13±0.03) and "n" (min=8, max=32, mean 16.03±4.65). The mean results by area are illustrated in Tab.1 and in the Fig. 3 and 4. All ANOVA tests were significant. All three parameters in the song samples of Red-billed Leiothrix differed significantly among the sites considered (one-way ANOVA: parameter "n": F = 7.16, P = 0.000; "p": F = 4.48, P <0.01; "s": F = 2.717, P<0.05). Our analyses showed differences in duration with a mean number of notes spanning wider than the 15 indicated by Collar et al. (2017); however, and in general, the current lack of research on the specific issue of song structure in the Red-billed Leiothrix allows a limited potential for comparisons and considerations.

DISCUSSION

A vast body of scientific literature has focused on the general topic of geographic variation in birdsong, which is most widespread among *Passeriformes*. Very distinctive intraspecific variations in syntax are found in a number of species and the microgeographic perspective primarily tends to focus on differences in phonetic variation (Mundinger 1982): genetic and cultural drift, natural, sexual and cultural selection are the causes called into question (Podos & Warren 2007). In the case of the Red-billed Leiothrix, a further source of variation may be the result of the species' ability to get adapted to the other species found in bird communities (Farina et al. 2013), and this might also have a role on a local scale.

The song repertoire of a species is affected by the environment and the density of individuals: the case of the Red-billed Leiothrix, an invasive and a new acoustically dominant species (Farina et al. 2013), a competitor with the power to impact on some native songbird species (Pereira et al. 2020) and a massive expansion throughout Western Europe (Herrando et al. 2010), can fit into this context.

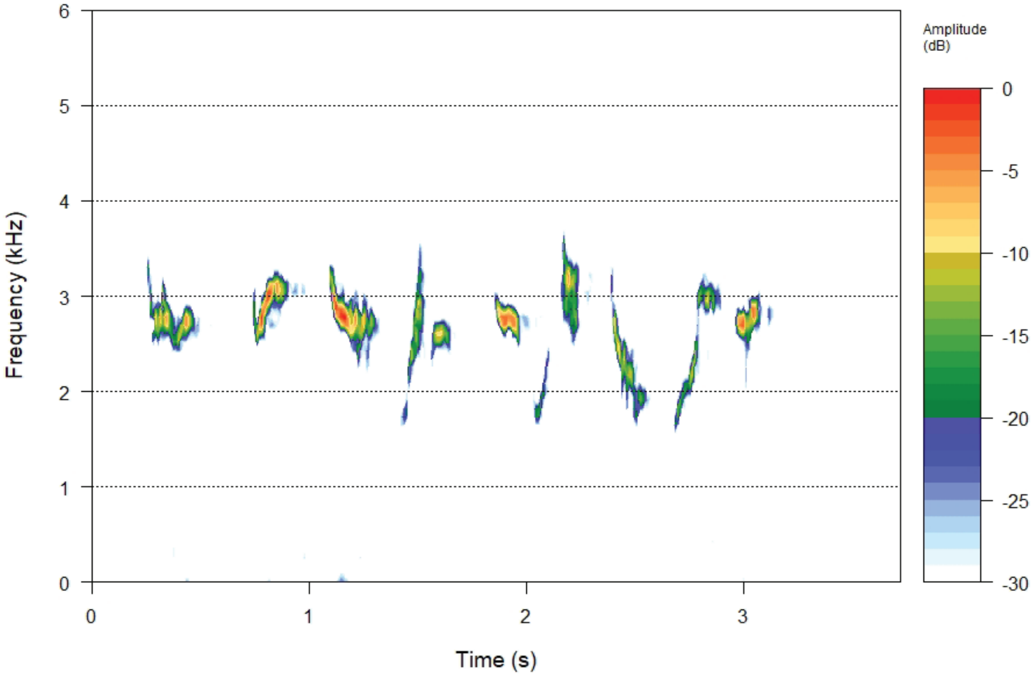

Figure 1. Spectrogram of male song obtained with "spectro ()" command. This function returns a two-dimension spectrographic representation of a time wave. The function corresponds to a short-term Fourier transform. We have run function using the default settings and modified the frequency Y-axis limits (in kHz), using flim = c (0.6).

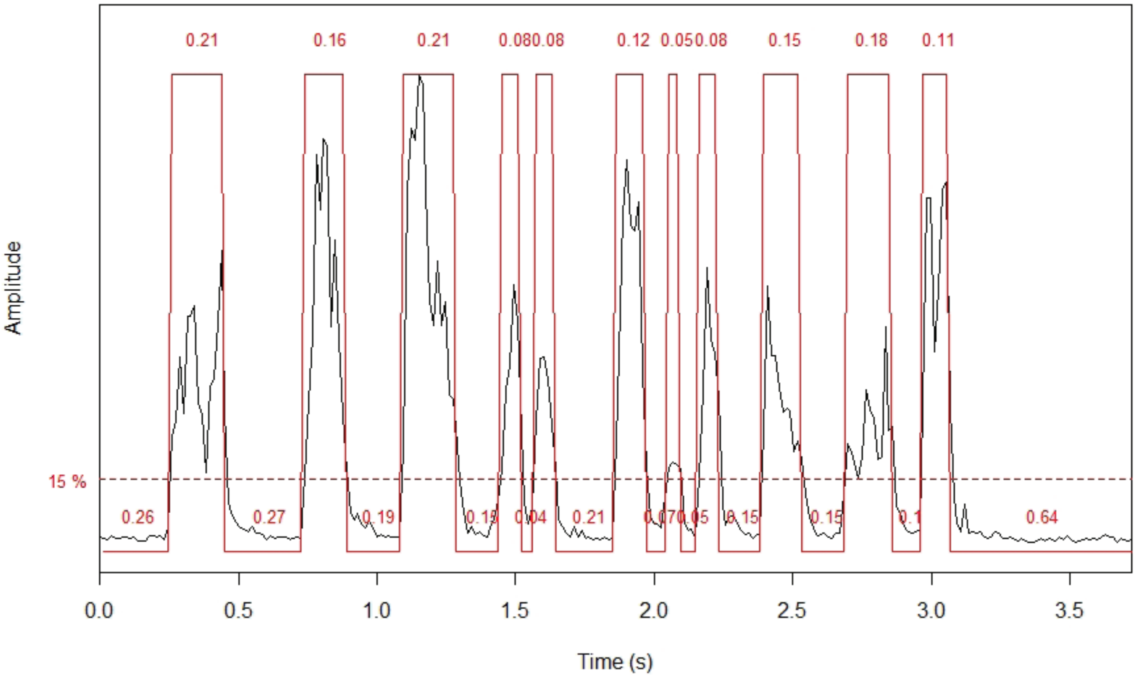

Figure 2. Plot resulting from the analysis of the parameters using the command "timer ()": this function computes and shows the duration of signal periods, the pause periods and their ratio. The amplitude threshold set for signal detection is 15%.

Table 1. Summary data of the song samples examined acoustically from recording sites of Northern Italy (V = Veneto; L = Liguria); the number of syllables, the duration of the emission and the duration of pauses are calculated with the mean ± standard deviation **(μ±SD)**; the measurement of time is in seconds.

Region	Site (province)	Geographic coordinates UTM WGS84	Habitat	Days/ session	Year	N strophes	N syllables (μ±SD)	Duration of the emission (μ±SD)	Duration of pauses (μ±SD)
V	Chiampo Valley (VI)	676325 5045795	Broadleaved woodland with thick undergrowth near a stream	1	2018	8	18.5±3.02	0.06	0.13±0.02
V	Colli Euganei, Torreglia (PD)	711950 5022070	Mixed woodland with predominant chestnut	1	2020	55	17.4±5.19	0.07±0.02	0.15±0.04
L	Deiva Marina (SP)	543370 4898100	Pinewood with thick undergrowth	1	2018	3	16.00±2.00	0.1±0.04	0.12±0.02
L	Mezzanego (GE)	534640 4914140	Shrubland with scattered patches of trees	2	2018	15	13.53±2.55	0.08±0.01	0.12±0.02
L	Castiglione Chiavarese (GE)	537770 4900750	Pinewood with thick undergrowth	1	2018	5	22.2±6.30	0.04±0.03	0.09±0.03
L	Casanova Lerrone (SV)	421230 4875700	Thermo-mesophilic woodland with undergrowth and ditches near a stream	1	2018	11	12.36±2.37	0.09±0.03	0.14±0.02
L	Garlenda (SV)	426600 4875100	Mixed woodland with thick and high undergrowth	1	2020	3	17.33±1.15	0.08±0.01	0.12±0.04

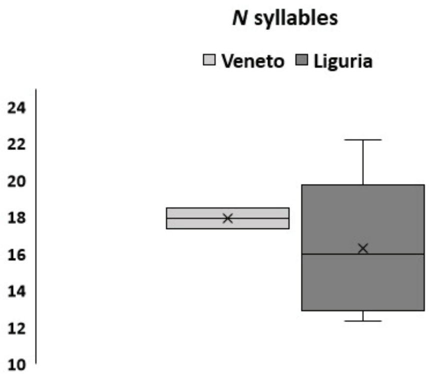

Figure 3. Number of syllables detected in the song samples from Veneto and Liguria regions.

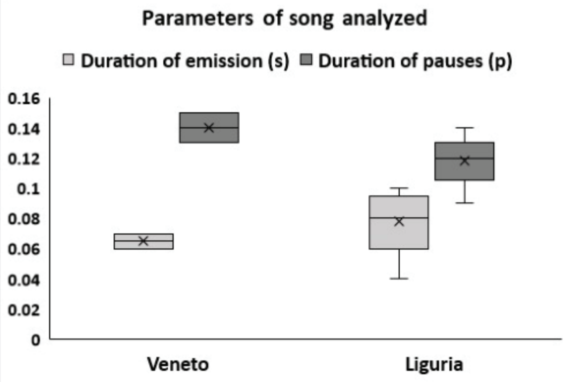

Figure 4. Parameters analysed (duration of emission and of pause in seconds) in the song samples from Veneto and Liguria regions.

The data collected represent an exploratory piece of research on this so far poorly known issue: our set of recorded samples with its differences in time duration is too numerically limited to argue if and how much such differences may be related to inter-individual variability or geographic isolation and habitat adaption (Lovell & Ross Lein 2013). And even as the song patterns of conspecific individuals from not very distant breeding areas of Northern Italy are different, we cannot make any assumptions about the various origins of these disjoint clusters of breeding birds.

Conversely, we were unable to expand the range of samples using materials available from the main website (www.xeno-canto.org) dedicated to sharing wild bird sounds. The recordings of species under pressure due to trapping are restricted, and it was not possible to download them.

Since bio-acoustic and eco-acoustic information is still largely lacking, further research is needed in regard to the variations of Red-billed Leiothrix vocalizations, with many more samples to be analyzed from wider geographical areas, both within and outside Italy.

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Italian Ornithological Commission (COI) - Report 30

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Abstract - Italian Ornithological Commission (COI) - Report 30. This report refers to records from January 1st 2020 to December 31st 2021, with the addition of a number of records from previous years that were submitted more recently. For each species, the records are listed by date and information is given as follows: English and scientific name, number of accepted records pre- and post-1950 (the numbers in this abstract refer to the total number of records), number of individuals if more than one, age or plumage and sex if known, location, date, names of the observers, and available documentation (photograph, sound recording, specimen, etc.). The taxonomy is in line with the new CISO-COI Italian Checklist, which also includes subspecies and follows the taxonomy adopted by the HBW-BirdLife Check-list, as decided by the CISO council in 2018. A total of 52 records involving 31 taxa were assessed. The following 40 records, involving 23 taxa, were accepted, including eight first records for Italy (Cat. AERC: A – COI Category 1A, 1B): Oriental Turtle-dove *Streptopelia orientalis* (Friuli-Venezia Giulia 2021, 4th record); Little Swift *Apus affinis* (Emilia-Romagna 2020, 7th record); **White-rumped Swift *Apus caffer*** (Calabria 2020, 1st record and 1st breeding); Allen's Gallinule *Porphyrio alleni* (Tuscany 2013, 9th record; Piedmont 2021, 10th record); **Atlantic Yellow-nosed Albatross *Thalassarche chlororhynchos*** (Latium 2021, 1st record); Brown Booby *Sula leucogaster* (Tuscany 2020, 8th record; Liguria 2020, 9th record; Tuscany 2021, 10th record); Pacific Golden Plover *Pluvialis fulva* (Campania 2020, 17th record; Basilicata 2020, 18th record; Apulia 2020, 19th record); **Grey-headed Lapwing *Vanellus cinereus*** (Umbria 2021, 1st record); White-tailed Lapwing *Vanellus leucurus* (Apulia 2020, 6th record); Upland Sandpiper *Bartramia longicauda* (Campania 2013, 11th record); **Western Sandpiper *Calidris mauri*** (Lombardy 2021, 1st record); Long-billed Dowitcher *Limnodromus scolopaceus* (Veneto 2013, 8th record; Latium 2020, 9th record); Lesser Yellowlegs *Tringa flavipes* (Latium 2021, 12th record; Apulia 2021 13th record); Black-winged Pratincole *Glareola nordmanni* (Lombardy 2021, 12th record); 'Russian Mew Gull' *Larus canus heinei* (Lombardy 2019-2021, 2nd to 11th records; Emilia-Romagna 2021, 12th record); Heuglin's Gull *Larus fuscus heuglini* (Abruzzo 2017, 4th record); **Thick-billed Murre *Uria lomvia*** (Liguria 2021, 1st record); Steppe Grey Shrike *Lanius excubitor pallidirostris* (Apulia 2020, 8th record); **Red-tailed Shrike *Lanius phoenicuroides*** (Sicily 2021, 1st record); Booted Warbler *Iduna caligata* (Tuscany 2021, 2nd record); Siberian Trush *Geokikla sibirica* (Lombardy 2020, 4th record); **Black-throated Wheatear *Oenanthe seebohmi*** (Abruzzo 2020, 1st record); Caspian Stonechat *Saxicola torquatus hemprichii* (Sicily 2019, 5th record). The addition of White-rumped Swift, Atlantic Yellow-nosed Albatross, Grey-headed Lapwing, Western Sandpiper, Thick-billed Murre, Red-tailed Shrike and Black-throated Wheatear brings the Italian list to 557 accepted species. Records not accepted (COI List 5A, 5B) were: Black-browed Albatross *Thalassarche melanophris* (Tuscany 2021); Yellow-billed Egret *Ardea brachyrhyncha* (Piedmont 2020); Steppe Whimbrel *Numenius phaeopus alboaxillaris* (Veneto 2020); Eastern Orphean Warbler *Sylvia crassirostris* (two records: Friuli-Venezia Giulia 2009-2011; Latium 2019); Ehrenberg's Redstart *Phoenicurus phoenicurus samamisicus* (Tuscany 2020); Naumann's Trush *Turdus naumanni* (Lombardy 2007); Western Yellow Wagtail *Motacilla flava iberiae* (Tuscany 2020); Yellow-breasted Bunting *Emberiza aureola* (Veneto 2019).

Introduction

This report details the records of rare species and subspecies in Italy submitted to and assessed by the Italian Ornithological Commission (Commissione Ornitologica Italiana - COI) as of 31st December 2021. The members who voted on the records in this report are Emiliano Arcamone, Nicola Baccetti, Pierandrea Brichetti, Adriano De Faveri, Giancarlo Fracasso, Egidio Fulco (Secretary), Andrea Galimberti, Ottavio Janni, Cristiano Liuzzi (Secretary), Sergio Nissardi, Menotti Passarella, Lorenzo Vanni and Michele Viganò. For more information on the Committee, including current members, please refer to the COI page on the CISO website (https://www.ciso-coi.it/coi/). Further details on the procedures with which the Committee operates and on the categorisations attributed to each examined record can be found in Report 24 (Janni & Fracasso 2012), available online at the address mentioned above. All previous COI reports are listed below:

Rivista Iitaliana di Ornitologia: (1) 1982, 52: 205-206; (2) 1983, 53: 194-195; (3) 1985, 55: 186-187; (4) 1986, 56: 245-246; (5) 1987, 57: 243-246; (6) 1989, 59: 269-272; (7) 1992, 62: 41-43; (8) 1993, 63: 193-198; (9) 1995, 65: 63-68; (10) 1995, 65: 147-149; (11) 1996, 66: 171-174; (12) 1997, 67: 189-192; (13) 1998, 68: 205-208; (14) 1999, 69: 211-214.

Avocetta: (15) 2002, 26: 117-121; (16) 2003, 27: 207-210; (17) 2004, 28: 41-44; (18) 2004, 28: 97-102; (19) 2005, 29: 93-97; (20) 2007, 31: 75-79; (21) 2008, 32: 82-86; (22) 2009, 33: 117-146; (23) 2010, 34: 71-106; (24) 2012, 36: 81-88; (25) 2013, 37: 67-70; (26) 2015, 39: 37-40; (27) 2018, 45-54; (28) 2019, 43: 177-188; (29) 2020, 44: 107-114.

The English names are those in the latest CISO-COI List of Italian Birds (Baccetti et al. 2021) or in the HBW & BirdLife International checklist (2022) for species first recorded in Italy. In accordance with the resolution adopted by the Committee in January 2018, this checklist includes all subspecies reported in Italy and follows the taxonomy of the HBW-BirdLife Checklist (del Hoyo & Collar 2014, 2016, HBW & BirdLife International 2018). The English names of the subspecies are not “official” because they are not reported in the world reference lists already mentioned. They were drawn from current literature. For each taxon, records are listed by date and accompanied by the following information: number of individuals (if more than one); age / sex if known (in non-adults the age is expressed in “calendar years” abbreviated to “cy”); updated number of accepted records since 1st January 1950 and before this date; locality including municipality (where applicable) and the province (abbreviated); names of the observers; and the nature of the provided documentation (photos, sound recordings, specimens, etc.).

ACCEPTED RECORDS (Category 1A, 1B)

Oriental Turtle-dove *Streptopelia orientalis*

(post-1949 = 3, pre-1950 = 1)

Rondover, Porcia (Pordenone Province), 29.III.2021; 1.IV.2021. Finder: Pier Luigi Taiariol (category 1A). Ssp. *meena;* documented by camera-trap on an artificial pond.

Little Swift *Apus affinis*

(post-1949 = 5, pre-1950 = 2)

Forlimpopoli (Forlì-Cesena province), 11.V.2020. Finder: Mattia Bacci (category 1B).

White-rumped Swift *Apus caffer*

(post-1949 = 1, pre-1950 = 0)

Umbriatico (Crotone province), 20.VI.2020 - 30.X.2020. Finder: Mario Pucci (category 1A). First report for Italy and first breeding record. (Fig. 1).

Two pairs of White-rumped Swifts were observed, both exhibiting territorial behavior. One of them successfully completed its breeding cycle, fledging at least one juvenile. In both cases, the species used a Red-rumped Swallow nest, as usual across its breeding range including the Iberian Peninsula, where 50-100 pairs breed (Chantler & Boesman 2020). This is an Afrotropical species with only small breeding populations in the Palearctic: Morocco and Iberia. It is very rare in the rest of North Africa (Tunisia) and

Europe (UK, Finland, Sweden and Norway, www.tarsiger.com). The species nested again at the same site in 2021 (Pucci in litt.).

Figure 1. White-rumped Swift *Apus caffer* found in spring 2020 by Mario Pucci in Umbriatico (Calabria). Adult using a Red-rumped Swallow's nest as breeding site. First Italian record. Ph. Giuseppe Martino.

Allen's Gallinule *Porphyrio alleni*

(post-1949 = 6, pre-1950 = 4)

Livorno, 5.XII.2013. Finder: Nicola Maggi, Giorgio Pesani (category 1A)."Lago Piccolo di Avigliana" (Torino province), 9.II.2021. Finder: Ivan Ellena (category 1A).

Atlantic Yellow-nosed Albatross *Thalassarche chlororhynchos*

(post-1949 = 1, pre-1950 = 0)

"Secche di Tor Paterno" protected marine area, Campo Ascolano, Pomezia (Rome province), 11.V.2021. Finders: Tiziano De Angelis, Corrado De Angelis (category 1A). First record for Italy and the Mediterranean. (Fig. 2).

The entire population of Atlantic Yellow-nosed Albatross, *Thalassarche chlorhynchos* breeds on a few islands in the Tristan da Cunha archipelago and on the nearby Gough Island in the South Atlantic Ocean. Outside the breeding season, which extends from September to April, the species disperses through the oceanic waters along the coasts of Argentina and Southern Africa, usually south of the Tropic of Capricorn. Similarly to Black-browed Albatross, *Thalassarche melanophris*, some birds cross the Equator and visit the North Atlantic up to the highest latitudes. These two mollymawks are the only albatrosses that occur regularly in the North Atlantic; Black-browed Albatross is relatively more frequent along the European seaboard, whereas the opposite has been observed along the eastern seaboard of North America, where Atlantic Yellow-nosed Albatross is an almost annual visitor. Atlantic Yellow-nosed Albatross remains a very rare vagrant to Europe, where it has been recorded mostly along the Atlantic seaboard (Norway, Faroe Islands, British Isles, France, Portugal and Spain), and exceptionally in the extreme south-western Baltic Sea (Sweden) and Mediterranean (Italy).

To date, 7 different individuals of Atlantic Yellow-nosed Albatross have been recorded and accepted by the relevant national rarity committees in the Western Palearctic (Fig. 3). In fact, the total number of reported observations is significantly higher because some records were very likely, or possibly, involved the same individual, an event that has been noted not uncommonly in other large seabirds, especially albatrosses. This is the case with the two British and one Swedish records of Atlantic Yellow-nosed Albatross in 2007, whereas two almost contemporaneous sightings in Norway have been attributed to a different individual. Even in 2020, two sightings a few days apart in Spain and Portugal probably involved the same bird (P. Ramalho in litt.). An almost contemporaneous observation in Spain was not sufficiently documented to ensure a specific identification, as is noted in the present report about the 2021 observation in Liguria.

Most North Atlantic observations have taken place between the late spring and late summer, a period that coincides with the post-breeding season of the species. The over 50 records along the eastern North America seaboard have occurred almost year-round but mostly from May to August; European records are concentrated in June and July, but the full range of dates spans from April to September.

The small sample of Atlantic Yellow-nosed Albatross records in Europe does not allow highlighting

Figure 2. Yellow-nosed Albatross *Thalassarche chlororynchos* found on 11.V.2021 in "Secche di Tor Paterno" protected marine area (Latium). Ph. Tiziano De Angelis.

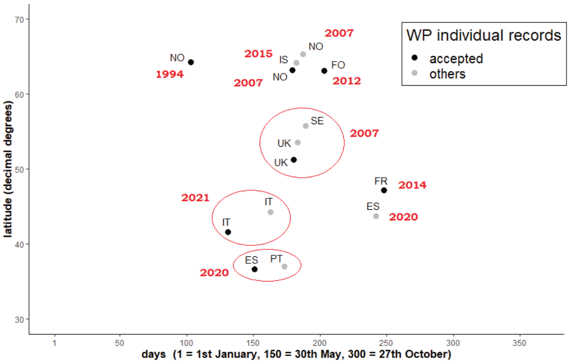

Figure 3. Latitudinal and seasonal distribution of *T. chlororynchos* records in the Western Palearctic. Black dots show individual records accepted by national committees. Circles encompass records that were likely or possibly attributed to the same bird, with black dots that show the first observation. Grey dots show subsequent observations of the same individual or records possibly attributed to this species. Country abbreviations: ES = Spain, FO = Faroe Islands (Denmark), FR = France, IS = Iceland, IT = Italy, NO = Norway, PT = Portugal, SE = Sweden, UK = British Isles.

any relationship between seasonal and geographical (latitudinal) occurrences. This is unsurprising for such an accomplished ocean wanderer, which can move freely through the European seas over the summer months once it has crossed the equatorial doldrums.

Brown Booby *Sula leucogaster*

(post-1949 = 10, pre-1950 = 0)

Mouth of the River Serchio, Vecchiano (Pisa province), 25.X.2020. Finder: Alessio Quaglierini (category 1B).

Tino island, Portovenere (La Spezia province), 23.XI.2020. Finder: Fabio Giacomazzi (category 1A); documented by photos.

Mouth of the River Serchio, Vecchiano (Pisa province), 9.VII.2021. Finder: Alessio Quaglierini (category 1B).

Pacific Golden Plover *Pluvialis fulva*

(post-1949 = 14, pre-1950 = 5)

Mouth of the River Regi Lagni, Castel Volturno (Caserta province), 21-26.V.2020. Finder: Marco D'Errico (category 1A); documented by photos (Fig. 4).

Mouth of the River Agri, Policoro (Matera province), 10.VII.2020. Finder: Alfredo Vilmer Sabino (category 1A); documented by photos.

Lake Lesina, Lesina (Foggia province), 24-25.X.2020. Giuseppe Amodeo (category 1A); documented by photos.

Figure 4. Pacific golden Plover *Pluvialis fulva* observed on 21.V.2020 in Castel Volturno (Campania). Ph. Marco D'Errico.

Grey-headed Lapwing *Vanellus cinereus*

(post-1949 = 1, pre-1950 = 0)

Olmo Lungo, Citerna (Perugia province), 18.VIII.2021. Finder: Mario Andreini (category 1A); documented by photos. First report for Italy. (Fig. 5).

This Asian species was first reported in the Western Paleartic in March 2018 in Turkey (Wiersma & Kirwan, 2020). The Turkish record was followed by three observations in May-June 2019 in Norway, Sweden and the Netherlands, probably referring to the same individual (Swedish Rarities Committee birdlife.se/rk/

raritetskatalogen). On 5 August 2021, an individual of this species was reported in Slovenia (http://www.tarsiger.com), where it remained for a few days. The sighting in central Italy occurred a few days after the last observation in Slovenia and very likely involved the same bird.

Figure 5. Grey-headed Lapwing *Vanellus cinereus* found on 18.VIII.2021 in Olmo lungo (Umbria). First record for Italy. Ph. Marco Andreini.

White-tailed Lapwing *Vanellus leucurus*

(post-1949 = 6, pre-1950 = 0)

Mouth of the River Fortore, Serracapriola (Foggia province), 21.I.2020-1.II.2020. Finder: Marco Zenatello (category 1A); documented by photos.

Upland Sandpiper *Bartramia longicauda*

(post-1949 = 9, pre-1950 = 2)

Ischia Island (Naples province), X.2013. Finder: Karl Ecke Demandt (category 1A). Feather's photos available (Fig. 6).

The circumstances of this record are noteworthy, for the collaboration shown by the many figures involved: the observer was Karl Ecke Demandt, who found some feathers on the island of Ischia in October 2013. The identification was made by two German ornithologists, Ralph Loesekrug and Hans-Joachim Böhr. Mr. Ecke Demandt unfortunately passed away recently and the feathers were kept by his wife. Hans-Joachim Böhr contacted Andrea Corso to whom he provided photos of the feathers and a clarification on the circumstances of the discovery. Andrea Corso subsequently informed the COI by sending the photos kindly provided by the German colleagues.

Figure 6. Upland Sandpiper *Bartramia longicauda*. Detail of tail feathers collected in October 2013 on Ischia Island by Mr. Karl Ecke Demandt (†). Ph. Hans-Joachim Böhr.

Western Sandpiper *Calidris mauri*

(post-1949 = 1, pre-1950 = 0)

Casei Gerola (Pavia province), 27.IX.2021. Finder: Lorenzo Prada (category 1A); documented by photos. First record for Italy.

A Neartic species breeding in Alaska and in North-eastern Siberia and wintering mostly along the eastern coasts of North, Central and South America (Franks et al., 2020). Very rare visitor in Europe, mainly in the Azores, Great Britain and France (www.tarsiger.it). A few days before the Italian observation, this same individual was observed in Switzerland, in the Maggia delta between 15 and 19 September, about 120 km north of Casei Gerola; the initial identification of the Swiss bird was made by Luca Giussani on the basis of photos posted on www.ornitho.ch and labeled as Dunlin (*Calidris alpina*). A number of plumage features, in particular an aberrant tuft of feathers, confirmed that the records in Switzerland and Italy referred to the same individual. This decision was shared with the Swiss Rarity Committee (Martinez & Schweizer 2022).

Long-billed Dowitcher *Limnodromus scolopaceus*

(post-1949 = 9, pre-1950 = 0)

Cascina Spinola, Livorno Ferraris (Vercelli province), X.2013. Finders: Franco Carpegna, Romeo Nicolini (category 1A); documented by photos.

Pantani dell'Inferno, Sabaudia (Latina province), 22.VII.2020. Finder: Giuseppe Di Lieto (category 1A); documented by photos and videos.

Lesser Yellowlegs *Tringa flavipes*

(post-1949 = 13*, pre-1950 = 0)

Lake Fogliano, Latina (Latina province), 22.IX.2021. Finder: Giuseppe Di Lieto (category 1A); documented by photos and videos.

Aloise, Zapponeta (Foggia province), 16.X.2021. Finder: Giuseppe Fiorella (category 1A); documented by photos.

There are currently 13 records of *Tringa flavipes* in Italy that are considered valid, but few clarifications are necessary: the first two sightings predate the establishment of the COI, and as such were never examined. During its initial decades of work, COI only examined species for which there were 5 or less records in Italy, so some of the records listed below (i.e. number 6 and 7) were never examined by COI. Tab. 1 shows the list of records known so far, indicating which are considered valid, which have been examined by the COI, and which are known to have been documented by photos or videos but have not yet been submitted to the Committee.

Black-winged Pratincole *Glareola nordmanni*

(post-1949 = 7, pre-1950 = 5)

Bordenotte, Viadana (Mantova province), 28.VIII.2021 to 2.IX.2021. Finder: Alessandro Pavesi (category 1A); documented by photos.

Russian Common Gull *Larus canus heinei*

(post-1949 = 12*, pre-1950 = 0)

Schiranna, Varese (Varese province), 11.I.2019. Finder: Luca Giussani (category 1A).

Ranco (Varese province), 24.I.2019-.11.II.2019; 28.XII.2019 - 3.I.2020. Finder: Luca Giussani (category 1A).

Onno, Oliveto Lario (Lecco province), 6.II.2020. Finder: Francesco Ornaghi (category 1A).

Bosisio Parini (Lecco province), 9.II.2020. Finder: Enrico Viganò (category 1A).

Mouth of the River Tresa, Germignana (Varese province), 21.II.2020. Finder: Luca Giussani (category 1A).

Mandello del Lario (Lecco province), 22.XII.2020. Finder: Enrico Viganò (category 1A).

Abbadia Lariana (Lecco province), 4.I.2021. Finder: Enrico Viganò (category 1A).

Oggiono (Lecco province), 8.I.2021 fino a 24.II.2021. Finder: Enrico Viganò (category 1A).

Oggiono (Lecco province), 9.II.2021. Finder: Enrico Viganò (category 1A).

Abbadia Lariana (Lecco province), 27.II.2021. Finder: Enrico Viganò (category 1A).

Miramare di Rimini (Rimini province), 28.II.2021. Finder: Christian Montevecchi (category 1A).

Now that field identification criteria have been established, we examined as many claims as we could to gauge the status of this taxon in Italy, and whether it should be subject to examination by COI. Overall, we examined 11 claims, each accompanied by excellent photographic documentation. All observations were accepted, mainly on the basis of the identification criteria indicated by Adriaens & Gibbins 2016, and followed the first national record (Fulco & Liuzzi 2021). With the exception of a record in the northern Adriatic coast, all the observations took place in the pre-Alpine lakes of northern Italy (e.g. Lake Maggiore, Lake Como, Lake Varese).

Based on this analysis, *Larus canus heinei* will no longer be evaluated by the Italian Birds Rarities Committee as of January 2022.

Heuglin's Gull *Larus fuscus heuglini*

(post-1949 = 4, pre-1950 = 0)

Giulianova (TE), 2.XII.2017; Finder: Dimitri Marrone (category 1A); documented by photos.

Further observations at Tortoreto-Martinsicuro (Teramo province) during 2020-2021 were attributed to the same individual already approved in Report 28 (Fulco & Liuzzi 2019). Overall, there are 4 approved records in Italy, as summarized in Tab. 2, although several photographically documented claims are yet to be submitted.

Table 1. List of known sightings of *Tringa flavipes* in Italy (updated December 2021). The symbol * denotes the records examined by the COI.

N	Site	Date	COI examination status	References
1	Molentargius Salt pans (Cagliari province)	16.V.1962	not examined	Walter 1964
2	Orbetello Lagoon (Grosseto province)	15-25.X.1978	not examined	Angle et al. 1980
3*	Stagno di Capoterra (Cagliari pronvince)	6.IV.1985	accepted 1B	Report COI 8 (Brichetti & Arcamone 1993)
4*	Montelargius Salt pans (Cagliari province)	22-23.III.1989	accepted 1B	Report COI 8 (Brichetti & Arcamone 1993)
5*	Lake Caprolace (Latina province)	Late July-early Sept. 1994	accepted 1A	Report COI 9 (Brichetti & Arcamone 1995)
6	Siracusa Salt pans and Augusta Salt pans	31.X.-1.XI.1995	not expected	Arcamone & Brichetti 1997
7	Montelargius Salt pans (Cagliari province)	14.IV.1999	not expected	Schenk 2012
8*	Codigoro (Ferrara province)	5.X.2003	accepted 1A	Report COI 18 (Brichetti & Occhiato 2004)
9*	Campobello di Mazara (Trapani province)	21.VIII-15.IX.2008	accepted 1A	Report COI 22 (Janni & Fracasso)
10	Valle Millecampi (Venice province)	25.VI.2011	not submitted, but documented. Pending	Sighele et al. 2012
11*	Aloise, Zapponeta (Foggia province)	13.XI.2011	accepted 1A	Report COI 25 (Janni &Fracasso 2013)
12	Pachino (Siracusa province)	8.IX.2012	not submitted, but documented. Pending	Corso in Nicoli et al. 2013
13*	Butera (Catania province)	12.XII.2013	accepted 1A	Report COI 26 (Janni & Fracasso 2015)
14	Casei Gerola (Pavia province)	27.X-7.XI.2020	not submitted, but documented. Pending	Torniolo in Nicoli et al. 2021
15*	Lake Fogliano (Latina province)	26.IX.2021	accepted 1A	present Report
16*	Aloise, Zapponeta (Foggia province)	16.X.2021	accepted 1A	present Report

Table 2. List of homologated records of *Larus fuscus heuglini* in Italy

Record	Age	Date	Place	Observers	References
1	Ad.	9.II.2001	Catania	A. Corso, L. Jonsson	Report COI 17 (Brichetti & Occhiato 2004)
2	Ad.	30.XI.2012-3.II.2013; 14.X.2013-13.II.2014	Mola di Bari (Bari provice)	C. Liuzzi	Report COI 27 (Fracasso et al. 2018)
3	Ad.	4.X.2017-10.XII.2017; 25.X.2018 2.XII.2019-20.I.2020	Tortoreto-Martinsicuro (Teramo province)	D. Marrone, E. Viganò	Report COI 28 (Fulco & Liuzzi 2019)
4	Ad.	2.XI.2017; 4.I.2018-4.II.2019 15.XII.2019-27.XII.2019; 9.XII.2021- 6.I.2022	Giulianova (Teramo province)	D. Marrone, E. Viganò	Present Report

Thick-billed Murre *Uria lomvia*

(post-1949 = 1, pre-1950 = 0)

12 miles off the Genoa coast, 9.VI.2021. Finders: Giovanni Lucchi, Daniela Papi, Alessandro Verga (category 1A). First record for Italy and the Mediterranean. (Fig. 7).

An exclusively marine species that is very rare outside its range. Occasionally ranges to Britain and Netherlands, more exceptionally to France; the present record also represents the southernmost one in Europe.

Figure 7. Thick-billed Murre *Uria lomvia*. First Italian sighting. Observed on 09.IV.2021 12 miles off the Genoa coast (Liguria). Ph. Giovanni Lucchi.

Steppe Grey Shrike *Lanius excubitor pallidirostris*

(post-1949 = 8, pre-1950 = 0)

Margherita di Savoia (Barletta province), 20.XII.2020 - 16.I.2021. Finder: Salvatore Giannino (category 1A); documented by photos (Fig. 8).

Wintering individual. First wintering case documented in Italy. The subspecies identification of this record, first attributed to "Great Grey-Shrike" *sensu lato,* was proposed by Ottavio Janni on the basis of photos published online.

Figure 8. Steppe Grey Shrike *Lanius excubitor pallidirostris*. First documented wintering (20.XII.2020 - 16.I.2021) in Margherita di Savoia (Apulia). Ph. Salvatore Giannino.

Red-tailed Shrike *Lanius phoenicuroides*

(post-1949 = 1, pre-1950 = 0)

San Filippo del Mela (Messina province), 16.V.2021. Finder: Enzo Lombardo et al. (category 1A); documented by photos (Fig. 9). First record for Italy.

Previous claims have been attributed to *Lanius phoenicuroides/isabellinus* due to the lack of adequate documentation that would allow discrimination between the two species (Fulco & Liuzzi 2019).

Figure 9. Red-tailed Shrike *Lanius phoenicuroides*. First Italian record in San Filippo del Mela (Sicily) on 16.V.2021. Ph. Enzo Lombardo.

Booted Warbler *Iduna caligata*

(post-1949 = 2, pre-1950 = 0)

Lake Massaciuccoli, Vecchiano (Pisa province), 27.IX.2021. Finder: Daniele Occhiato (category 1A); documented by photos.

Siberian Thrush *Geokichla sibirica*

(post-1949 = 1, pre-1950 = 3)

Càrzen Mount, Capovalle (Brescia province), 10.X.2020. Finder Alessandro Micheli (category 1A). 1st winter plumage.

The bird was accidentally shot by a hunter who showed the unidentified specimen to Alessandro Micheli. Subsequently Alessandro Micheli, having identified the species, submitted the record to the COI. Only 3 pre-1950 records are known in Italy. The only other post-1949 observation, referring to a subject caught by hand in 1991 in the province of Brescia, was attributed to an escaped bird (Brichetti & Arcamone 1995, Brichetti & Fracasso 2008).

Black-throated Wheatear *Oenanthe seebohmi*

(post-1949 = 1, pre-1950 = 0)

Campo Imperatore, L'Aquila, 14.V.2020. Finder Eliseo Strinella (category 1A); documented by photos (Fig. 10).

First record for Italy.

Figure 10. Black-throated Wheatear *Oenanthe seebohmi*. First Italian record. Campo Imperatore, L'Aquila (Abruzzo) on 14.V.2020. Ph. Eliseo Strinella.

Caspian Stonechat *Saxicola torquatus hemprichii*

(post-1949 = 5, pre-1950 = 0)

Linosa Island (Agrigento province), 28.X.2019. Finder Michele Viganò (category 1A); documented by photos.

ACCEPTED RECORDS (Category 1C)

Albatros sp. *Talassarche sp.*

Genoa, 21.VI.2021. Finder Carlo Ruaro e Gianfranco Giolfo (category 1C).

Despite the high probability that this individual was the same *T. chlororhynchos* observed and well documented a few months later in Rome province, the available documentation does not allow for a species-level identification.

Sykes's/Booted Warbler *Iduna rama/caligata*

Sesto fiorentino (Firenze province), 27.IX.2021. Finder Daniele Occhiato (category 1C).

Based on the description received and given the objective difficulty in discriminating with reasonable certainty between the two very similar species of "Asian warblers", the record has been attributed to the species aggregate *Iduna rama/caligata*.

Atlas/Iberian Pied Flycatcher *Ficedula hypoleuca speculigera/iberiae*

Ventotene Island (Latina province), 23.IV.2019. Finder Fabrizio Cimino (category 1C).

The only picture available appears to be compatible with *Ficedula hypoleuca speculigera*; however, given the great uncertainty in discriminating between *F. h. speculigera* and *F. h. iberiae*, and the frequent hybridization between "pied" *Ficedula* species, it is considered necessary to have at least a sound recording for safe identification. Recent studies have shown that it is almost impossible to distinguish the two taxa on morphological features in the field (Corso et al., 2015).

RECORDS NOT ACCEPTED (LIST COI 5)

Black-browed Albatross *Thalassarche melanophris*

Bocca di Serchio, Vecchiano (Pisa province), 4.III.2021. (category 5A).

Yellow-billed Egret *Ardea brachyrhyncha*

Castel'Alfero (Asti province), 18.I.2020. (category 5A).

Steppe Whimbrel *Numenius phaeopus alboaxillaris*

Porto Tolle (Rovigo province), 31.VII.2020. (category 5A).

In order to evaluate this difficult record, which only had poor photographic documentation, the Committee contacted Gary Allport, in light of his considerable experience with this taxon. The opinion received confirmed that the photographic documentation available is not sufficient to identify this subspecies with reasonable certainty. The record, therefore, was not approved.

Eastern Orphean Warbler *Sylvia crassirostris*

Corona di Mariano del Friuli (Gorizia province), VII.2009. (category 5A). Breeding.

A bird attributed to this species was claimed to have bred during the period 2009 to 2012. However, the available documentation consists only of a very short recording of the song made in 2009 that does not exclude Western Orphean Warbler *Sylvia hortensis* or other species. Furthermore, no evidence of nesting was provided.

Ventotene Island (Latina province), 9.V.2019 (category 5B).

Ringed individual. The characters of the plumage and the biometric data are compatible with Western Orphean Warbler *Sylvia hortensis*.

Ehrenberg's Redstart *Phoenicurus phoenicurus samamisicus*

Arnino, San Pietro a Grado (Pisa province), 4.IV.2020 (category 5A).

This taxon is particularly challenging to identify in the absence of clear and unambiguous documentation. Recent research (Martinez et al. 2022) found a moderate frequency of breeding individuals showing some plumage features of *P. p. samamisicus* west of its known range (from the south-eastern Balkans to central Asia). The same article recommends attributing to this taxon only individuals with all or most typical characters. In conclusion, based on the available documentation, it is not possible to attribute this individual with reasonable certainty to the proposed taxon.

Naumann's Trush *Turdus naumanni*

Valtorta (Bergamo province), 15.XI.2007. (category 5B).

The observation concerns an individual that was captured and caged. Based on the images provided, it can be identified as a very rare hybrid *Turdus pilaris x Turdus iliacus*.

Western Yellow Wagtail *Motacilla flava iberiae*

Castiglione della Pescaia (Grosseto province), 15.V.2020. Breeding. (category 5B).

Yellow-breasted Bunting *Emberiza aureola*

Trissino (Vicenza Province), 5.VII.2019. (category 5B).

ITALIAN BIRD CHECK-LIST UPDATE (CISO-COI Lists A, B and C)

With the addition of White-rumped Swift, Atlantic Yellow-nosed Albatross, Grey-headed Lapwing, Western Sandpiper, Thick-billed Murre, Red-tailed Shrike and Black-throated Wheatear, the total number of species on the Italian bird list (A, B and C) increases to 557 (Baccetti et al. 2021).

Acknowledgments

Despite the risk of sounding rhetorical, we sincerely thank all the observers who believed in the work of the Committee by sending their reports. Without the collaboration of all the active ornithologists and birdwatchers who put in countless hours in the field, it would not be possible to achieve such results. Special thanks to Andrea Nicoli and EBN Italia for their valuable contribution for disseminating rare bird observations. Thanks to Andrea Corso and Maurizio Sighele for the stimulating discussions and the help provided in tracking down a number of older records. We also are grateful to Swiss Rarities Committee and Bernard Volet for a useful exchange of information regarding the Western Sandpiper record. Many thanks to Ralph Loesekrug and Hans-Joachim Böhr for sending photos of the Upland Sandpiper's feathers found by Karl Ecke Demandt, to whose memory all our thanks go. Special thanks to Gary Allport and Lars Svensson, for kindly helping us for some particularly challenging sightings. Many thanks to Giancarlo Fracasso, for his numerous advice and for having drafted the text on Atlantic Yellow-nosed Albatross. Thanks to Pierandrea Brichetti, Nicola Baccetti and Ottavio Janni for reviewing the report.

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https://doi.org/10.30456/AVO.2022205 Avocetta 46: 135-138 (2022)

Bird news

This column aims to collect a series of interesting observations and to make it accessible to the scientific community in future. We collect observations without time, space or species limitation but we focus on a limited series of category of interest. See more on Avocetta website: http://www.avocetta.org/bird-news-column/

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1. Common Swift *Apus apus*

Observer: Roberto Brembilla (bremby.var@gmail.com)

Category: Unusual breeding location

Number of individuals: 3-4 active nests

Status: Breeding

Site location: Montespluga, Madesimo (Sondrio), Italy (1908 m asl)

Date of observation: 26th June 2022

Notes of the observer: The colony has been active since 1992 at least. Regular breeding has been confirmed since 2010.

Reason of interest: This is one of the highest known breeding colonies of the species in the Italian Alps.

2. Common Swift *Apus apus*

Observer: Mario Caffi (tubocaffi@libero.it)

Category: Unusual chromatic aberration

Number of individuals: 1

Status: Breeding

Site location: Swift tower of San Paolo (Brescia), Italy

Date of observation: Between April and July 2022

Reason of interest: Leucistic individual. It successfully bred inside the Swift tower, which in the breeding season 2022 hosted 124 pairs.

3. Scopoli's Shearwater *Calonectris diomedea*

Observers: Roberto Vento (roberto.vento01@community.unipa.it), Sara Pedone
Category: Unusual breeding location
Number of individuals: 4 nests estimated
Status: Breeding
Site location: Lipari (Messina), Italy
Date of observation: 1st and 2nd August 2022
Notes of the observers: The observations have been made according to the guidelines from ISPRA for the monitoring of the species.
Reason of interest: This is a new and unpublished breeding site of this species of conservation interest.

4. Yelkouan Shearwater *Puffinus yelkouan*

Observers: Roberto Vento (roberto.vento01@community.unipa.it), Andrea Cusmano
Category: Unusual breeding location
Number of individuals: 6 nests estimated
Status: Breeding
Site location: Ustica (Palermo), Italy
Date of observation: 25th-27th April 2022
Notes of the observers: The observations have been made according to the guidelines from ISPRA for the monitoring of the species.
Reason of interest: This is a new and unpublished breeding site of this species of conservation interest.

5. Eurasian Thick-knee *Burhinus oedicnemus*

Observers: Sandro Bertè, Daniele Ecotti, Franco Roscelli, Guido Sardella (oasighirardi@wwf.it)
Category: Unusual behaviour
Number of individuals: 4
Status: Breeding
Site location: Ingegna River, Albareto (Parma), Italy (480 m asl)
Date of observation: Between June and August 2022
Notes of the observers: Placed on the border of the Ghirardi Nature Reserve, Ingegna is a stream tributary of the Taro River in the Parmesan Apennines. It flows in a North-South direction having a large and flat gravel bed, flanked by woods and meadows regularly mowed in spring-summer. For the first time, we observed reproductive behaviours (calls, injury-feigning, two adults with two juveniles) in this site, located at 480 m asl.
Reason of interest: In Northern Italy, Eurasian Thick-knees nest usually from sea level up to 250 m asl.

6. Lesser Grey Shrike *Lanius minor*

Observer: Giuseppe Speranza (gisperbw@gmail.com)

Category: Unusual breeding location

Number of individuals: 4 (1 adult and 3 juveniles)

Status: Breeding

Site location: Atessa (Chieti), Italy (42.106352 N; 14.501270 E; 240 m asl)

Date of observation: 16th - 18th August 2019

Notes of the observer: I observed one adult feeding three recently fledged juveniles. I also saw one individual 1 cy in the same place at the end of August 2019, so I suppose that one or more pairs could breed in this area.

Reason of interest: The species is considered a very rare breeder in Abruzzo, with no confirmed breeding attempts in the last years.

7. Common Raven *Corvus corax*, Northern Goshawk *Accipiter gentilis*

Observer: Alessandro Berlusconi (aberlusconi@uninsubria.it)

Category: Unusual behaviour

Number of individuals: 1 Common Raven, 1 Northern Goshawk

Status: Foraging

Site location: Colle di San Maffeo, Rodero (Como), Italy (45.831944 N; 8.922222 E; 505 m asl)

Date of observation: 27th September 2022

Notes of the observer: Kleptoparasitic behaviour by Common Raven on Northern Goshawk during prey (probably a Passerine bird) transport.

Reason of interest: Unusual behaviour, never described for the Common Raven on Northern Goshawk so far.

8. Eurasian Crag Martin *Ptyonoprogne rupestris*

Observers: Maurizio Saltarelli, Marco Pantalone (pantalone.marco@libero.it)

Category: Unusual behaviour

Number of individuals: Between 4 and 7

Status: Breeding

Site location: Gorge of Furlo, Acqualagna (Pesaro e Urbino), Italy

Date of observation: Between May and June 2022

Notes of the observers: Some individuals of Eurasian Crag Martin have been observed for a long period and for the whole day capturing insects near a Peregrine Falcon *Falco peregrinus* nest. The abundance of winged insects was due to the numerous remains of prey not consumed by the three Peregrine Falcon nestlings. This situation created a preferential hunting area for the Eurasian Crag Martins breeding in the surroundings. The behaviour began about ten days after the hatch of the Peregrine Falcon chicks, continuing until their fledging. In the Gorge of Furlo, Peregrine Falcon nests (1-3 breeding pairs per year) have been monitored constantly since 1997 and this behaviour has never been observed before.

Reason of interest: Unusual commensal behaviour for an Hirundinidae; some individuals have learned to exploit the abundance of food around a raptor nest.

9. Collared Sand Martin *Riparia riparia*

Observers: Salvatore Surdo (salvatore.surdo@unipa.

it), Andrea Cusmano, Danilo Graffeo, Roberto Vento

Category: Unusual phenology

Number of individuals: 1

Status: Wintering

Site location: Trapani saltpans (Trapani), Italy

Date of observation: 6th December 2022

Notes of the observers: Observation of a single individual flying over the saltpans and feeding for a long time.

Reason of interest: The Collared Sand Martin is an occasional wintering species for Italy, with very few confirmed observations.

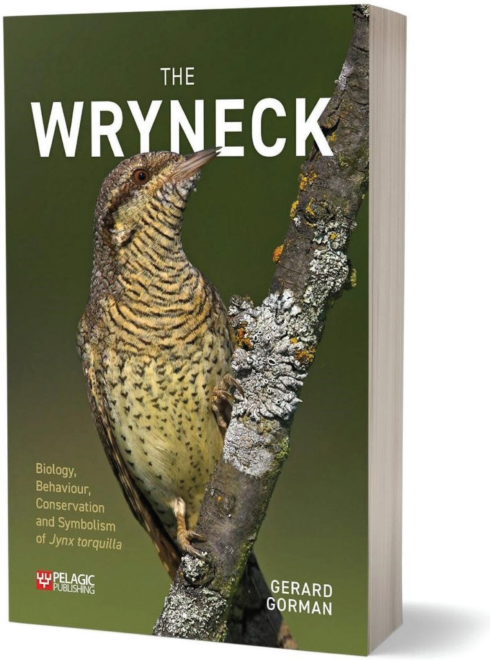
Columns

Avocetta 46: 139-143 (2022)

Book reviews

Publishers and Authors are invited to submit a copy of their books for a review in the journal. Books are to be sent to the Deputy Editor-in-chief of Avocetta (Dr. Michelangelo Morganti - CNR-IRSA Consiglio Nazionale delle Ricerche, Istituto di ricerca sulle acque - Via del Mulino 19, 20861 Brugherio - MB)

A quite bizarre woodpecker: the first monograph on the Eurasian Wryneck



Woodpeckers present an outstanding suite of adaptations which enables them to live a life deeply connected to woodlands. This uniqueness was recognised when Charles Darwin took woodpeckers as an example to illustrate the evolutionary origin of adaptation in *On the Origin of Species* (1859). Today these characteristic birds continue to be celebrated in the books by Gerard Gorman who has been studying woodpeckers of the Picidae family for years. In his latest work published in 2022, Gorman shifts his focus to one member of the family who stands out from the rest of the group because of its differences - the Wryneck *Jynx torquilla* – writing the first monograph on the species entitled "The Wryneck, biology, behaviour, conservation and symbolism of *Jynx torquilla"*.

Gorman skilfully writes a book based on an extensive scientific bibliography and enriches it with personal observations coming from his experience and long time spent observing the species in the field. As a result of this combination, the book is enjoyable to read and understandable by a very wide audience such as professional ornithologists, birdwatchers as well as less experienced readers who are approaching for the first time the wonderful world of woodpeckers.

The book consists of 16 chapters (208 pages) embellished with photographs that depict the habitats in which it nests and forages and that portray peculiar aspects of Wryneck behaviour such as the amazing "neck-twisting and head-turning", or details of its plumage, vocalisation, and anatomy. The structure of the chapters guides the reader towards a progressive discovery of this unusual woodpecker, starting with the origin, taxonomy, anatomy and moult, followed by the description of the distribution and the numerous ecological and behavioural aspects known so far. The reader's attention is constantly stimulated by the frequent comparisons the author makes with other members of the Picidae family highlighting differences and similarities. To provide a complete view of the genus *Jynx*, one chapter is dedicated to the only other relative, the Red-Throated Wryneck, *Jynx ruficollis,* with whom the Eurasian Wryneck overlaps in sub-Saharan Africa during the non-breeding season. Finally, the book closes with a chapter in which the author tells us about the distant and manifold links between the Wryneck and folklore of various cultures, some of which have ascribed esoteric roles and powers to this bird due to its bizarre movements and sounds, and gave birth to myths and legends. Finally, the price is affordable and the paperback is light, compact and easily transportable.

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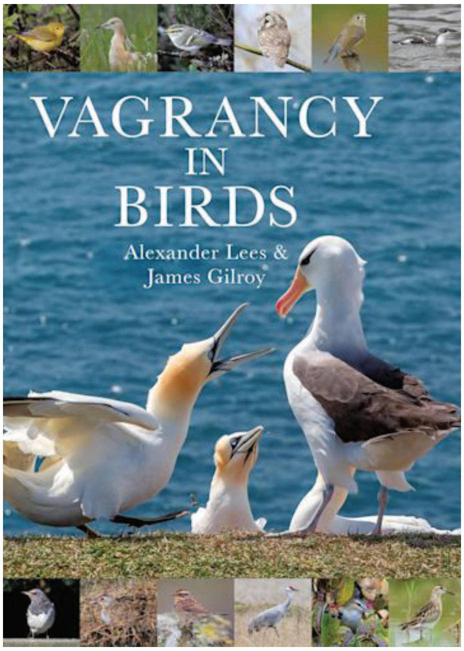
Reference

Gorman G., 2022. The Wryneck, biology, behaviour, conservation and symbolism of *Jynx torquilla*. Pelagic publishing, Exeter, UK. 202 pp. 24.99 £

Blowing in the wind: insights into the life of vagrant birds



Vagrants, cross and delight of so many birdwatchers around the world. Every time a feathered traveller finds itself lost on a lonely island, on the outskirts of a busy city, or perhaps in a field in the middle of nowhere, thousands of km far away from home, a crowd of birders grab their binoculars and come, no matter how long the trip will be. For some, a quick glance and a tick in the checklist are enough. Others spend most of their time looking at every distant silhouette, listening to every feeble call in search of the sighting of a lifetime.

But how many of us find a minute to wonder how this particular individual came to be displaced from its range, while we admire the details of its plumage or we wait for the ideal light for a photo? Was it a gust of wind or maybe an instant of confusion during the fight? Far from being a marginal circumstance, vagrancy is the result of the mechanisms of migration, and could even lead to unsuspected consequences on populations and ecosystems. “Vagrancy in Birds” illustrates this intriguing phenomenon from the perspective of a bird.

A long introduction takes us into the world of bird migration. Reviewing literature from the origin of migration research to the most up-to-date studies, it provides a striking summary of how orientation and internal clocks work (and how they can fail) and outlines the complex patterns of wind streams that birds have to cope with as they roam the sky. From mirror-image misorientation to extreme weather spells, from overshooting to ship-assisted journeys, from nomadism to exploratory movements, all the possible reasons for vagrancy are thoroughly explored.

The second part of the volume presents an overview of the propensity to travel off the “right” routes across the whole avian tree of life. If it is not surprising to find out that waders are much more prone to wander the world than ostriches, we can still be impressed by the long section dedicated to the dumpy pheasants and grouse, or by the fact that remote islands are sometimes inhabited by highly sedentary bird groups, and vagrancy is a good candidate to explain some of these distribution patterns. Family accounts, which make up most of the volume, detail the range and movements of a vast sample of species, along with vagrancy records, and the hypotheses on the underpinning causes. Nice photos and exhaustive captions enrich the book throughout the text.

"Vagrancy in birds" is not only for twitchers. It is a must-have on the shelves of all people thrilled by the enigma, still not fully solved, of bird migrations.

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Reference

Lees A. & Gilroy J., 2022. Vagrancy in Birds. Bloomsbury Publishing. 400 pp. 40.00 £

The Birds of Italy 3

The third volume of *Birds of Italy* is the closing chapter of a huge effort to review and synthesize the knowledge on the birds of our Country. This colossal work was in fact started by Pierandrea Brichetti and Giancarlo Fracasso in 2003 when they published the first of nine volumes of *Ornitologia Italiana*. With *Birds of Italy*, the authors embarked on an even more worthy venture: to make our collective knowledge accessible to an international readership, by designing a synthetic and updated series of three volumes fully written in English.

This third volume, which follows the style and the structure of the previous two, spans from the Cisticolidae to the Icteridae families according to the IOC World Bird List (Gill F., Donsker D. & Rasmussen P. (Eds.) 2021. IOC world bird list. IOC) and is updated to 2019. Overall, 249 species are presented. For regular ones, synthetic —though meticulous— data on distribution, habitat, population size and density, trend, breeding calendar, movements, and wintering are given. For vagrants, each accepted occurrence record is listed, providing an important baseline to understand the occurrence patterns of rare species in Italy.

The book is completed by rich iconography, including very detailed and updated distribution maps of most species, a remarkable number of graphs that illustrate phenology and trends, and a closing section with high-quality colour photographs of the regular species of the Italian fauna.

The volume is further enriched by three opening chapters written by specialists on the Country's geography, bioclimate, and vegetation, a brief history of ornithology in Italy, and an interesting review of the Italian bird fossil record. A rich reference list closes the volume; this, along with the in-text references, will be a formidable heritage for the next generations of Italian ornithologists. However, not only standard literature was scrutinized here, but also a wealth of grey literature products and unpublished records, often originating from the plethora of online databases and platforms that are having the undoubted merit to collect a huge and increasing amount of ornithological records, but often at the expense of their trackability.

This volume, along with the two previous ones, is an exquisite distillate of faunistic science, a matter often neglected and relegated to amateurs, which however is the baseline of any other taxonomical, biogeographical, and ecological research. The international ornithological community should be grateful to the authors who worked more than 20 years to produce this invaluable review and hope this effort will continue in the years to come.

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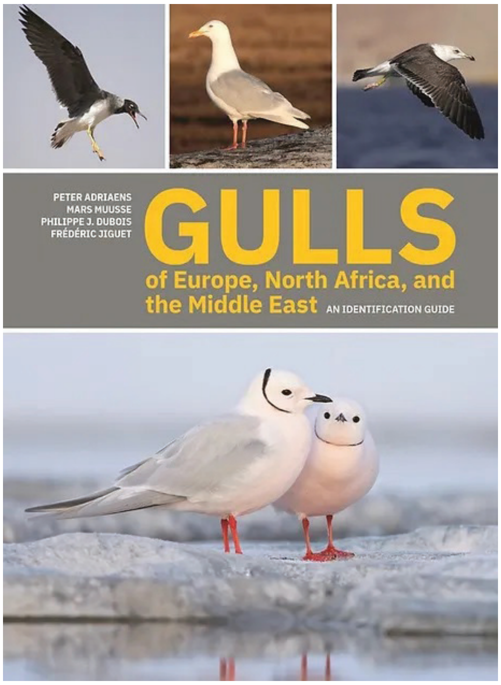
Reference

Brichetti P. & Fracasso G., 2O22. The Birds of Italy. Volume 3. Cisticolidae-Icteridae. Edizioni Belvedere, Latina (Italy), “historia naturae” (10), pp. 436. 45€.

For Gull lovers: a photographic Guide to Gulls of Europe, North Africa, and the Middle East



For a birder who operates in the Western Palearctic, gulls are among the trickiest birds to identify. However, most of us love challenges and these long-living wanderers, with their variability across age groups and their ability to suddenly appear to brighten up a boring winter day, have all the features to melt our hearts.

In the last years, a handful of guides came out in an attempt to meet the increasing interest raised by this fascinating group. Thus, “Gulls of Europe, North Africa and Middle East: An Identification Guide” is not the very first book to address this topic, but is certainly the most up-to-date one for this region and, in my opinion, also the easiest and most enjoyable to browse. Weird to say, its main strength lies in the choice of using photos instead of drawings. Indeed, these are better suited to illustrate how plumage worn over time, and which features could be seen in every static or dynamic real-life pose.

Identification is based on ageing and moult, which are the first, fundamental steps for anyone who wants to get involved with gulls. Species are split according to size, which in turn determines how long they take to reach the definitive plumage. For medium and large gulls, up to five “cycles” are thoroughly explained in the introduction, along with some specific cases and exceptions.

Species accounts are organized as follows: first, a short description of the general structure, including size, proportions, and jizz; then the different cycles, starting from adults, each one stretching over one or more pages. “Similar taxa” boxes provide comparisons with other species, pointing out, for each age class, the essential elements to look at when it comes to deciding between two or more species. A very useful tool. Finally, the range and vagrancy occurrences are described in detail, also introducing any changes which have taken place in the last decades.

With 45 illustrated species and subspecies and nearly 1400 images, this superb book looks like one of the most complete guides on this topic and cannot be missed by Gull experts. Moreover, thanks to its innovative approach, it could be appreciated also by the many beginners who are a little intimidated and confused by those big plates which have become a tradition among identification guides. Last but not least, its surprisingly small size and low weight, thanks to the paperback cover, make it easier to take it to the field. A little gem!

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Reference

Adriaens P., Muusse M., Dubois P.J. & Jiguet F. 2022. Gulls of Europe, North Africa, and the Middle East: An Identification Guide. Princeton University Press, Princeton and Oxford. 320 pp. 30.00 £

Obituary

Marco Borioni (28th June 1946 / 16th August 2022)

On August 16th, at age of 76, after a short but painful illness, Marco Borioni passed away in Ancona, his hometown. He approaches environmentalism at the beginning of the 1970s, becoming member of the World Wildlife Fund (WWF) and immediately engaging in associative life. Over the years, he became more and more passionate about ornithology, becoming a member of Italian League for the Protection of Birds (LIPU, BirdLife Italy) in 1982 and dividing his free time between the two associations. In these years he began to observe the birdlife of Conero promontory (Central Italy) constantly: he was one of the first to do so, immediately understanding the great potential of that territory. As an intelligent person with no academic background, he began to study ornithology and bird identification by himself with rigour and constancy, continuing to do so throughout his life. He did not neglect the advice of scholars and experts, to which he added an extensive amount of time dedicated to field observations: the latter became his main study room. His love for the Conero was absolute and was sublimated in 1983 when he observed for the first time the peregrine falcons nesting on sea cliffs. For decades, he devoted himself to the study of this species, iconic for the Ancona scholars and his studies about the Peregrine Falcon, now the symbol of that territory, contributed decisively to the establishment of the Conero Regional Park (AN) in 1987. Starting this year, Marco begun to devote himself with commitment to the observation of the spring migration of birds of prey, having realized the enormous potential of the site. The success of this project was mainly due to the great talents of Borioni. To his boundless passion and perseverance, Marco combined an extraordinary ability in recognition which, refined by practice and constant study of manuals, led him to grasp every minimum detail useful for the identification of raptors. So much so that in the following decades he became one of the leading experts in this field at the national level. Thus began the first raptor migration camp on the Adriatic coast (one of the first in Italy, not long after the Messina strait camp, which started in 1983) and Borioni published the results in the book *“Rapaci sul Conero”* (1993), based on his observations in the years 1987-1990. This study highlights the importance of the Conero as a crucial point for the migratory routes of birds of prey, which here cross the Adriatic in one of its narrowest points or use it as a reference to proceed towards north-eastern Europe. In 1994 Borioni was one of the promoters of the creation of the monitoring camp to protect the Peregrine Falcon and above all for the "Permanent Camp for the study of the spring migration of raptors through the Conero territory". From this moment, Gradina del Poggio (Conero, AN) becomes a very important national point for ornithological observations (included in 2010 by LIPU in the list of ten Italian locations of extraordinary importance for birdwatching), starting to attract numerous researchers and birdwatchers. In 1997 Borioni presented the book *"Ali nel parco" ("Wings in the park")*, in which the first check list of the Conero birds was published. This study was accompanied by new research always related to the same area, published in the main Italian ornithological reviews, some also presented in national and international conferences about birds of prey. In addition to the observations at the Conero, since 2008 Borioni also actively participated in the migration camp "Campo Versilia - Alpi Apuane", both in the spring and in the autumn section. In 2012, the Conero park stopped supporting the local field study of raptor migration, but Borioni continued to keep it active as a volunteer, dedicating all his free time to it and carrying out studies on migration with the help of many friends. During 35 years of uninterrupted monitoring activity at the Conero, Borioni observed numerous species of rare nationwide raptors, counted over 160,000 birds of prey (up to 2000 in a single day) and about 180,000 total migrants. To facilitate the observation by the increasing number of birdwatchers in the Conero, he also created illustrative panels on the various bird species in the habitats of the protected area. Despite the small number of scientific publications, Borioni has contributed in an important way to the study of migration along the Adriatic coast: however, the greatest contribution he has given to Italian ornithology has been the training of many young people (many of which later became scholars and researchers), teaching at two generations of ornithologists and for decades in the field, not only the rules and secrets of identifying birds of prey, but transmitting his great passion to everyone. For this reason, many researchers returned for years to the Gradina, where Marco remained for his observation until May 2022, a few months before his departure. He had created, as a truly great master of field observation as he unquestionably was, a place where everyone could meet, observing raptors and confronting each other. Gruff and severe, especially with young people if they mistake identification, he was at the same time likeable and engaging. He loved telling about birds of prey (even by photographing, sculpting and painting them), covering everything with his personal style, concrete but also romantically poetic. The death of Marco Borioni leaves a great void in all his friends and in everyone that discovered the Conero thanks to him: his experience, his great skills in identification, his constancy in observation and above all his example, will be severely missed. We wish to express our deep sympathy to his family, first of all to his wife Mariarosa Baldoni, beloved and faithful partner of life and observations, always at his side on the field.

Marco Pantalone