

A fine-grained bird Atlas as tool for spatial monitoring: a case study from a remnant wetland during the breeding period (Torre Flavia, central Italy)

Corrado Battisti^{1, *}, Giuseppe Dodaro², Mario Vannuccini³

Abstract - During the 2019 breeding period we carried out a bird atlas for a small coastal natural reserve (Torre Flavia wetland, Special Protection Area IT6030020, central Italy), comparing quantitative data of spatial occurrences with records from an analogous study carried out in 2005. From 2005 to 2019 some water-related species increased their frequency of occurrence (*Fulica atra*, significantly). Among the reed and rush-bed species, *Acrocephalus scirpaceus* spatially increased and *Cisticola juncidis* decreased significantly. Among ecotonal, synanthropic and open habitat species, we registered a significant increase of *Chloris chloris*. A decreasing trend of *Passer italiae*, *Saxicola torquatus*, *Emberiza calandra*, although not significant, may be probably linked to regional or continental factors. Both causes at local (reedbed expansion, rushbed reduction, water-level management) and at larger scale (decline in their continental range) can explain the observed changes in spatial occurrences during this medium-long temporal range. Local atlases can be quick tools useful to drive management strategies in remnant wetlands.

Key words: local atlases, changes in spatial occurrences, reed beds, rush beds, management strategies, local vs. large scale factors, long term monitoring.

Riassunto - L'Atlante ornitologico come strumento per il monitoraggio della distribuzione spaziale delle specie durante il periodo riproduttivo: un caso studio applicato a un'area umida residuale mediterranea (Torre Flavia, Italia Centrale).

L'Atlante ornitologico del Monumento naturale Palude di Torre Flavia, una piccola zona umida costiera residuale (ZPS IT6030020; Lazio, Italia centrale), illustra i dati relativi alla presenza e alla distribuzione spaziale delle specie ornitiche durante il periodo riproduttivo (aprile - giugno) del 2019, riportando anche una comparazione con dati analoghi raccolti nello stesso arco temporale nel 2005.

I risultati evidenziano alcune differenze, in qualche caso anche molto marcate. Si registra un generale incremento delle specie più strettamente legate agli ambienti umidi, particolarmente rilevante per quanto concerne *Fulica atra*. Relativamente alle specie tipiche dei canneti e delle praterie alofile a dominanza di giunchi, aumentano le aree in cui è presente *Acrocephalus scirpaceus* mentre diminuiscono sensibilmente quelle in cui si rinviene *Cisticola juncidis*.

Tra le specie caratteristiche delle aree ecotonali e sinantropiche si riscontra una maggiore frequenza di *Chloris chloris*. La presenza ridotta – sebbene in maniera non particolarmente accentuata – di *Passer italiae*, *Saxicola torquatus* ed *Emberiza calandra* è presumibilmente da mettere in relazione con dinamiche di livello regionale e continentale.

I cambiamenti nella distribuzione spaziale delle specie - osservati in questo arco temporale di media lunghezza – dipendono dunque sia da fattori di area vasta (alcuni degli Uccelli contattati hanno popolazioni in declino in tutta Europa) che da elementi di carattere ambientale riferiti invece in maniera specifica a questa piccola area protetta. Tra quelli più incisivi si evidenziano l'applicazione di un nuovo regime di gestione dei livelli idrici – con una disponibilità di risorsa maggiore e più continua – l'espansione del canneto e la contemporanea riduzione della vegetazione alofila e sub-alofila.

Gli atlanti locali sono strumenti in grado di fornire concreti benefici per il *management* di piccole aree protette. La rappresentazione spaziale della distribuzione delle specie sul territorio – soprattutto quando ripetuta a intervalli regolari – consente di individuare le zone sensibili e quelle di maggiore interesse ecologico, così come facilita l'interpretazione dei processi ecologici in corso, rappresentando così un supporto di grande utilità per una pianificazione adeguata di interventi e strategie di gestione.

Parole chiave: atlanti locali, modifiche nella distribuzione spaziale, canneti, giuncheti, strategie di gestione, fattori locali vs fattori di scala vasta, monitoraggio

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INTRODUCTION

Wetlands provide many ecosystem services (Okruszko *et al.*, 2011; Mitsch *et al.*, 2015) and play a major role in maintaining well-being and economic activities (Mediterranean Wetlands Observatory, 2012, 2018). This role is particularly relevant in the Mediterranean basin, where natural and human-made wetlands cover ca. 0.15-0.22 million km² – about 1.1-1.5 % of wetland area globally (Davidson *et al.*, 2018) – and have a recognized importance for the protection of biodiversity on a global scale (Cuttelod *et al.*, 2008; Malcolm *et al.*, 2006). Nevertheless, wetlands are the most threatened ecosystems throughout this area and their surface continues to decline very rapidly (Finlayson & Spiers, 1999; Perennou *et al.*, 2012;

Mediterranean Wetlands Observatory, 2018), with effects on biodiversity, although with significant differences between different areas and groups of species (Fraixedas *et al.*, 2019; Galewski *et al.*, 2011; Green *et al.*, 2002), also due to the increase in some pressures linked to the climate change (Cramer *et al.*, 2018). In this scenario it is necessary and urgent on the one hand to use the knowledge acquired regarding the state of conservation and the most effective wetland restoration techniques (Zalidis *et al.*, 1999; Ortega *et al.*, 2004), on the other to improve knowledge regarding the conservation status of species and habitats at local scale, to create management models capable of responding adequately to new environmental conditions and improving the conservation of biodiversity.

Birds are good indicators of the health status of wetlands (Robledano *et al.*, 2010; Hoffmann *et al.*, 1996) and monitoring the trend of species populations provides useful indications regarding the changes taking place and the strategies to be adopted (Galewski & Devictor, 2016).

Small Mediterranean wetlands play an important role as stepping stones for migratory birds and as a reproductive habitat for breeding species, also of conservation concern (Benassi *et al.*, 2009). Quantitative surveys on species and communities occurring in these sites (*e.g.* fine-grained spatial distribution trends obtained from atlases) can also be important for their medium-long term monitoring and management (Sutherland, 2006).

In this work, we characterized the local scale distribution of breeding birds in a small coastal wetland in central Italy. The quantitative data of spatial occurrences were compared with those obtained with the same method carried out in 2005, obtaining first information on distributional changes at local scale of breeding species related to these wet and ecotonal environments.

MATERIALS AND METHODS

Study area

The study area is included in the “Palude di Torre Flavia” natural Monument (central Italy; 41°58'N; 12°03'E; Fig. 1), a small protected wetland (40 ha) on the Tyrrhenian coast (Special Protection Area IT6030020, according to the EC Directive on the Conservation of Wild Bird 2009/147/EC), remnant of a larger wetland drained and transformed by land reclamation in the last Century and now embedded in an agricultural and urbanized matrix (Battisti, 2006; Battisti *et al.*, 2006). At local scale, it shows a semi-natural heterogeneity with *Phragmites australis* reed-beds, channels used for fish farming (*Anguilla anguilla* and three species of mullets: *Mugil cephalus*, *Liza saliens*, *Liza ramada*), flooded salt meadows with *Carex hirta*, *Juncus acutus* and Cyperaceae (corresponding to 1410 Mediterranean salt meadows (*Juncetalia maritimi*) habitat type according EC “Habitat” Directive 92/43/EC), dune and backdune areas (Acosta *et al.*, 2007). Hereafter, we refer to “open habitat” to comprise flooded meadows, edge areas, dunes and backdunes. Climate is xeric-meso-Mediterranean (Tomaselli *et al.*, 1973; Blasi & Michetti, 2005). The water in the wetland area is mainly of mete-

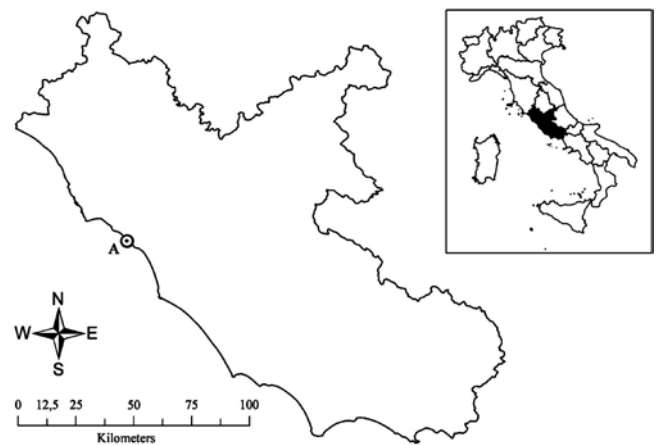


Fig. 1 - Geographic localization of the study area (Latium, central Italy). Location of the coastal study site (A). On the right: geographic location within Italy. / Localizzazione del sito di studio (A) all'interno dell'area vasta (Lazio, Italia Centrale). Sulla destra: localizzazione rispetto al territorio nazionale (Italia).

oric and sea-storm origin and flow from surrounding areas is scarce. Depth is variable in time, and no water is present from July to October (Battisti, 2006). Water stress is one of the main local direct threats known for Torre Flavia wetland (Battisti *et al.*, 2008). This threat has been actively mitigated from the management Agency (Battisti *et al.*, 2020a).

Protocol

We obtained a local atlas (Bibby *et al.*, 2000; Sutherland, 2006) defining a squared grid that was superimposed on the entire study area during the breeding period (and some immediately adjacent sites). This grid was made up of 64 survey units (SU), each 100 x 100 m wide (based on the Regional Technical Map scale 1: 10,000; Regione Lazio, 1990).

In the spring 2019 (from 2 April to 6 June), coinciding with the local breeding season, we randomly moved through the sector of each SU twice (two sessions/SU) during each seasonal period (the first in March and April, the second in May and June). In each of the two sessions, a route was randomly carried out, as representative as possible of the entire SU, keeping the detection time constant (5 minutes/SU/session).

During each sampling, a direct contact (observation of individuals) and indirect contact (recognition through singing, voice and other sound emissions relating to species presumably nesting in the area), were noted on a specially prepared detection sheet, thus obtaining a data of presence for each detection unit (occurrence/SU). For the purpose of graphically returning the occurrences in the Atlas, we considered a species as occurring in a SU if at least a direct or indirect contact of the species was obtained in at least one session. We have accumulated the occurrence data obtained from the two sessions for each SU. The species in high flight (> 25 m) were not considered.

In total 128 sessions were completed, corresponding to about 640 minutes of sampling research effort. No abundance data for individual species were obtained.

Subsequently, a binary / species matrix was initially built, where 1 indicated the certain presence of the species (cumulated over two sessions), while 0 indicated the probable absence within each SU. For each species, a local scale distribution map was built, also obtaining a map of overall richness. For each species we obtained the number of SU occupied (N_{SU}) and the percentage frequency of sampling units (fr_{SU} , i.e. n. SU/64). The percentage frequency (or frequency of incidence: Magurran, 2004) provides information on the degree of local distribution of the species in the study area. The relative frequency of occurrence of the species was also calculated (fr , i.e. the ratio between the number of SU occupied by a species and the total number of occurrences; fr_{occ}). This frequency data was used to obtain preliminary information on the local distribution of the breeding bird community in the study area. Since in this observational study, time effort for each SU is limited, we do not have certain breeding evidence for each species in each SU. Consequently, this atlas reports only information of the occurrence of species in each SU during the breeding period (i.e. habitat use during breeding period), without implication on the confirmed nesting.

On this basis, a map of overall species richness for each SU was also obtained. The single-species maps were created with QGIS software and geo-referenced based on AGEA 2014 ortho-photo (Datum Roma 1940, Gauss Boaga projection, east time zone).

The average value of N_{SU} (and standard deviation) was calculated obtaining a mean species richness value. Finally, from the data of the frequency of occurrence, we obtained a spatially-referred Shannon-Wiener diversity index (Shannon-Weaver; Magurran, 2004). The results were compared with similar data obtained in 2005 when we carried out a similar atlas using the same methodology (Malavasi *et al.*, 2006).

In order to compare the values obtained in 2019 with those of 2005, we applied the Mann-Whitney U test applied to mean species richness; χ^2 test to compare the frequencies of occurrence at single species level. Alpha was set at 0.05 level. The SPSS 13.0 software (SPSS Inc. 2003) was used. Reference was made to the nomenclature and the new systematic order (CISO, 2019).

RESULTS

In 2019, 221 occurrences of 27 species were obtained compared to the 243 occurrences and 24 species in 2005. *Gallinula chloropus*, *Fulica atra*, *Cisticola juncidis*, *Acrocephalus scirpaceus*, *Cettia cetti*, *Turdus merula*, *Passer italiae*, *Chloris chloris* were dominant ($fr > 0.05$). Maps of single species are in Fig. 2. Mean species richness was 3.45 (± 2.67) species/SU in 2019 vs 4.92 (± 2.31) in 2005. Mean species richness decreased significantly from 2005 to 2019 ($Z = -2.722$, $p = 0.006$; Mann Whitney U test). Shannon-Wiener diversity index was $H^{\prime} = 2.74$ in 2019 and $H^{\prime} = 2.76$ in 2005.

The SU with highest richness are located in the edge of the study area (Fig. 3).

The comparison between the years showed an increase in the distribution at the local scale of some water-related species (*Anas platyrhynchos*, *Gallinula chloropus*, *Fulica atra*, the latter significantly; Tab. 1). Among the reed-bed related species, *Acrocephalus scirpaceus* showed a significant incre-

ase in its frequency of occurrence, while *Cisticola juncidis* showed a significant reduction. Ecotonal, synanthropic and open habitat species showed contrasting trends: among these only *Chloris chloris* recorded a significant increase. Marked decreases, although not significant, were recorded for *Passer italiae*, *Saxicola torquatus*, and *Emberiza calandra* (Tab. 1).

DISCUSSION AND CONCLUSIONS

The data obtained show an increase in the local scale distribution of water-related and reedbeds-related species and a decrease in a focal rushbeds species (*Cisticola juncidis*). This can be due to (i) the increase in reed bed extension (and consequent reduction of surrounding rushbeds), and (ii) to an effective water level management (promoted by Park Agency; Battisti *et al.*, 2020a) during the last years. These environmental and management factors are important for small wetlands since many species linked to these habitats are area- or fragmentation-sensitive (Benassi *et al.*, 2009): therefore the increase in habitat size (reed beds) and quality (effective water level management) could make more suitable these remnant ecosystems for reed bed specialists (as *Acrocephalus* spp.) and water-related species (as ducks and rails). These local-scale distributional data (spatial occurrences) corroborate the findings for the same area using a different method (mapping) which recorded an increase in density in the breeding pairs of the reed beds species and a reduction in the rush beds species (Battisti *et al.*, 2020b).

However, beyond local factors, also causes on a larger scale could explain the decline of some species related to ecotonal, synanthropic and open environments (e.g. *Saxicola torquatus*: Sanderson *et al.*, 2006; *Passer* sp.: De Laet & Summers-Smith, 2007; *Emberiza calandra*: Massa & La Mantia, 2010; *Cisticola juncidis*: Campedelli *et al.*, 2009; all species showing decreasing or large temporal fluctuations on a regional/continental scale). The decline of these species can explain also the significant decrease in mean species richness and the consequently apparently reduction in the Shannon-Wiener index from 2005 to 2019.

The approach using in this study has some weakness. First, a disadvantage with atlas grids of any type is that boundaries rarely match those of habitats, making them unsuitable for some types of ecological studies (Donald & Fuller, 1998). Secondly, we carried out a strict comparison between two years without an analysis ranging along all the period 2005-2019: consequently, fluctuations in populations due to causes related to wintering/migration areas, predators/parasites and so on have not considered. A part this weaknesses, this study also highlights some usefulness of this quick methodological tool (i.e. requiring a relatively low research effort) on a local scale to highlight responses in terms of spatial occurrences by species in relation to environmental changes, so as to provide for appropriate management measures. In our case, the historical comparison has made it possible to trace environmental changes on a local scale (increase in size and ageing of reed beds, rush bed reduction, reduction in water stress) which will enable management actions to be prepared (e.g. reed bed management by mowing, habitat restoration for rush beds, water level management).

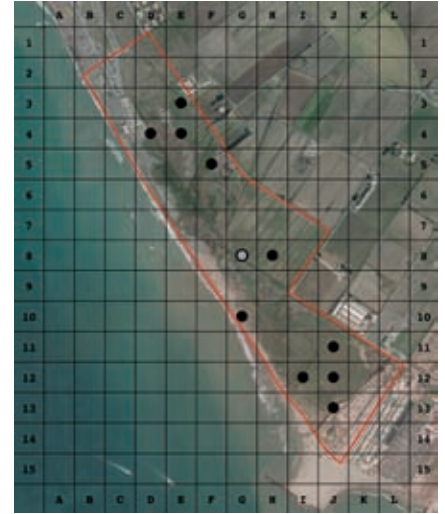
Fig. 2 - Local distribution maps at local scale of breeding bird species in Torre Flavia wetland (Latium, central Italy; 2019). Black points: occurrences; grey points: contacts outside the sampling methods (not included in the analyses). / Mappe di distribuzione alla scala locale delle specie nidificanti nella palude di Torre Flavia (Lazio, Italia centrale; 2019). Pallini neri: presenze; pallini grigi: contatti al di fuori dei tempi di campionamento (non compresi nelle analisi statistiche).



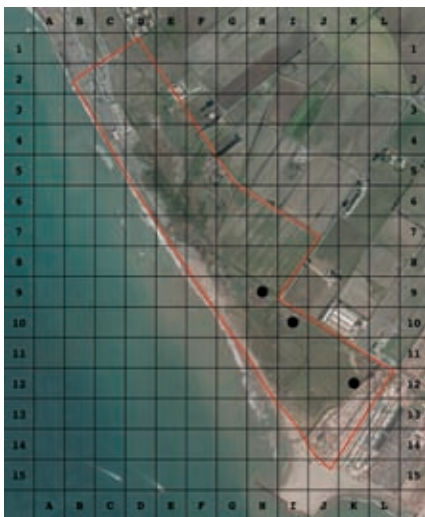
Coturnix coturnix



Phasianus colchicus



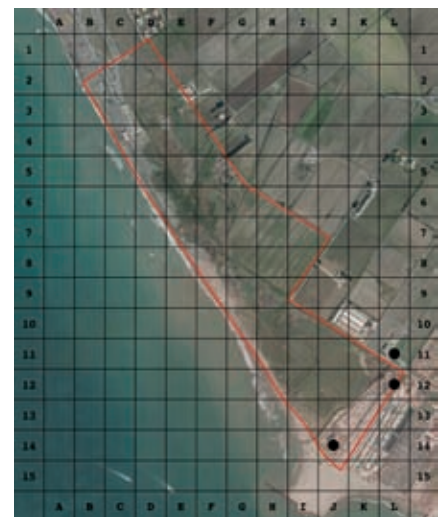
Anas platyrhynchos



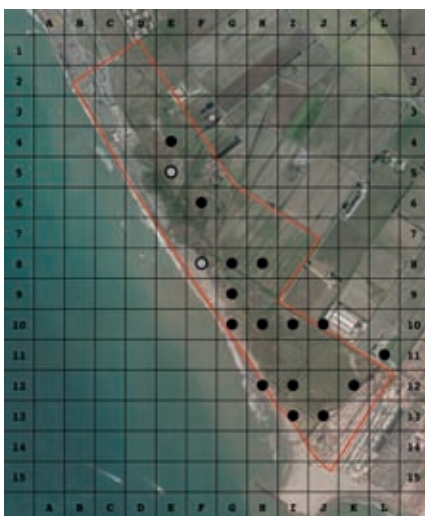
Tachybaptus ruficollis



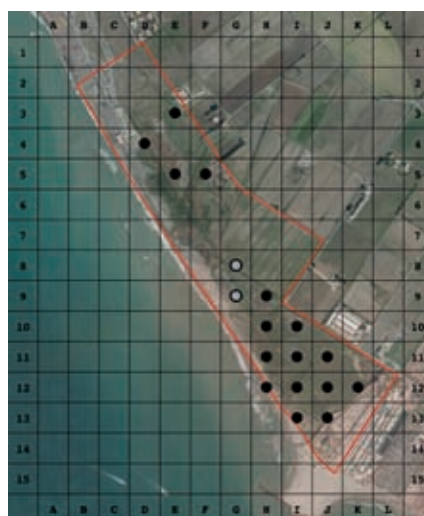
Columba livia forma domestica



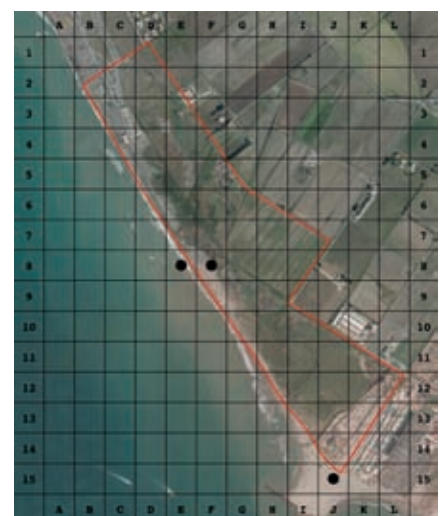
Streptopelia decaocto



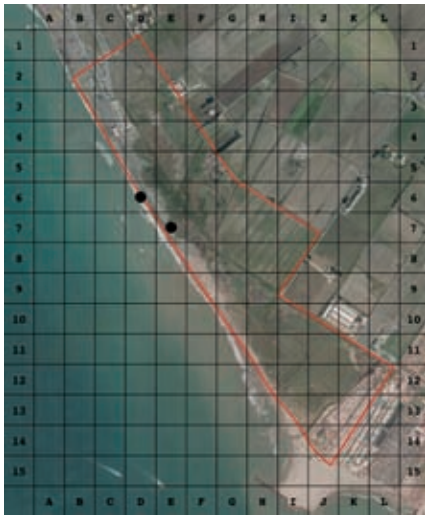
Gallinula chloropus



Fulica atra



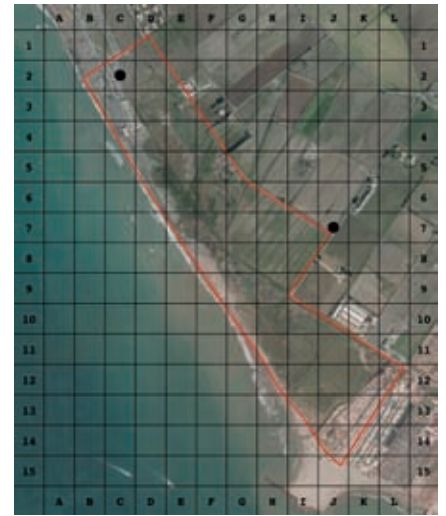
Charadrius dubius



Charadrius alexandrinus



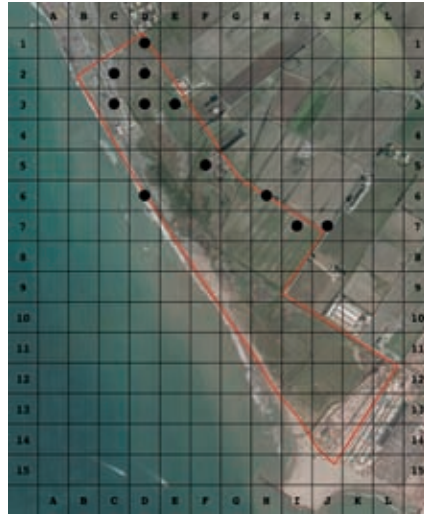
Lanius collurio



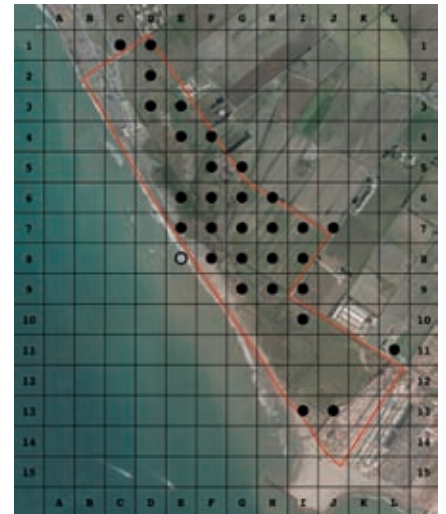
Pica pica



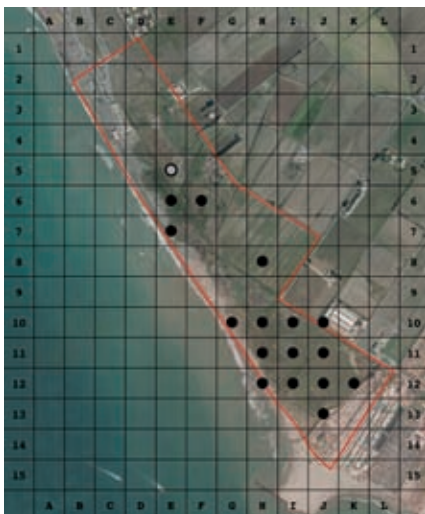
Parus major



Galerida cristata



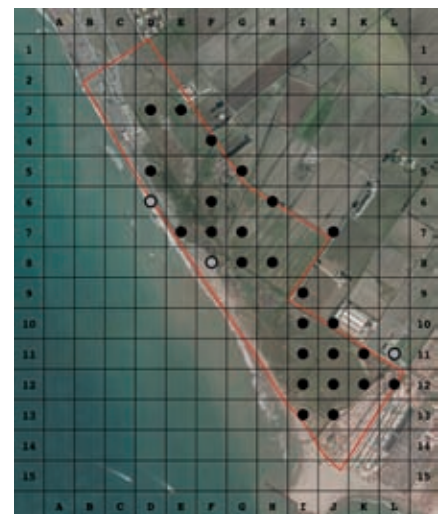
Cisticola juncidis



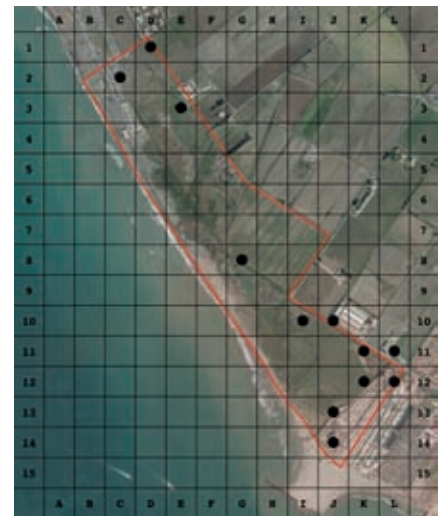
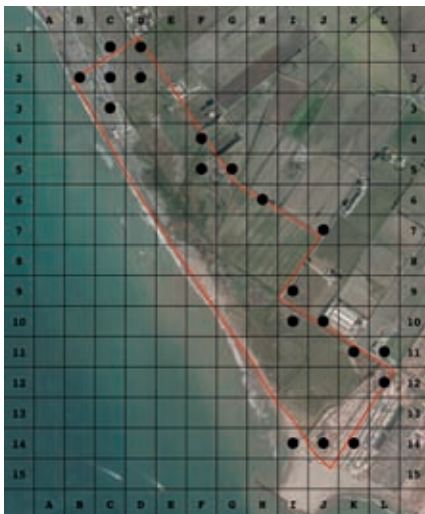
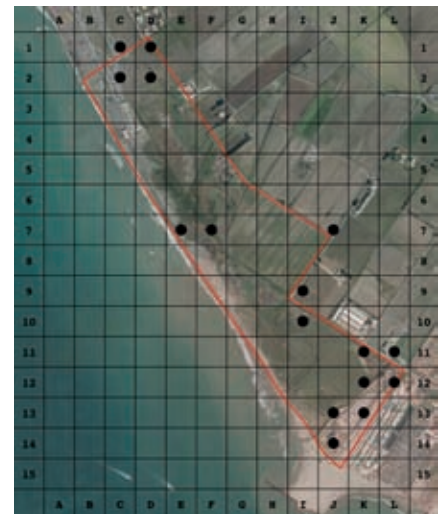
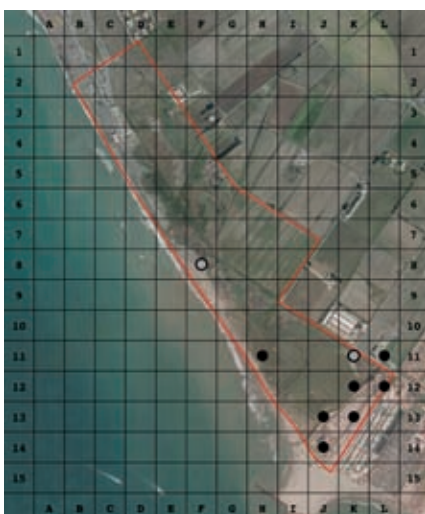
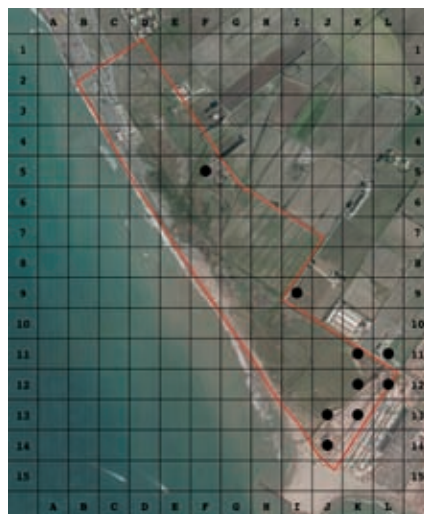
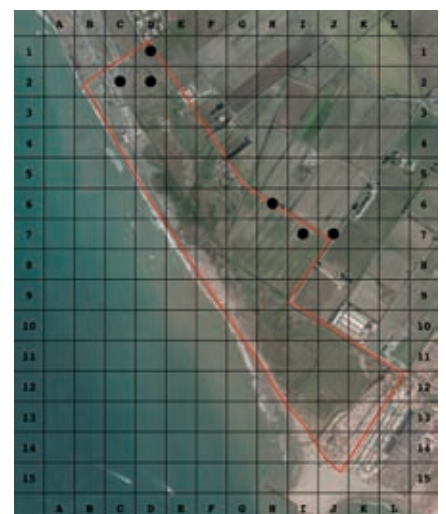
Acrocephalus scirpaceus



Acrocephalus arundinaceus



Cettia cetti

*Sylvia melanocephala**Sturnus vulgaris**Turdus merula**Passer italiae**Motacilla alba**Chloris chloris**Carduelis carduelis**Serinus serinus**Emberiza calandra*

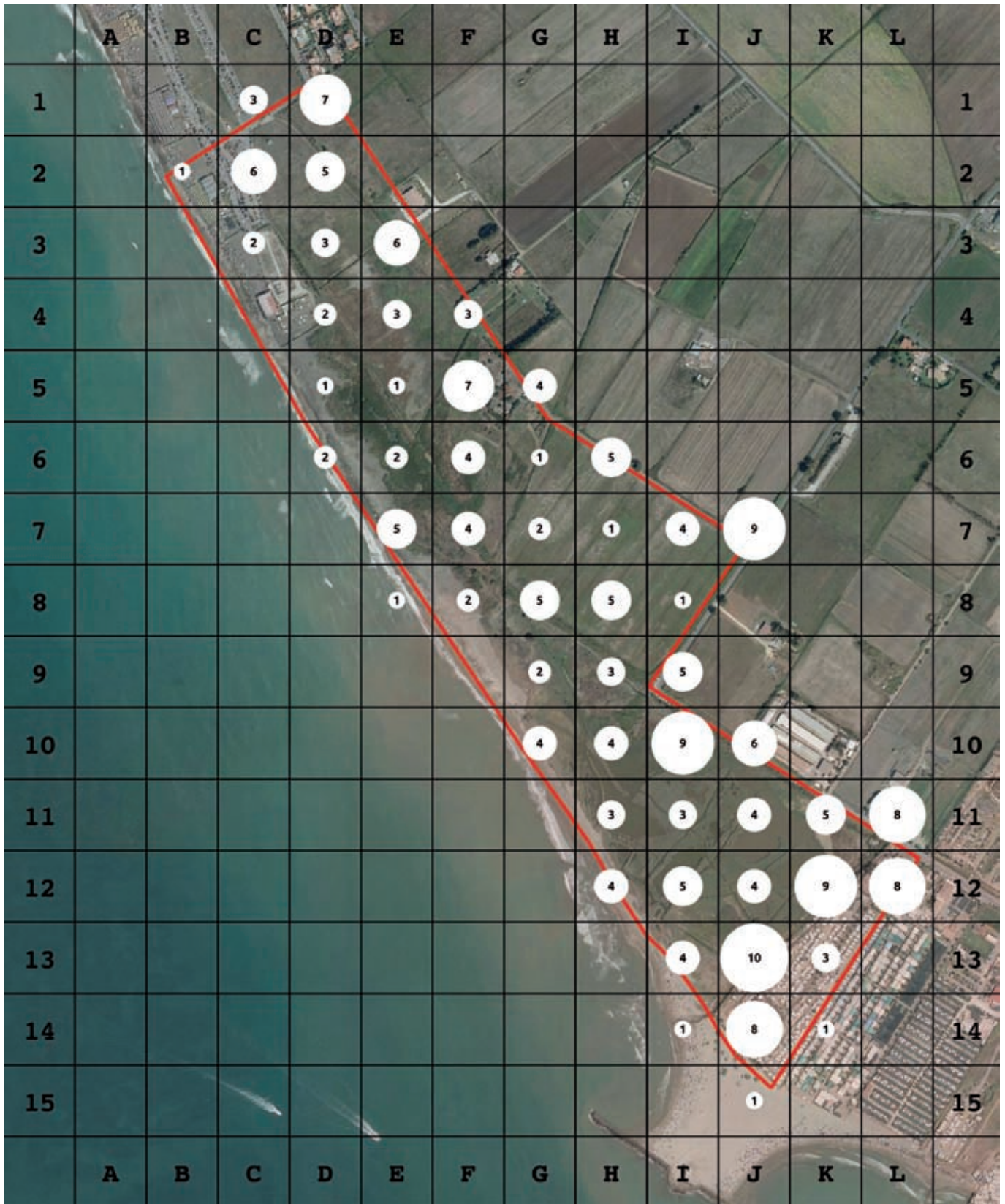


Fig. 3 - Map of species richness of breeding birds in the Torre Flavia wetland (2019). Number of species have been reported inside the white circles. / Mappa della ricchezza di specie di Uccelli nidificanti nella palude di Torre Flavia (2019). All'interno dei pallini bianchi è riportato il numero di specie nidificanti per ciascuna UR.

Tab. 1 - Spatial occurrences and relative frequencies (on SU and in total of occurrences) of breeding bird species in the Torre Flavia wetland (central Italy). Data from 2005: Malavasi *et al.* (2006). Comparisons between frequencies has been performed with the χ^2 test (see Methods). / Presenze spaziali e relative frequenze (su SU e sul totale delle occorrenze) di specie di uccelli nidificanti nell'area umida di Torre Flavia (Italia centrale). Dati del 2005: Malavasi *et al.* (2006). I confronti tra le frequenze sono stati eseguiti con il test χ^2 (vedi Metodi).

	2005			2019			χ^2	P
	N _{SU}	Fr _{occ}	Fr _{SU}	N _{SU}	Fr _{occ}	Fr _{SU}		
<i>Coturnix coturnix</i>				1	0.005	0.016		
<i>Phasianus colchicus</i>				1	0.005	0.016		
<i>Anas platyrhynchos</i>	8	0.033	0.119	10	0.045	0.16	0.199	0.656
<i>Tachybaptus ruficollis</i>				3	0.014	0.047		
<i>Columba livia f. domestica</i>	8	0.033	0.119	1	0.005	0.016		
<i>Streptopelia decaocto</i>	3	0.012	0.045	3	0.014	0.047		
<i>Gallinula chloropus</i>	7	0.029	0.104	15	0.068	0.234	3.094	0.079
<i>Fulica atra</i>	6	0.025	0.09	16	0.072	0.25	4.824	0.028*
<i>Ixobrychus minutus</i>	2	0.008	0.03					
<i>Charadrius dubius</i>				3	0.014	0.047		
<i>Charadrius alexandrinus</i>				2	0.009	0.031		
<i>Lanius collurio</i>				1	0.005	0.016		
<i>Pica pica</i>	4	0.016	0.06	2	0.009	0.031		
<i>Parus major</i>				3	0.014	0.047		
<i>Alauda arvensis</i>	5	0.021	0.075					
<i>Galerida cristata</i>	15	0.062	0.224	11	0.05	0.172	0.128	0.721
<i>Cisticola juncidis</i>	45	0.185	0.672	30	0.136	0.469	18.42	0.001**
<i>Acrocephalus scirpaceus</i>	6	0.025	0.09	16	0.072	0.25	60.58	0.001**
<i>Acrocephalus arundinaceus</i>	1	0.004	0.015	2	0.009	0.031		
<i>Cettia cetti</i>	23	0.095	0.343	25	0.113	0.391	0.25	0.617
<i>Sylvia melanocephala</i>	5	0.021	0.075	1	0.005	0.016		
<i>Sturnus vulgaris</i>	8	0.033	0.119	3	0.014	0.047		
<i>Turdus merula</i>	19	0.078	0.284	12	0.054	0.188	0.711	0.399
<i>Saxicola torquatus</i>	8	0.033	0.119					
<i>Passer italiae</i>	37	0.152	0.552	20	0.09	0.313	3.36	0.067
<i>Passer montanus</i>	3	0.012	0.045					
<i>Motacilla alba</i>	1	0.004	0.015	2	0.009	0.031		
<i>Chloris chloris</i>	4	0.016	0.06	16	0.072	0.25	7.476	0.006**
<i>Carduelis carduelis</i>	8	0.033	0.119	7	0.032	0.109	0.035	0.852
<i>Serinus serinus</i>	6	0.025	0.09	9	0.041	0.141	0.508	0.476
<i>Emberiza calandra</i>	11	0.045	0.164	6	0.027	0.094	0.624	0.429
Total	243	1		221	1	1		

Acknowledgments

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CB and GD defined the atlas design, carried out the field sampling and performed the statistical analyses, MV developed the species map. All the authors discussed the results and commented on the manuscript.

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