Breeding bird species on Ventotene Island (Latium, Italy)

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Abstract - Ventotene Island is a well-known stopover site for bird species, especially during the spring migration. Despite the high number of scientific works on migratory birds, less information is available for the breeding species of the island. This study aims to provide a preliminary characterization of the breeding bird species on Ventotene Island by using standard bird atlas protocols. A high number of standardized field surveys (contact points) were carried out respectively during the first weeks of May, June, and July 2024 to sample bird species' presence and July 2024 to sample bird species' presence through visual and vocal identification. Frequency analyses. Frequency analyses and Shannon-Weiner indices were used to evaluate the diversity of the species during the sampling months. All the bird-contacted species were classified into one of the three breeding categories ("Probable Nesting, PN", "Eventual Nesting, EN" and "Not-Evidenced Nesting, NN") based on the following criteria on the following criteria: breeding vocalizations, suitable habitat, and suitable breeding period. Of the 19 contacted species, 8 were classified as PN, 5 as EN and the remaining 6 as NN. Further research and sampling strategies are needed to achieve a more detailed classification of the species, primarily for the "Confirmed Nidification" category.

Key words: bird migration, Ventotene, breeding species, Shannon-index.

Riassunto - Le specie di uccelli nidificanti nell'isola di Ventotene. Come evidenziato dalla vasta letteratura scientifica disponibile, l'isola di Ventotene rappresenta un'importante area di sosta per numerose specie di uccelli migratori. Nonostante la grande quantità di studi riguardanti la fenologia e le tratte delle specie migratrici, le informazioni sulle specie nidificanti sull'isola risultano assai scarse e spesso integrate con i dati dell'intera area delle Isole Ponziane. Questo studio ha come obiettivo una prima caratterizzazione delle specie nidificanti sull'isola di Ventotene mediante l'utilizzo di protocolli di campionamento standardizzati ed ampiamente utilizzati per la creazione di atlanti ornitologici su piccola e larga scala. In totale, sono stati effettuati 57 campionamenti, distribuiti su 19 punti d'ascolto, con tre repliche ciascuno, nelle prime settimane di maggio, giugno e luglio 2024. Dai campionamenti effettuati sono stati ottenuti 302 contatti, relativi a 19 specie di uccelli, contattate maggiormente durante i primi mesi di campionamento. Il progressivo decremento negli indici di diversità evidenzia l'importanza dell'isola come area di sosta durante la migrazione primaverile. A seconda di determinati criteri standardizzati e ampiamente utilizzati nella letteratura scientifica, le specie contattate sono state classificate come "Nidificazione probabile", "Nidificazione eventuale" e "Nidificazione non evidenziata". Tra queste, alcune delle specie comuni, quali *Passer italiae*, *Serinus serinus* e *Sylvia melanocephala* sono state classificate come Nidificazione Probabile (PN), mentre altre specie, quali *Merops apiaster* e *Oriolus oriolus* sono state classificate come Nidificazione Eventuale (EN), in particolar modo considerando la mancanza di habitat idoneo alla nidificazione sull'isola di Ventotene. I risultati di questo studio hanno incrementato la conoscenza delle specie presenti sull'isola durante la stagione riproduttiva, sottolineando la necessità di ulteriori ricerche e di metodi di campionamento più accurati per una classificazione più precisa delle specie.

Parole chiave: migrazione degli uccelli, Ventotene, specie nidificanti, Shannon-index.

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INTRODUCTION

Ventotene Island is a well-known stopover site for migratory bird species (Goymann *et al.*, 2010; Tenan & Spina, 2010). A wide number of spring migrant species arrive at Ventotene Island from North Africa, by non-stop flights (Spina *et al.*, 1993). The island provides them rest and resources, such as water and food (e.g., nectar; Cecere *et al.*, 2011) before continuing their migration routes (Tenan & Spina, 2010).

Most of the information about the species that breed in the Pontine Islands complex is available in the last atlas of the breeding species in Latium (Brunelli *et al*., 2011), where about 35 species are reported in different breeding categories. Focusing on Ventotene Island, despite the extensive information available on spring migratory species (e.g., Montemaggiori & Spina, 2002; Goymann *et al.*, 2010; Tenan & Spina, 2010), limited knowledge is available for breeding species, primarily for small passerine birds. Several seabird colonies, including the Scopoli's Shearwater (*Calonectris diomedea*) and Yelkouan Shearwater (*Puffinus yelkouan*) are localized in the island (Capizzi et *al.*, 2023) and, in the last local bird atlas of Lazio (Brunelli *et al.*, 2011), the following species are reported as breeders: *Phalacrocroax aristotelis* (last record in 1985), *Passer hispaniolensis* (later classified as *P. italiae* by genetic analyses; Hermansen *et al*., 2011) and *Sylvia conspicillata* (two records in 2006 and 2010). Also, *Falco peregrinus* is a well-known breeding species on Ventotene island (Brunelli & Sarrocco, 2021).

The aim of this study is a first characterization of the bird breeding species on Ventotene Island, through bird presence/absence species data, collected during the breeding season and according to the standard guidelines of a local-scale bird atlas.

Study area

Ventotene is a small island in the Pontine Archipelago located in central Italy, about 25 nautical miles off the coast of Lazio, in the Tyrrhenian Sea (Cecere *et al.*, 2011; Manica *et al.*, 2020; Capizzi *et al.*, 2023). The island is characterized by a surface area of approximately 135 ha, an independent municipality and an estimated population of 690 residents, distributed mainly in the city and tourist port (Manica *et al.*, 2020; Capizzi *et al.*, 2023). The island is included in the Ventotene and S. Stefano Islands Nature Reserve and part of the Special Protection Area Islands of Ponza, Palmarola, Zannone, Ventotene, and S. Stefano (code IT6040019; Capizzi *et al.*, 2023).

The mainland is mainly characterized by agricultural areas, followed by artificial surfaces and, to a lesser extent, by forests and semi-natural areas. Agricultural areas are characterized by crop rotation and the cultivation of legumes and fruits, but the progressive abandonment of the once-cultivated areas is leading to the colonization of the lands by *Arundo donax* and pioneer vegetation. The natural and semi-natural areas are characterized by natural Mediterranean maquis, including remnants of the Mediterranean scrub vegetation (e.g., *Pistacia lentiscus*, *Phillyrea angustifolia*, and *Myrtus communis*) and cliffs (Cecere *et al.*, 2011; Capizzi *et al.*, 2023).

MATERIALS AND METHODS

According to local atlases methodology (Bibby *et al.*, 2000; Sutherland, 1996; Brunelli *et al.*, 2011), a universal transverse mercator squared grid was superimposed on the study area (i.e., entire island territory) by using QGIS 3.16.0 software (QGIS Development Team, 2024) and the latest available online map (Google Earth, April 2022). The grid divided the surface of the island into 52 survey units (SU), each one of 200×200 m, identified by a numeric code. To reduce the field effort, from the total number of SU, 19 grid cells (SU) were randomly chosen for bird field sampling. Within each SU, a single bird contact point (Bibby *et al.*, 2000; Gregory *et al.*, 2004) was selected using both QGIS software and field surveys, in order to cover the widest range of habitats, including inaccessible areas, such as farmland and cliffs, resulting in a total of 19 bird contact points (Fig. 1). To cover an extensive island area, all contact points had a minimum distance of approximately 150 m.

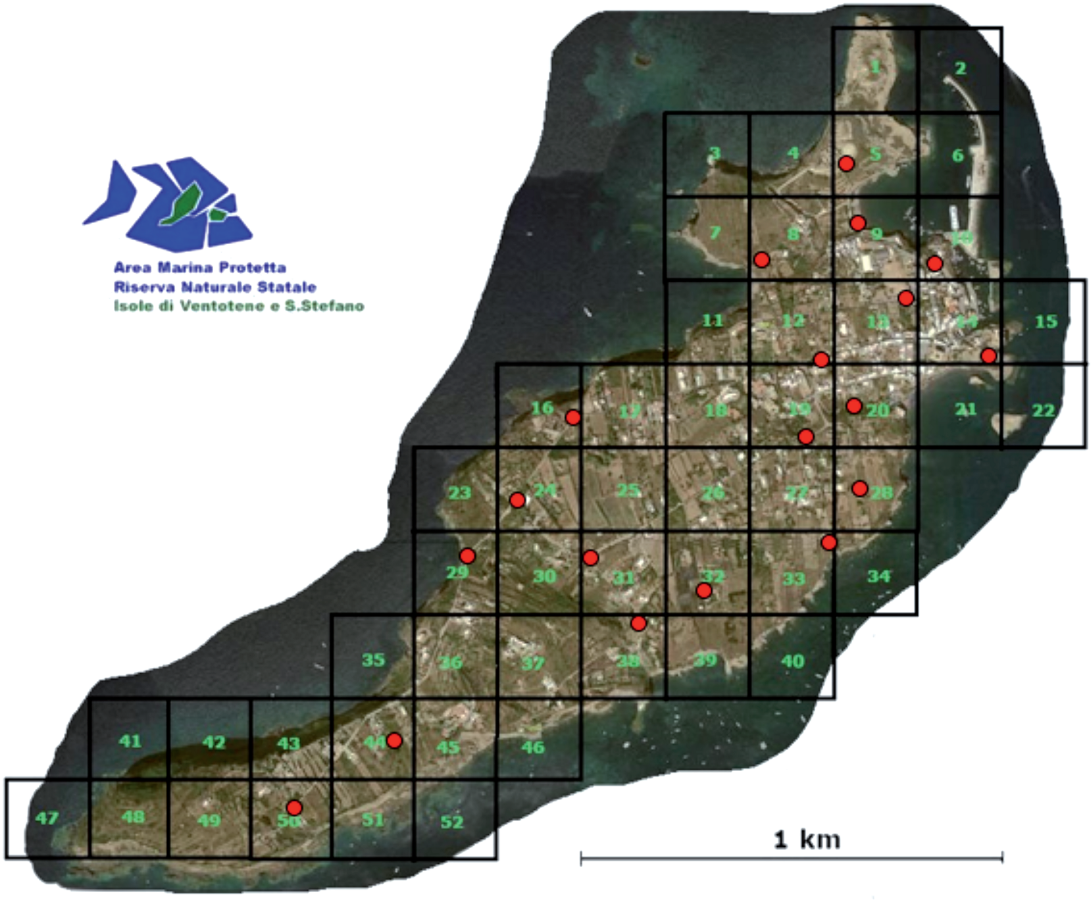

Fig. 1 – Map of the study area with the universal transverse mercator grid, delineating the 52 Survey Units (SU). Contact-points for bird field surveys are evidenced with red plots. Modified from: Google Earth Pro (April 2022); Image © 2024, TerraMetrics. / Mappa dell'area di studio con sovrapposizione di griglia UTM. I siti di campionamenti sono stati indicati mediante marcatori rossi. Modificata da: Google Earth Pro (April 2022); immagine © 2024, TerraMetrics.

Bird surveys were carried out during the local breeding seasons (May, June, and July 2024) of bird species. Each contact point was surveyed once during the first weeks of the three months, totalizing 57 field surveys (19 contact points * 3 months). To contact bird species was used a standardized protocol of 10-minute sampling per session, during sunrise hours (5.30 and 9.00 AM), avoiding adverse meteorological conditions. To obtain presence/absence data (occurrence/SU) of bird species, both visual observations and vocalizations were recorded during each survey using a standardized detection sheet. When possible, distinctions among reproductive and other types of vocalizations (e.g., calls) were made during field surveys. A species was considered as occurring in a SU if direct or indirect contacts of the species were obtained in at least one of the three field sampling sessions.

Following the protocol described in Battisti *et al.* (2020), a specific binary matrix was built, where the scores 0 and 1 indicated, respectively, the absence or presence of the species within each SU/month. By using a binary matrix, the total number of occurrences, the number of occurrences/month, the number of species detected, and the number of species detected were estimated in each month were estimated. For each species, the number of SU occupied (NSU), the frequency of the bird presence in each SU/month (frSU), and the relative frequency of occurrence of the species considering the total number of occurrences (frOcc) were estimated. To evaluate species diversity in the study area, mean species richness was estimated as the average number of species per SU/month, and the Shannon–Weiner index (Konopiński, 2020) was calculated for each month.

To compare mean species richness across months, the non-parametric Kruskal–Wallis test was used, while the χ^2 test was applied to compare occurrence frequencies at the single-species level. All statistical analyses were performed using PAST 3.4.0 software (Hammer *et al.*, 2001), with a significant threshold level of 0.05.

For qualitative analyses, the standard criteria proposed by the European Ornithological Atlas Committee, previously adopted in other bird atlases, were applied (Brunelli *et al.*, 2011; Sorace *et al.*, 2017). Each contacted species was classified into one of three different categories: "Probable Nesting" (PN; reproductive behaviors of the species, such as territory defense and reproductive songs, in suitable period and habitat) and "Eventual Nesting" (EN; bird individual observed in suitable habitat and reproductive period) and "Not Evidenced Nesting" (NN; for bird species that could not be included in one of the previous categories) (i.e., not observed in suitable habitat and/or during the breeding season and/or no reproductive behavior of the species observed).

All information about the bird species phenology and suitable habitats was extrapolated from Brunelli *et al.* (2011).

Due to the limited survey effort and the lack of direct evidence of breeding within each SU, the aim of this study is to report presence/absence data for bird species in suitable habitats during the breeding period, and to provide a preliminary classification based on standard criteria, without implication on confirmed nesting. Bird nomenclature follows Baccetti & Fracasso (2021).

RESULTS

In total, 302 occurrences of 19 species were obtained during all field surveys. Of the total, 116 occurrences were obtained in May and 101 and 85 occurrences respectively in June and July (Tab. 1). Dominant species (fr>0.5) for all sampling months were *Passer italiae*, *Streptopelia decaocto*, *Larus michahellis*, *Serinus serinus,* and *Sylvia melanocephala*. Of the total number of species (n=19), 17 bird species were contacted in May, while in June and July, respectively, 13 and 11 species (Tab. 1). Only 8 species were detected in all the sampling months, while considering single monthly-combinations, 3, 2 and 1 species were respectively detected for May-June, June-July and May-July. Only 4 species were detected in a single month (Tab. 1).

The NSU, frSU, and frOCC results can be seen in Tab. 1. Differences in the number of occurrences per species between sampling months were significant ($p<0.05$) only for *S. serinus*. Mean species richness was 6.11 (±1.45) species/SU in May, 5.32 (±0.89) in June, and 4.47 (±1.12) in July. The decrease in the mean species richness was significant between months ($\chi2=12.45$, $p=0.001$; Kruskal-Wallis test). Shannon-Weiner indices were 2.32, 2.12, and 1.99, respectively, in May, June, and July.

A total of 11 bird species were detected by territorial songs: *Carduelis carduelis*, *Chloris chloris*, *Hippolais icterina*, *Luscinia megarhynchos*, *Muscicapa striata*, *Oriolus oriolus*, *Passer italiae*, *Serinus serinus*, *Streptopelia decaocto, Sylvia melanocephala*, and *Turdus merula*. All 11 species were contacted by reproductive songs/vocalizations in May, while 8 and 6 species, respectively, in June and July (Tab. 2). The remaining species were contacted by either sight observations or non-strictly reproductive vocalizations.

For qualitative analyses, 8 species were considered as PN (Tab. 2): *Carduelis carduelis*, *Chloris chloris*, *Muscicapa striata*, *Passer italiae*, *Serinus serinus*, *Streptopelia decaocto*, *Sylvia melanocephala*, and *Turdus merula*. The species classified as EN are 5: *Apus apus*, *Corvus corone cornix*, *Hirundo rustica*, *Falco peregrinus*, and *Larus michahellis*; the remaining 6 species, *Hippolais icterina*, *Luscinia megarhynchos*, *Motacilla flava*, *Merops apiaster*, *Oriolus oriolus*, and *Upupa epops*, were classified as breeding NN.

DISCUSSION

During the field surveys, a high number of bird species and occurrences were detected. Most species were detected during the first sampling months, corresponding to the period of spring migration and the beginning of the breeding season (i.e., May and June). The statistically significant decreasing trend in both the mean species richness and the values of the Shannon-Weiner indices, togheter with the highest number of species detected in May and June, confirms the already known stopover role of the island during the bird migration (Pilastro & Spina, 1997; Montemaggiori & Spina, 2002).

Focusing on bird species, those most frequently detected (fr>0.5) across all sampling months are common Italian mainland species (e.g., Dinetti, 2008; Calvi *et al*., 2018).

Tab. 1 – Spatial occurrences, relative frequencies on the total number of occurrences and in the survey unit of the bird sampled species. Comparisons between frequencies has been performed with the χ^2 test. / Presenze spaziali, e relative frequenze su unità di rilevamento e sul totale delle occorrenze di specie di uccelli campionate. I rispettivi confronti tra le frequenze sono stati eseguiti con il test χ^2.

	May			June			July				
Species	N_{SU}	Fr_{occ}	Fr_{SU}	N_{SU}	Fr_{occ}	Fr_{SU}	N_{SU}	Fr_{occ}	Fr_{SU}	χ^2	p
Apus apus	0	0	0	2	0.02	0.105	1	0.012	0.053	1.33	0.513
Carduelis carduelis	1	0.009	0.053	0	0	0	1	0.012	0.053	-	-
Chloris chloris	0	0	0	2	0.02	0.105	1	0.012	0.053	1.33	0.513
Corvus corone cornix	2	0.017	0.105	4	0.04	0.211	2	0.024	0.105	0.389	0.823
Falco peregrinus	2	0.017	0.105	2	0.02	0.105	0	0	0	1.556	0.459
Hirundo rustica	1	0.009	0.053	1	0.001	0.053	0	0	0	-	-
Hippolais icterina	1	0.009	0.053	0	0	0	0	0	0	-	-
Larus michahellis	10	0.086	0.526	16	0.158	0.842	8	0.094	0.421	1.433	0.489
Luscinia megarhynchos	1	0.009	0.053	0	0	0	0	0	0	-	-
Motacilla flava	2	0.017	0.105	0	0	0	0	0	0	-	-
Merops apiaster	1	0.009	0.053	0	0	0	0	0	0	-	-
Muscicapa striata	13	0.112	0.684	7	0.069	0.368	17	0.2	0.895	2,205	0.332
Oriolus oriolus	5	0.043	0.263	1	0.001	0.053	0	0	0	3,619	0.164
Passer italiae	18	0.155	0.947	19	0.188	1	19	0.224	1	0.018	0.991
Serinus serinus	16	0.138	0.842	16	0.158	0.842	2	0.024	0.105	9.07	0.017*
Streptopelia decaocto	16	0.138	0.842	16	0.158	0.842	15	0.176	0.789	0.021	0.990
Sylvia melanocephala	15	0.129	0.789	11	0.109	0.579	14	0.165	0.737	0.334	0.846
Turdus merula	7	0.06	0.368	4	0.04	0.211	5	0.06	0.263	0.413	0.814
Upupa epops	1	0.009	0.053	0	0	0	0	0	0	-	-
Total	116	1		101	1		85	1			

N_{SU}, spatial occurrences; Fr_{occ}, relative frequencies on the total number of occurrences; Fr_{SU}, frequency of the bird presence in each survey unit/month.

Tab. 2. – Bird species sampled by reproductive songs/other breeding vocalizations and their classification in one of the three breeding categories. / Lista delle specie contattate mediante canti ed altre vocalizzazioni in ambito riproduttivo e la classificazione nella rispettiva categoria di nidificazione.

Species	Reproductive songs/other breeding vocalizations	Breeding category
Apus apus	-	EN
Carduelis carduelis	May	PN
Chloris chloris	June	PN
Corvus corone cornix	-	EN
Falco peregrinus	-	EN
Hirundo rustica	-	EN
Hippolais icterina	May	NN
Larus michahellis	-	EN
Luscinia megarhynchos	May	NN
Motacilla flava	-	NN
Merops apiaster	-	NN
Muscicapa striata	May, June, July	PN
Oriolus oriolus	May, June	NN
Passer italiae	May, June, July	PN
Serinus serinus	May, June, July	PN
Streptopelia decaocto	May, June, July	PN
Sylvia melanocephala	May, June, July	PN
Turdus merula	May, June, July	PN
Upupa epops	-	NN

Passer italiae was observed in all but one SU, within each sampling month. Due to its colonial behavior and short-range and errant migratory movements (Brichetti *et al.*, 1993; Ghisolfi, 2016), the species is expected to breed on the island, particularly in artificial cavities, rock cliffs, and trees. In fact, *Passer italiae* had already been classified in the confirmed nesting category for the Ventotene Island (referred to as *P. hispaniolensis* and *P. domesticus* in Brunelli *et al.*, 2011). In this study, the species was classified as PN, considering the suitable habitat, the breeding seasons, and the reproductive vocalizations sampled during the field surveys.

Sylvia melanocephala and *Serinus serinus* were detected during all sampling months and in most of the survey units, indicating a wide distribution across the island. Both species were classified as PN, based on data collected during field surveys, including territorial songs and observation in suitable breeding habitats (Brunelli *et al.,* 2011). *Sylvia melanocephala* is a common Mediterranean maquis species, selecting scrub-dominated areas (e.g., Moreno-Mosquera *et al*., 2024). The species is expected to breed on Ventotene Island, particularly within areas of Mediterranean vegetation. For *Serinus serinus*, the results indicate a significantly decreasing detection trend across the sampling months, possibly due to the end of its breeding season (July) in Mediterranean areas (e.g., Mansouri *et al.,* 2021).

The only waterbird species detected, *Larus michahellis*, was primarily is aldready well-known contacted in June. The presence of the species on the island is well known, particularly around the port and on the island's rocky cliffs, where it nests (Montemaggiori A., pers. comm.). In this study the species was classified as EN, due to the lack of evidence about reproductive behaviors of the species and the inadequate sampling strategy.

The last most frequent species, *Streptopelia decaocto*, was classified as PN, due to the high number of occurrences and the sampling of breeding vocalizations. The presence confirms the ongoing colonization of Italian territories since the last century (Brichetti *et al.,* 1986; Brunelli *et al.,* 2011; Battisti & Zullo, 2019). Due to its high behavioral plasticity and the tolerance of human-altered habitats (Fujisaki *et al.,* 2010; Battisti & Zullo, 2019), the species is expected to nest in trees and artificial surfaces (i.e., houses).

Among the less-contacted species, Muscicapa striata was the only long-distance migratory bird classified as PN, based on the high number of occurrences across all months and the detection of reproductive vocalizations during field surveys. The species is expected to breed on the island due to the presence of suitable habitats, such as heterogeneous farmland and anthropogenic areas (Brunelli *et al.,* 2011). The blackbird, *Turdus merula*, was contacted in each sampling month, mainly through song vocalizations and classified as PN. This easily detectable species is linked to ecotones, farmlands, woodlands, and high human-altered habitats (e.g., Hatchwell *et al.,* 1996; Alessandri *et al.,* 2021), and is very likely to nest on the island near artificial surfaces, within shrubs and small trees.

Fringillidae species, such as *Carduelis carduelis* and *Chloris chloris*, were detected in low numbers during the field surveys. Both species were classified as PN due to the presence of suitable habitats, such as open farmlands and heterogeneous habitats (Brunelli *et al.,* 2011; Bensouilah *et al.,* 2014), and the sampling of territorial songs. Bird species, such as *Apus apus*, *Corvus corone cornix*, and *Hirundo rustica*, were contacted mostly by sight observations and within a relatively low number of SUs. For all these species, classified as EN, the field sampling strategy was inadequate to estimate their eventual nesting as their presence can be possibly linked to errant migratory movement or the nesting in the nearby islands (Ponza and Santo Stefano). The Peregrine Falcon (*Falco peregrinus*) was also classified as EN due to the inadequate sampling strategy, but the nests and the breeding of the species on the island are already well known in scientific literature (Brunelli & Sarrocco, 2021). All the remaining species, *Hippolais icterina*, *Luscinia megarhynchos*, *Motacilla flava*, *Merops apiaster*, *Oriolus oriolus,* and *Upupa epops*, were classified as NN: their occurrences in May an June are linked to the spring migration pathways and the usage of Mediterranean islands as stopover areas (Spina & Volponi, 2008).

All the species sampled in this study were previously classified either as NE, PN, or Confirmed Nesting in Brunelli *et al.* (2011) within the Pontine Islands complex areas, except for 6 species: *Hippolais icterina, Luscinia megarhynchos*, *Motacilla flava*, *Merops apiaster*, *Oriolus oriolus*, and *Turdus merula*. Only for the last species, the Blackbird, the result of this study indicates a new colonization of the Pontine Island complex by the species. Also, Ventotene Island could present suitable habitats (i.e., Mediterranean maquis and heterogeneous farmland landscapes) for several bird species not detected during field surveys, such as *Sylvia atricapilla, Sylvia cantillans,* and *S. perspicillata*, that are particularly linked to bushes and Mediterranean vegetation (e.g., Cody & Walter 1976; Schaefer & Barkow, 2004). Despite the previous report of their breeding on the island, their absence is probably linked to external factors, such as the high presence of human disturbance and the ongoing change in the vegetation structure caused by agricultural activities.

CONCLUSIONS

The Ventotene Island hosts a wide number of bird species. The highest number of occurrences was sampled in May and June, indicating the study area as a fundamental stopover site during spring migration, also supported by the decline in species richness. All species were classified into different breeding categories based on their consistent presence, suitable habitats, and reproductive vocalizations. Most of the dominant species (i.e., more occurrences) were classified as PN, while several long-distance migratory species, except for *Muscicapa striata*, were considered as NN. This work should be considered as an update to the list of breeding species of Ventotene Island and the entire Pontine Islands complex. Lastly, different approaches and sampling strategies are necessary to obtain a better classification of the species, such as the Confirmed Nesting category, and to monitor seabirds and nocturnal species.

CONTRIBUTIONS

SR conducted the field surveys, while JG carried out the data analysis. Both authors wrote and edited the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

AVAILABILITY OF DATA AND MATERIALS

Data are available on request.

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