Steady turnover in a bird community in a periurban landscape in Northern Italy: a look at the change in species richness over time

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Abstract - From November 2017 until February 2022, with a partial interruption during 2020 linked to the COVID 19 pandemic, the bird community was monitored in a 30 hectares periurban plot in northwestern Lombardy, in the province of Varese. The study area consists of a mosaic of farmland/ urban habitat (Luino and Germignaga municipalities) with scattered strips of woodland on the east side of Lake Maggiore. The farmland is mainly cultivated ryegrass or maize and permanent grassland. The turnover and phenology of the avifauna was regularly monitored. The year was divided up 4 seasons: winter, spring migration, breeding season and autumn migration. Each season was further divided into 10-day periods, giving a total of 37 ten-day periods over the whole year. For each ten-day period, there was a minimum of 4 surveys, alternating a 500m transect over 30 minutes with a single point count for 30 minutes. A total of 134 species were observed. The trend in species richness follows a sinusoidal curve relating to the migration periods. The area of farmland, while not having any regularly breeding species, supported 65 foraging species, with permanent grassland being more species rich than either maize or ryegrass. The Sorensen Similarity Index, based on incidence matrices, ranged from the lowest value of 0.6480 (during the winter of 2018/19 to spring migration in 2019) to the highest value of 0.8572 (from spring migration 2019 to the breeding period in 2019). Most of the nesting species are synanthropic, occupying the urban areas of this plot, including a colony of northern house martins.

Key words: abundance, bird community turnover, farmland, periurban area, richness.

Riassunto - Il costante ricambio in una comunità ornitica in un paesaggio periurbano dell'Italia settentrionale: uno sguardo al cambiamento della ricchezza di specie nel tempo.

Dal novembre 2017 fino al febbraio 2022, con l'interruzione parziale nel 2020 dovuta alle restrizioni imposte dalla pandemia di Covid 19, ho analizzato la variazione della comunità ornitica di un'area periurbana (30 ettari) ubicata nell'Italia nord-occidentale, in provincia di Varese. L'area di studio è un piccolo mosaico centrato su una area agricola (coltivi di loglio e mais e prati stabili) a margine della periferia urbana di Luino e Germignaga, sulla sponda est del Lago Maggiore. Il turnover della comunità e la fenologia è stata basata sulla serie temporale delle 37 decadi annuali, suddividendo l'anno in 4 periodi funzionali: inverno, migrazione primaverile, nidificazione e migrazione autunnale. Ogni decade è stata censita con un minimo di 4 rilievi giornalieri, composti da un'alternanza di un transetto di 500 metri di lunghezza e durata di 30 minuti, e da un punto di osservazione anch'esso di 30 minuti. Ho censito 134 specie: la variazione della ricchezza per decade segue un andamento sinusoidale, che corrisponde ad una marcata variazione stagionale connessa ai periodi migratori; la superficie agricola supporta il foraggiamento di 65 specie, con i prati stabili che presentano una maggiore ricchezza rispetto al loglio ed al mais. L'indice di similarità di Sorensen, basato sulle matrici di incidenza, mostra una variazione da un valore minimo di 0.6480 (dallo svernamento 2018/19 alla migrazione primaverile 2019) ad un massimo di 0.8572 (dalla migrazione primaverile 2019 al periodo riproduttivo 2019). La maggior parte delle specie nidificanti sono sinantropiche, occupando il settore urbanizzato dell'area di studio, anche con una colonia di balestrucci.

Parole chiave: abbondanza, ricambio della comunità ornitica, terreni agricoli, area periurbana, ricchezza.

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INTRODUCTION

The province of Varese has limited agricultural land: the National Institute of Statistics (ISTAT, www.istat.it) identifies 6 different Agricultural Regions (A.R.) and the study plot is located in the A.R. 2 area which contains about a quarter of the provincial agricultural surface area (PTCP, 2007). The Agricultural Surface Area (ASA) of A.R. 2 has 70% permanent pasture and only 24% of arable crops with the latter generally located in periurban areas. The quoted Territorial Plan states that "in the periurban areas, agricultural activity has a marginal role in socio-economic terms and is under pressure from urbanization and infrastructures that limit the availability of land resources". Apart from the A.R.1 on the eastern margins of Lake Maggiore (Eastern Lake Maggiore) and A.R. 2 (mountains between lakes Maggiore and Ceresio) the northern part of the provincial territory belongs to the first level of the Ecological Regional Network, Pre-Alps and Alps sector (Bogliani *et al*., 2009). In the last few decades European farmland birds have suffered a severe decline (Knaus *et al.,* 2018; Bowler *et al.,* 2019; Reif & Vermouzek, 2019) and in Italy the conservation status of many species reveals worrying trends (Rete Rurale Nazionale & LIPU, 2018; Brambilla, 2019). For the lowland areas, the Farmland Bird Index shows a decline of 46.3% (Silva L. & Brambilla M., 2021) with corresponding negative

trends also for the Lombardy region (Bani *et al.,* 2016; Brambilla *et al*., 2017). From an ecological point of view, keeping mixed farmland (permanent grass and crops) close to suburban areas has both advantages and disadvantages (Reynolds *et al.*, 2019): a disadvantage is that there may be human disturbance and habitat fragmentation but, at the same time, it may represent a useful mosaic to conserve local biodiversity and enhance the ecological connectivity (Assandri *et al*., 2017). Species richness is the most widely used measure of biodiversity (Kery *et al.,* 2009) and it is a fundamental part of community diversity (Gotelli & Coldwell, 2001) which can be measured simply by repeated monitoring over time.

The seasonal variation in the bird community was analysed to determine: 1) the variation in total species richness and abundance and how it changed when measured regularly over 10-day periods 2) the turnover of the bird species within the community, 3) how farming (crops and grassland) contributed to species richness when measured regularly and 4) the phenology of selected species.

STUDY AREA

The study was carried out in the northern part of the Province of Varese, in the municipalities of Luino and Germignaga (45° 99' N; 8° 74' E), on the eastern side of Lake Maggiore (Fig. 1). It is a periurban area in a lowland valley (Valtravaglia). The landscape is farmland surrounded by built-up areas with broadleaf woods. The Territorial Management Plan of the two municipalities both classify the farmland area as "agricultural landscape of environmental concern". The 30 ha study plot includes a sewage treatment plant, scattered houses and farm buildings with patches of woodland.

Overall, the landscape is dominated by urban and wooded areas (Tab. 1). The classification of the land cover was obtained from the Vegetation Map of the Province of Varese (Tosi & Zilio, 2002) with QGIS (Vers. 3.4.14). For the 30 ha plot, the land cover types were obtained from a 1:1.000 ortho-photo from National Geoportal.

Tab. 1 - Land cover for the 30 ha study plot and for the buffer zone with a radius of, respectively, 500 m and 1000 m. / Copertura del suolo per l'area di studio di 30 ettari e per la zona cuscinetto con un raggio di 500 m e 1000 m rispettivamente.

	Hectares		
Land cover	plot	buffer r= 500 m	buffer r= 1000 m
Urban	11.3	35.2	156.2
Crops	3.7	20.1	36.4
Grassland	11.6	16.6	59.9
Woodland	3.4	6.1	60.1
Total	30	78	312.6

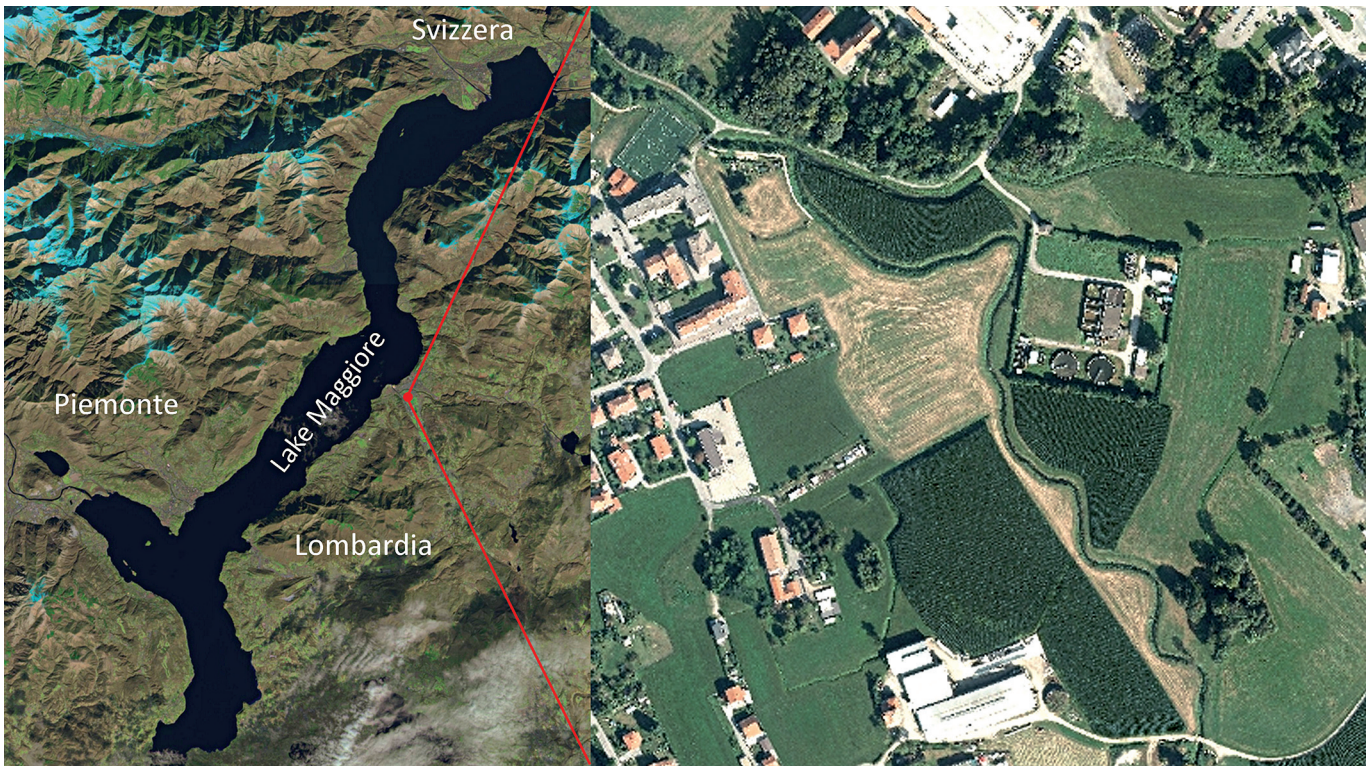

Fig. 1 - Location of the study area in northern Italy. Lake Maggiore is on the left (image of the 13_01_2019; www.landsatlook.usgs.gov, access on 25 October 2019); the study plot is on the right. From National Geoportal 2012 ortho-photo image from www.pcn.minambiente.it, access on 14 June 2021. / Localizzazione dell'area di studio nell'Italia settentrionale. Il Lago Maggiore è a sinistra (immagine del 13_01_2019; www.landsatlook.usgs.gov, accesso il 25 ottobre 2019); l'area di studio è a destra. Da un'immagine ortofotografica del Geoportale Nazionale 2012 di www.pcn.minambiente.it, accesso il 14 giugno 2021.

The farmland area is made up of permanent grassland (hereinafter "grassland", 11.6 ha) which is regularly mown (a minimum of 5 times per year) for feeding dairy cattle in a nearby farm, and non-irrigated crops (3.7 ha) in a rotation of mainly maize and ryegrass (Fig.2) and sometimes with wheat. No chemical fertilisers or pesticides are used and the grassland is fertilized regularly with cattle manure. A very small stream meanders through the grassland.

About half of study plot has patches of crops (12.3%) and grassland (38.6%): ryegrass is a winter/spring crop being sown in November and harvested in May/June after which the fields are sown with maize (rarely with wheat) in June, for harvesting around mid October. The maize stubble remained in the fields from two weeks in 2018 to a maximum of four months in 2021.

METHODS

Monitoring started in November 2017, but was suspended in 2020 due to the COVID 19 pandemic. It was resumed at the end of November 2020 and was concluded in February 2022. For studying the phenology of bird species, the year was divided up into four main (ornithological) seasons (Tab. 2), each one split into 9 10-day periods except for the autumn migration, which was split into 10 10-day periods (making a total of 37 10-day periods).

Fig. 2 - The study plot with grassland and maize fields, October 2019. In the background is the mountain ridge on the western side of Lake Maggiore, in the Region of Piedmont. / L'area di studio con prati e campi di mais, ottobre 2019. Sullo sfondo la dorsale montuosa sul lato occidentale del Lago Maggiore, nella Regione Piemonte.

Tab. 2 - Dividing the year into four seasons for bird phenology. Suddivisione dell'anno in quattro stagioni per la fenologia degli uccelli.

Season	Start	No. of 10-day period	End	No. of 10-day period
Wintering (W)	27 November	34	19 February	5
Spring Migration (SM)	20 February	6	20 May	14
Breeding (B)	21 May	15	18 August	23
Autumn Migration (AM)	19 August	24	26 November	33

The temporal series of bird phenology was calculated on the basis of 10-day periods, with a minimum of four survey per ten-day period, each one made up of at least one 30 minute transect and one 30 minute point count; the 10-day periods were grouped into the four divisions of the year (or seasons). The surveys were divided among three different transects (each one 500 m long) and alternated with four different points counts: both with a maximum distance of 400 m; all data were gathered (with binoculars and spotting scope) in the morning (h. 6.00-11.00), with only occasional surveys in the early afternoon. Three years (2018, 2019 and 2021) have a complete coverage of the 37 ten-day periods (Tab. 3), while 2017 and 2022 were respectively surveyed to start and finish the wintering season.

There was no difference in the mean number of point counts and transects carried out for each complete year (paired t test, $t = -0.8951$, $p = 0.4651$). All birds (resting, feeding, singing) were assigned to the four land cover types (Tab. 1), using a custom-made data form. The data were then transferred to a spreadsheet for analysis. The nomenclature follows the CISO-COI Check-list of Italian birds - 2020 (Baccetti *et al.,* 2021).

Data analysis

The analysis were conducted using *R version 4.0.2* (2020 The R Foundation for Statistical Computing). The richness (S) was calculated for each daily survey together with the maximum abundance of each species. Ten-day period richness (DR) was then recomputed as a matrix with the species as rows and daily surveys as columns, while season richness (SR) was obtained from a matrix with the species as rows and the ten-day periods as columns. Mean and median values were calculated for each season with standard error (SE). Finally, the richness for the 10-day period was assessed for any differences between cropland and permanent grassland. The community similarity of each season with the following categories (W -> SM; SM -> B; B -> AM; AM -> W) was calculated using the function SimilarityPair of the package *"SpadeR"* (Chao *et al*., 2016) with the Sorensen Index. This index, for binary data (incidence raw matrix) takes values from 0 to 1: the closer to 1 the more similar the communities. The SimilarityPair function compares equal matrices (season

Tab. 3 - Point counts, transects and daily surveys carried out in each year with the corresponding number of ten-day periods. / Conteggi puntiformi, transetti e rilievi giornalieri effettuati in ogni anno con il corrispondente numero di decadi.

Year	2017	2018	2019	2020	2021	2022
Number of point counts	12	188	201	13	166	25
Number of transects	15	193	197	11	176	25
Total daily surveys	9	180	187	12	173	25
Number of ten-day periods	4	37	37	4	37	5

1 with season 2) where the rows are 10-day periods and the columns are species. This returned an estimate (with a standard error SE) of a classic richness-based Sorensen Index with n=100 replications. In order to calculate the Sorensen Index, it is necessary to have the same number of columns (9 for both seasons) for each year. For this reason, the 24th 10-day period, which has almost the same value as the 25th 10-day period, was deleted. The species that foraged in permanent grassland or cultivated land were divided into two groups: regular or irregular. For a species to be regarded as regular, there had to be a minimum of 50 sightings. The annual phenology of selected species is described on the basis of the 10-day period time series, with the trend line obtained with "loess" method using a smooth local regression (Wickham, 2016). The abundance value for the whole plot was calculated for each daily survey as the maximum number of individuals observed for each species, then the mean calculated for each 10-day period. Parametric, or non-parametric tests for non-normally distributed data, were used.

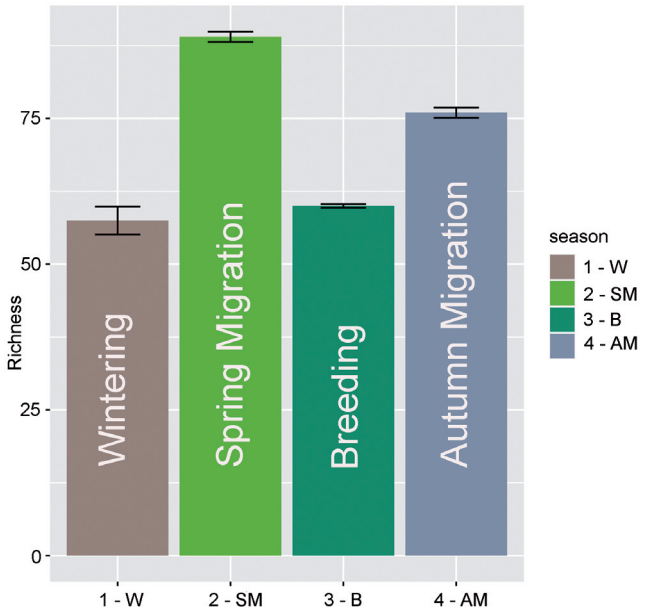

Fig. 3 - Median values (± SE) of Richness in the four seasons. / Valori mediani (± SE) della ricchezza nelle quattro stagioni.

RESULTS

Season Richness (SR), 10-day period richness and abundance

The total number of species observed in the study plot from November 2017 to February 2022 was 134. For each year the maximum richness coincided with spring migration (SM_{mean} = 89.3, median = 89, SE = 0.88), followed by autumn migration (AM_{mean} = 76.3, median = 76, SE = 0.88). The breeding and wintering seasons have very similar median values of 60 and 57.5 respectively. SR shows a marked seasonality in the median values among seasons (Fig. 3 and Tab. 4) with a limited variation within each period, namely during spring, autumn migration and breeding, as confirmed by the low standard error. Only the wintering season denotes a relatively bigger spread of inter-annual variation, related to a decreasing wintering richness from 2017 to 2022.

The same pattern applies to the variation of richness in the 10-day period time series over the three years, with no significant differences in the median values (Kruskal-Wallis rank sum test = 0.1821, df = 2, p = 0.913; Fig. 4 and Tab. 5). Noticeable changes were observed for the highest values of richness during spring migration: in 2018 the maximum value was reached in the 9th 10-day period (22-31 March, S = 55), in the 10th 10-day period (1-10 April, S = 51) and 13th (1-10 May, S = 51) in 2019 and in the 13th and 14th (1-10 May and 11-20 May, S = 51 respectively) in 2021. The autumn migration reveals a lower scattering, with maximum values for the 30th ten-day period in 2018 and 2019 (18-27 October, respectively S = 48 and S = 50) and the 29th 10-day period for 2021 (8-17 October, S = 49).

Within the breeding seasons the variation of richness is extremely low (S_{median} = 60, SE = 0.33) and the species pool for the three years reveals a stable sub-group of 27 synanthropic taxa that regularly breed in the urban or woodland patches of the study plot: among them a colony of northern house martins (*Delichon urbicum*) with over 30 occupied nests in 2019. Many species nest in the surrounding territory and forage regularly in the study plot: for example, raptors such as black kite (*Milvus migrans*), common buzzard (*Buteo buteo*), eurasian sparrowhawk (*Accipiter nisus*) and eurasian hobby (*Falco subbuteo*). This last species preyed on many juvenile northern house martins resting on the power lines in 2018. Mute Swan (*Cygnus olor*), goosander (*Mergus merganser*) with juveniles in May of 2019, and common kingfisher (*Alcedo atthis*) from the nearby River Tresa and Lake Maggiore foraged along the stream. The only species nesting in the cropland area was common pheasant. The pattern of variation in abundance has a different trend compared to

Tab. 4 - Season Richness (with median and standard error) for the period 2017-2022. / Ricchezza stagionale (con mediana ed errore standard) per il periodo 2017-2022.

Season	2017/18	2018	2018/19	2019	2020/21	2021	2021/22	median	SE
W - wintering	65		59		54		56	57,5	2,4
SM - spring migration		91		89		88		89	0,88
B - breeding		60		61		61		60	0,33
AM - autumn migration		75		79		76		75	0,88

Tab. 5 - Richness values for the 10-day periods in 2018, 2019 and 2021. / Valori di ricchezza per decadi nel 2018, 2019 e 2021.

10-day period	S 2018	S 2019	S 2021
1	34	39	41
2	42	40	40
3	46	41	39
4	38	42	40
5	40	38	40
6	41	43	37
7	51	49	41
8	49	49	48
9	55	42	46
10	53	51	43
11	51	50	44
12	52	45	46
13	42	51	51
14	40	48	51
15	37	42	45
16	36	36	37
17	34	35	35
18	38	32	30
19	37	38	34
20	36	33	32
21	34	36	33
22	34	35	33
23	34	32	32
24	36	37	37
25	38	39	38
26	44	42	44
27	34	39	44
28	37	39	41
29	46	48	49
30	48	50	43
31	44	40	45
32	39	40	45
33	46	43	40
34	39	39	38
35	41	42	44
36	36	39	42
37	34	36	42

richness: there are significant differences in the median values (Kruskal-Wallis rank sum test = 11.536, df = 2, p = 0.003; Fig. 5). The median values of abundance per 10-day period per year range within a narrow interval (122-137 individuals) and only a few species show an upward trend in the wintering season such as white wagtail (*Motacilla alba)*, carrion crow (*Corvus c. cornix*), common starling (*Sturnus vulgaris*), common chaffinch (*Fringilla* coelebs) and eurasian siskin (*Spinus spinus*), sometimes with groups numbering over 200 birds. The smooth trend line has a more or less flat progression from the 1st 10-day period till the 25th. During the late autumn migration an upward trend in abundance began which confirmed an overall increase in total abundance similar to that for the 3 years, but there was a progressive decrease in the maximum values from 2018 to 2021, (corresponding to the 31st to 37th 10-day period), that isn't however statistically significant (Kruskal-Wallis rank sum test = 5.729, df = 2, p = 0.056).

The turnover in community from one season to the next reveals a steady change in species assemblages, as confirmed by the Sorensen Index (Tab. 6). As expected, the largest changes occur when passing from the winter season to the spring migration (SI_{mean} = 0.7105; SE = 0.04) and from the breeding period to the autumn migration (SI_{mean} = 0.7189; SE = 0.02). The variation from spring migration to the breeding period has a higher value for the Sorensen Index (SI_{mean} = 0.8014; SE = 0.03) and hence a more similar community, since some migrating species, mainly Trans- Saharan migrants, are breeding too: e.g. black kite, eurasian hobby, common swift (*Apus apus*), barn swallow (*Hirundo rustica*), northern house martin, common redstart (*Phoenicurus phoenicurus*), spotted flycatcher (*Muscicapa striata*). A slightly higher value of the Sorensen Index (SI_{mean} = 0.8101; SE = 0.06) corresponds with the transition from autumn migration to the wintering period, in which some intra-Palearctic migrants are common wintering species: e.g. great white egret (*Ardea alba*), meadow pipit (*Anthus pratensis*), dunnock (*Prunella modularis*), northern wren (*Troglodytes troglodytes*), european robin (*Erithacus rubecola*), chiffchaff (*Phylloscopus collybita*), reed bunting (*Emberiza schoeniclus*).

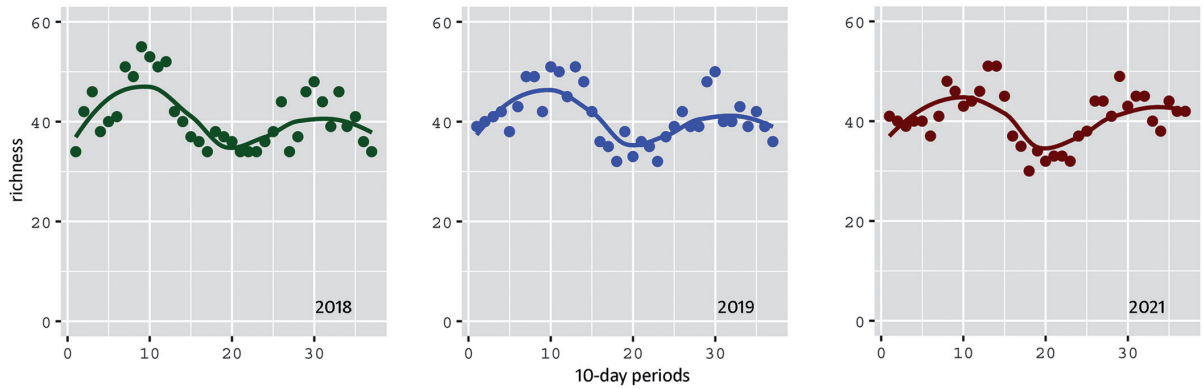

Fig. 4 - Pattern of variation of Richness for 10-day periods for 2018, 2019 and 2021. / Tendenza della variazione della ricchezza per decadi per il 2018, 2019 e 2021.

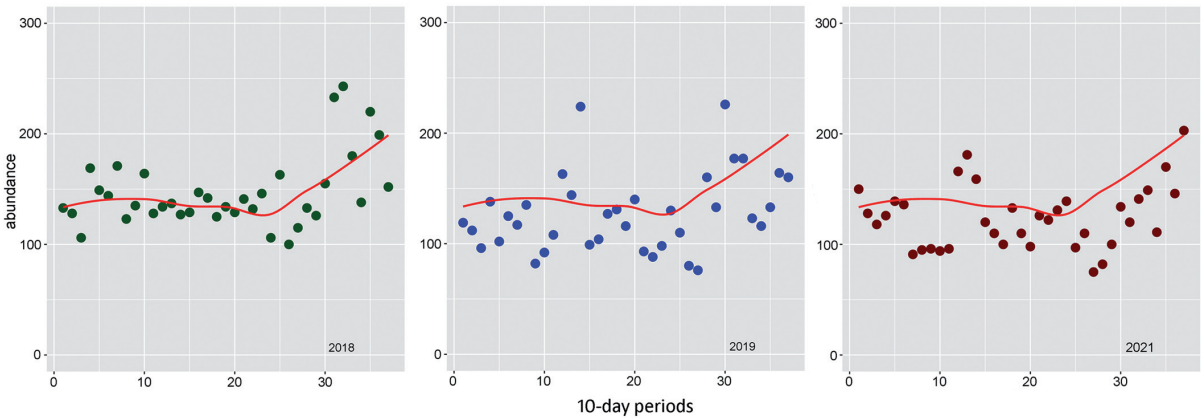

Fig. 5 - Pattern of variation of abundance for 10-day period for 2018, 2019 and 2021. / Tendenza della variazione dell'abbondanza per decade per il 2018, 2019 e 2021.

Tab. 6 - Value of Sorensen Index for the sequence of seasons from 2017 to 2022. / Valore dell'indice di Sorensen per la sequenza di stagioni dal 2017 al 2022.

Sequence of seasons			Sorensen Index	SE
W 2017/18	⇨	SM 2018	0,7912	0,098
SM 2018	⇨	B 2018	0,7989	0,0675
B 2018	⇨	AM 2018	0,7685	0,0921
AM 2018	⇨	W 2018/19	0,8731	0,1051
W 2018/19	⇨	SM 2019	0,648	0,0511
SM 2019	⇨	B 2019	0,8572	0,1063
B 2019	⇨	AM 2019	0,7036	0,0866
W 2020/21	⇨	SM 2021	0,6925	0,0688
SM 2021	⇨	B 2021	0,7482	0,0586
B 2021	⇨	AM 2021	0,6845	0,0567
AM 2021	⇨	W 2021/22	0,7472	0,0561

Cropland and grassland richness

Twenty-six out of the 65 species which regularly forage in crops and grassland, belong to 12 families (Tab. 7), with an ongoing variation and turnover throughout the seasons (Tab. 8, three years combined data). Richness is always greater in grassland than in crops (Fig. 5, three years combined data), mostly in winter and during the breeding season.

Values for spring and autumn migrations are similar, but there is always a difference that is highly significant during autumn migration. The maturation of the maize crop (generally between the 22nd and 29th 10-day period, from the end of July to the first half of October) partly

Tab. 7 - Species regularly foraging in crops and grassland. / Specie che foraggiano regolarmente nei coltivi e nei prati stabili.

1	*Anas platyrhynchos*
2	*Bubulcus ibis*
3	*Casmerodius albus*
4	*Ardea cinerea*
5	*Gallinula chloropus*
6	*Chroicocephalus ridibundus*
7	*Larus michahellis*
8	*Columba livia* var. *domestica*
9	*Streptopelia decaocto*
10	*Alauda arvensis*
11	*Anthus pratensis*
12	*Anthus spinoletta*
13	*Motacilla flava*
14	*Motacilla cinerea*
15	*Motacilla alba*
16	*Erithacus rubecola*
17	*Phoenicurus ochruros*
18	*Saxicola rubetra*
19	*Saxicola torquatos*
20	*Turdus merula*
21	*Turdus philomelos*
22	*Corvus monedula*
23	*Corvus corone*
24	*Corvus cornix*
25	*Sturnus vulgaris*
26	*Passer italiae*
27	*Fringilla coelebs*

Tab. 8 - Total and mean Richness of crops and grassland in the four season (three years combined data). / Ricchezza totale e media delle colture e dei prati stabili nelle quattro stagioni (dati combinati per tre anni).

Season	Wintering		Spring Migration		Breeding		Autumn Migration	
land cover	crop	grassland	crop	grassland	crop	grassland	crop	grassland
Total Richness	28	36	26	33	22	27	34	39
mean 10-day period Richness	4,9	10,9	4,2	9,1	2,9	6,5	6,2	8,1
median	4,5	11	3	9	2	6	6	7,5
s.e.	0,39	0,36	0,53	0,8	0,46	0,51	0,76	0,66
two.sided paired t test	t=-12.882 df=35 p=0.0213*		t=-5.6021 df=26 p=0.0171*		t=-5.5092 df=26 p=0.0218*		t=-2.9732 df=29 p=0.0058**	

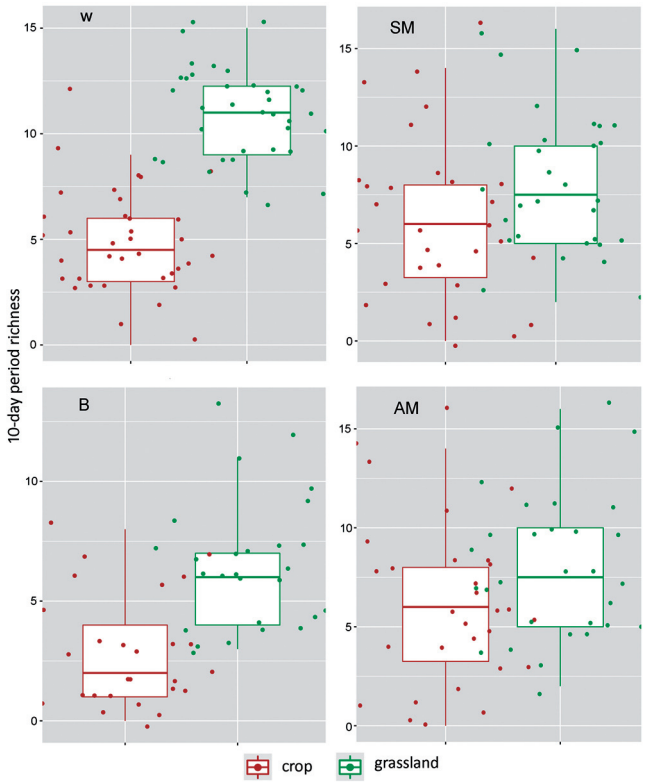

Fig. 6 - Distribution of 10-day period richness of cropland and grassland in the four periods (W= Wintering, SM= Spring Migration, B= Breeding, AM= Autumn Migration; three years combined data). / Distribuzione della ricchezza per decade dei coltivi e dei prati stabili nei quattro periodi (W= Inverno, SM= Migrazione primaverile, B= Nidificazione, AM= Migrazione autunnale; dati combinati di tre anni).

overlaps with the breeding and autumn migration periods. Although it is harder to detect and identify birds during autumn migration due to the thickness of the crop, this factor is mitigated once the crop is harvested, leaving behind the stubble. This time frame is from the 28th till the 32nd ten-day period (from the end of September to the first half of November), and coincides with the main migration phase (highest value of richness, Tab. 5) of the study period. The highest value of the mean 10-day period richness for grassland corresponds to the wintering period when several intra - Palaearctic migrants/wintering are common.

Annual phenology in crops and grassland

Examples of different phenological patterns of species with different habits (resident or migratory) account for both turnover and overlap in the use of the agricultural land-cover.

White wagtail is a resident species with scattered pairs breeding in the nearby human settlements. However, the study plot acts as a gathering place on the landscape scale as well as a place for the wintering population that is building up in numbers from the 28th 10-day period (28 September-7 October) until the 36th ten-day period (17-26 December) reaching high mean values in the 33rd to 36th ten-day period (maximum number of 87 individuals foraging in permanent grassland on 18 December 2019).

The meadow pipit is a regular intra-Palaearctic migrant and wintering species and the annual phenology shows two main periods: an extended stop-over in the late autumn and winter periods, with a very regular migration starting from between the end of September till the first half of October (28th and 29th ten-period; median date 7 October). The few wintering individuals (generally fewer than 10) are joined from half-way through the 8th ten-day period (12-21 March) by pre-nuptial migrants whose numbers reach a peak in the 9th and 10th ten-day period (22-31 March and 1-10 April respectively), with a maximum number of over 70 on 29 March 2018.

The migration of winchat (*Saxicola rubetra*) overlaps with the growth phase of maize (2<h<3m) in late August (median date 24/08, with the earliest date of 06 August). The birds often fly out from the top of the maize stems to catch insects. During spring migration, the first individuals arrive between the 10th (1-10 April) and 11th ten-day period (11-20 April; median date of 11 April) with numbers peaking during the 13th ten-day period (1-10 May).

The common starling reveals a structured pattern of grassland use: it is extremely rare in December and January and the phenological time series shows 3 different peaks. The bulk of migration is recorded mainly between the 30th (18-27 October) and 32nd (7-16 November) 10-day periods with very few individuals remaining after the 33rd ten-day period (17-26 November). After the start of the New Year the first breeding birds are detected mostly from the 6th ten-day period (from 20 February till 1 March) and spring migration is concentrated between the 7th (2-11 March) and 9th (22-31 March) ten-day periods, after which time the few remaining individuals

stay to breed in the nearby farms and settlements. Then, starting from the 15th ten-day period (21-30 May) until the 19th ten-day period (30 June-9 July) foraging groups are seen which are mostly made up juveniles that disappear by the end of the 21st ten-day period (20-29 July). From the end of July until mid September (2019 and 2021) or October (2018) the species is absent from the study plot.

DISCUSSION

Habitat heterogeneity may foster a diverse bird community (Benton *et al.*, 2003; Caula *et al*., 2008; Capello & Boano, 2010; Pollo, 2020) which is however suppressed in intensive agricultural ecosystem (Laiolo, 2005; Ferlini, 2009; Scarton, 2016). In the farmland ecosystem, urban sprawl is one of the main factors leading to a decrease in bird richness, particularly for specialist taxa (Chace & Walsh, 2006; Filippi-Codaccioni *et al.*, 2008) with increasing urbanization leading to biological homogenization (McKinney, 2006). Sedentary species are more adapted than migratory ones to occupy patches of suburbs with moderate and high levels of urbanization (Caula *et al*., 2008; Husté & Boulinier, 2011) and in the Alpine urban settlements it was shown that synanthropic bird species benefit from the presence of meadows (Assandri *et al*., 2017). In Lombardy the annual cycle of the bird community in large agricultural ecosystems has been analyzed in the Oltrepò Pavese, in an area on the southern side of the Padana Plain (Ferlini, 2007, area A; Ferlini 2009, area

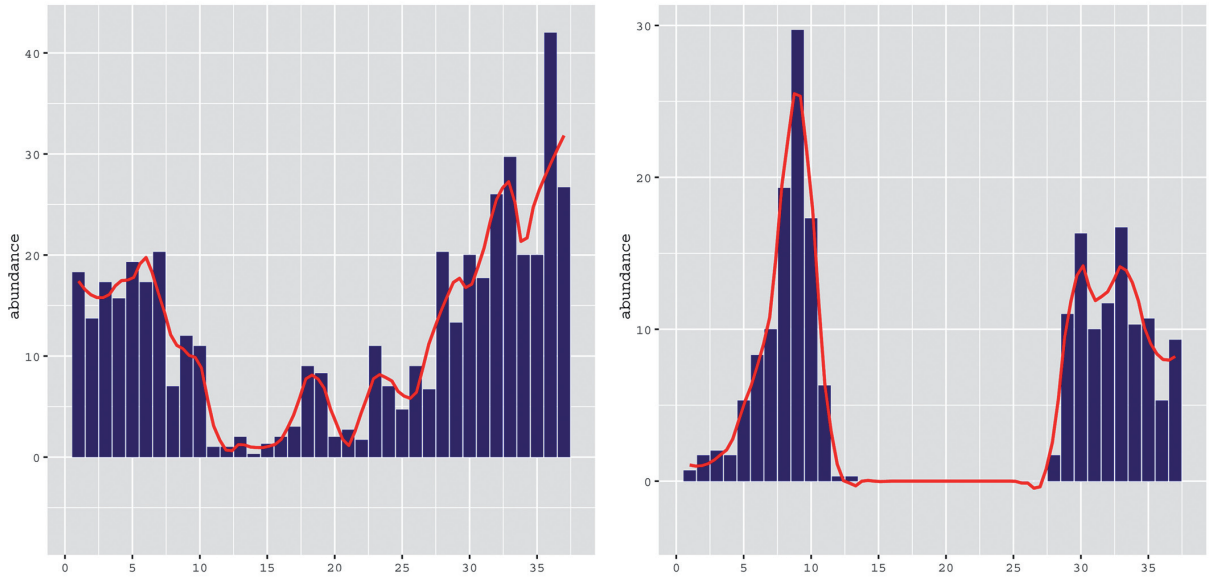

Fig. 7 - Annual phenology of *Motacilla alba* (left) and *Anthus pratensis* (right). / Fenologia annuale di *Motacilla alba* (sinistra) e *Anthus pratensis* (destra).

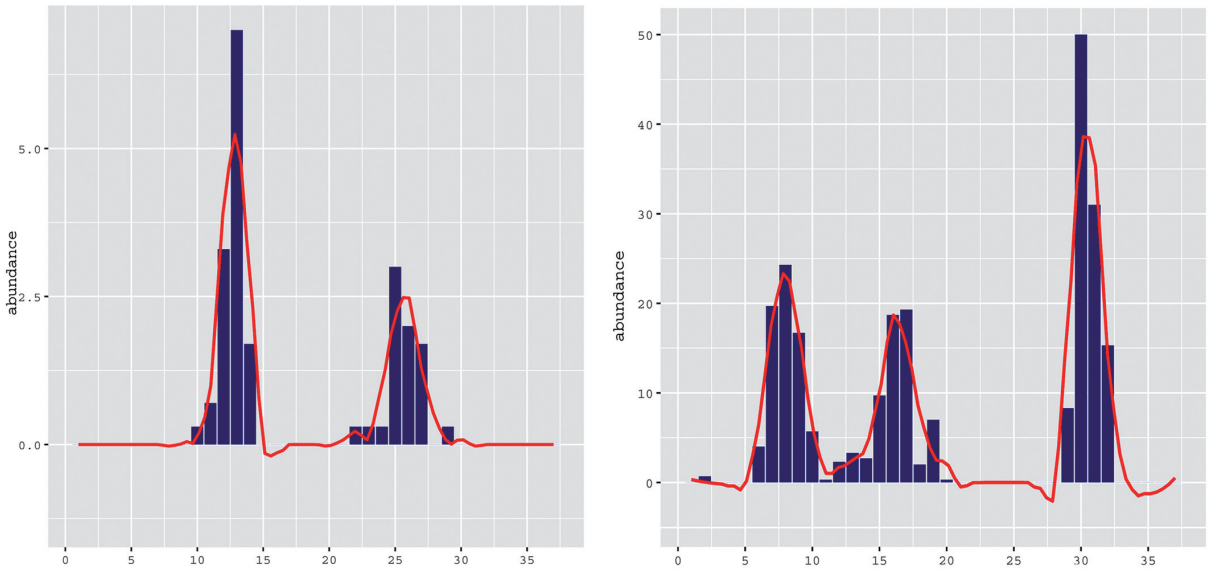

Fig. 8 - Annual phenology of *Saxicola rubetra* (left) and *Sturnus vulgaris* (right). / Fenologia annuale di *Saxicola rubetra* (sinistra) e *Sturnus vulgaris* (destra).

B). In the largest area, area A, of 156 hectares within the Castelletto di Branduzzo municipality that was mainly cultivated with cereals and sugar beet, 67 species were observed, 21 of which were breeding. Among them was the nowadays rare eurasian skylark (*Alauda arvensis*), western yellow wagtail (*Motacilla flava*) and common stonechat (*Saxicola torquata*), together with the very rare ortolan bunting (*Emberiza hortulana*) and corn bunting (*Emberiza calandra*). In area B, an alfalfa field of 39.3 ha in the Bastida Pancarana and Sommo municipalities, 25 species were counted, of which only 3 were breeding: common quail (*Coturnix coturnix*), eurasian skylark and corn bunting; it is interesting to note that this plot was already considered "an ecological trap", with low breeding success due to frequent mowing (up to 6 times a year). This value is similar to the one observed in my study area, in which the management of the grassland (mowing and fertilizing with cattle manure) does not permit any of the open habitat species to breed successfully: its ecological value now is due only to its environmental connectivity and to the foraging area that provides an important stop-over site for many migrants, within the Lake Maggiore ecological corridor. For birds migrating north over the Alps, it forms the last stop-over of lowland farmland area before the Swiss Bolle di Magadino Reserve, just over 20 km away, which is in turn connected to the northern agricultural area of the Natural Park of the Magadino Plain (PUC-PPdM, 2012). And of course the reverse is true for birds migrating southwards: it is the first area of lowland farmland where they can feed up after leaving the Magadino Plain. It is interesting to note that more than 50 years ago, in a paper by Bianchi *et al.* (1969), dealing with the birds of the Province of Varese, there are explicit references to this study plot as "the irrigated plain between Germignaga and Voldomino" where Montagu's and hen Harrier "follow different pathways in the two directions of migration" and "coming from the Magadino Plain, bordering the Lake Maggiore, they slowly hunt in the countryside of Germignaga and Voldomino". In fact, we can still see today that this area is a "bottleneck area for migration" in spite of the major environmental changes that have occurred since then. To support the importance of the study area for migrating birds, 40 taxa (29.8%) of total number observed during this study are trans-Saharan migrants. Among them many species which breed in reedbeds, sedge-fens and scrub (6 species from the genus *Locustella* and *Acrocephalus*). These are migrants that forage during migration in the vegetation along the side of the stream or in the hedgerow bordering the sewage treatment plant. The first and only record of aquatic warbler (*Acrocephalus paludicola*) for the province of Varese was found here on 30 April 2016 (by Michele Viganò; Aletti, 2021) and was noted among the few records in Lombardy reported in the ornitho.it database for the period 1989-2021 (access on 03 March 2022 www.ornitho.it). Only 3 records for this species were recorded from the Bolle di Magadino Reserve for the period 2008-2018 (access on 03 March 2022 www.ornitho.ch). This species is a habitat specialist of eutrophic sedge fens (Flade & Kalyakin, 2020) and is classified as Vulnerable in the European Red List of Birds (BirdLife International, 2015). Regular migrants are common snipe (*Gallinago gallinago*) and green sandpiper (*Tringa ochropus*): the first one feeding in grassland and on the banks of the stream and the latter only on the stream. This small area, part of the "bottleneck" on the Lake Maggiore ecological corridor, plays an important role for wintering and migrating birds, even if not for breeding birds. Clearly the conservation of this area of farmland, without any further urban encroachment, is key to maintain the essential ecosystem under the auspices of the Regional Ecological Network.

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