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Six (or nearly so) big challenges for farmland bird conservation in Italy

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Abstract – Italy harbours a large proportion of the breeding populations of several threatened or declining farmland species, but has been under-represented for a long time in studies about ecology and conservation of farmland birds. In the last two decades, several studies have partially filled the gap, providing key knowledge for their conservation; however, the practical implementation of conservation strategies had been very limited, and many aspects still require research. I analyse the status of farmland birds in Italy, identify main issues for their conservation, and propose directions for effective conservation strategies. Species tied to grassland-like habitats (hay meadow, montane grassland, pasture, pseudosteppe) currently have the most concerning conservation status, followed by species occupying agricultural mosaics and shrubland; only generalist species are performing better and include many species with favourable conservation status. Several factors/pressures negatively affect breeding farmland birds in Italy. Main threats could be tentatively assigned to six "challenges": agricultural intensification, land abandonment, pest management, low breeding success, difficult practical implementation of conservation measures, within-season shift in distribution and habitat by breeding species. They are interconnected by means of direct effects or by acting on the same ultimate drivers of population dynamics. Such challenges mostly act at two levels: the landscape scale, and the field management level. For each one, I summarise available evidence from studies carried out in Italy, discuss conservation implications and their current/possible implementations, and highlight main needs in terms of future research. In general, key issues for conservation are: planning measures at the right scales; conserving, restoring and correctly managing grassland; conserving/enhancing 'marginal' features and heterogeneity; correctly managing ground vegetation in perennial crops; facing the 'nest crisis'; considering the temporally different suitability and the connectivity among patches; evaluating the economic outcomes and the broader benefits of different conservation strategies. Implementation of measures for farmland birds requires multi-faceted efforts, targeted at different stakeholders; a focus also on the ecosystem services arising from a biodiversity-friendly management could provide a broader support for conservation initiatives. Now it is time to intensively cooperate with practitioners (farmers at first) to translate into management protocols and appealing agri-environmental schemes the conservation implications of research carried out in the last decades.

Key-words: farmland birds, conservation strategies, agriculture intensification, land abandonment.

INTRODUCTION

Farmland birds represent one of the main conservation concerns of recent decades, especially in Europe, where the population of several species collapsed in the last decades of the past century (Donald *et al*. 2001), with negative trends often continuing (or even exacerbating) in the first years of the new one (Heldbjerg *et al*. 2017), including in Italy (Rete Rurale Nazionale & Lipu 2015a).

Italy is home to a fairly large proportion of the breeding populations of several farmland bird species that are threatened or are undergoing population declines in Europe (Gustin *et al*. 2010, 2009). Despite the potential importance that the country has for farmland bird conservation, Italy has been for a long time under-represented in studies about ecology and conservation of farmland birds (Tryjanowski *et al*. 2011). In the meanwhile, the conservation status of farmland birds has worsened, as suggested by large-scale monitoring programs and national assessments (Gustin *et al*. 2016, 2010, Nardelli *et al*. 2015, Rete Rurale Nazionale & Lipu, 2015a), as well as by the dramatic decline of some once common species (Brichetti *et al*. 2008). Protected areas apparently do not provide substantial contributions to farmland bird conservation, which mostly occur outside them (Campedelli *et al*. 2010) and do not seem to perform better within the network of protected sites in Lombardy than outside it (Sicurella *et al*. 2017). While studies evaluating the potential benefits brought by agri-environmental schemes to avian species have increased in several European countries (e.g. Llusia & Oñate 2005,

Ponce *et al*. 2014, Walker *et al*. 2018), they have been almost totally lacking in Italy, with a very few exceptions (e.g. Brambilla & Pedrini 2013, Calvi *et al*. 2018, Campedelli *et al*. 2016). Nevertheless, an increasing interest towards farmland birds and their ecology and conservation recently emerged and, in the last two decades, several studies carried out in Italian agroecosystems have partially filled the existing knowledge gap. This process has lead to tens of new studies, especially in the first years of the new millennium, investigating drivers of species ecology (e.g. Brambilla *et al*. 2017a) and community structures in different types of agricultural systems (e.g. Laiolo 2005), or the use of farmland birds as indicators or proxies for general biodiversity (e.g. Brambilla *et al*. 2009a) or for natural (Morelli *et al*. 2014) or cultural value of the investigated landscapes (Assandri *et al*. 2018b). Even if some studies were carried out according to a largely descriptive approach, several others were driven by quantitative analyses aimed at responding in a robust way to challenging conservation issues. These studies provide key knowledge for farmland bird conservation, highlighting the basic ecological needs of several species of conservation concern and/or the factors dictating community traits; however, the practical implementation of the conservation strategies proposed by such studies had been very limited until now. In addition, there are still many aspects that urgently require new, dedicated researches, because the information currently available is too sparse to allow the definition of conservation strategies; such knowledge gaps still impede the design and implementation of effective strategies.

In this work, I aim at analysing the current status of farmland birds in Italy, identifying the main current issues for their conservation, and proposing directions for effective conservation strategies considering the ecology of the target species and the outcomes of recent or still ongoing conservation projects and actions. To do this, I first analyse the conservation status of farmland birds in Italy in relation to their broad ecology and habitat association. Then, by reviewing available studies and analysing their main conclusions, I try to identify the main threats for farmland bird conservation in Italy, and the scales or levels at which they mostly act. I don't pretend to carry out an exhaustive review of whatever had been published on farmland birds in Italy, but I hope to pick out the papers most relevant for the identification of the current threats for the study group.

Finally, I try to highlight the potential strategies to face such challenges experienced by farmland birds in Italy, according to recent or ongoing projects aimed at implementing practical solutions for bird conservation in agricultural areas.

CONSERVATION STATUS OF BIRD SPECIES IN DIFFERENT AGRO-ECOSYSTEMS

To evaluate the current status of farmland birds in Italy, I analyse conservation status and trend of farmland birds according to the agro-ecosystem they are mainly associated with. For the sake of simplicity, I have considered the following agricultural systems and related macrohabitats: arable land, shrubland, grassland, montane grassland and pastures, pseudosteppe, agricultural mosaics; I also added a category 'generalists' to include all species inhabiting several different types of habitats, including different agricultural systems. Then, I assigned each species to a given type of agricultural systems (*sensu lato*); for each species, I reported the conservation status according to the traffic light approach, as defined by Brambilla *et al.* (2013b) and applied to the Italian breeding species by Gustin *et al*. (2016), and the short-term and long-term population trend, derived from Nardelli *et al*. (2015).

Considering the above defined agricultural systems and related habitats occurring in Italy, species tied to grassland and grassland-like habitats (hay meadow, montane grassland, pasture, pseudosteppe) currently have the most concerning conservation status (see also Campedelli *et al*. 2012), closely followed by species occupying agricultural mosaics and shrubland; only generalist species not associated with specific farming systems are performing better and include a non-negligible proportion of species with favourable conservation status (Table 1), coherently with the reported increase of generalist species in Italy and elsewhere (Velatta *et al*. 2016).

SIX CHALLENGES, TWO LEVELS

Several factors and pressures negatively affect the breeding populations of farmland birds in Italy. Considering the species listed in the Annex I of the Birds Directive (2009/147/EC), according to the national reporting (Nardelli *et al*. 2015) the following specific threats have high or medium impact on avian species: agricultural intensification (11 species), abandonment of pastoral systems and lack of grazing (8), threats and pressures from outside the EU territory (7), use of biocides, hormones and chemicals (7), grassland removal for arable land (6), modification of cultivation practices (5), removal of hedges and copses or scrub (5), abandonment / lack of mowing (4), trapping, poisoning, poaching (2).

The review of the increasingly available number of studies confirmed many of the above listed threats and, in addition, allowed the identification of further threats to

farmland birds. In general, such threats could be tentatively assigned to six main broad categories, which I refer to as the "six challenges" throughout the paper: agricultural intensification, land abandonment, pest management, low breeding success, difficult practical implementation of conservation measures, within-season shift in distribution and habitat by breeding species. The six challenges are not independent among each other: they are indeed interconnected in several ways by means of direct effects as well as by acting on the same ultimate drivers of population decline (Fig. 1). These challenges are discussed in the following section, but before entering into challenge-specific issues, it is worth noting that all or most these challenges act at two levels, which are particularly important for farmland birds: the landscape scale, and the field management level. The former identifies traits belonging to the land-cover/land-use and determining habitat composition and broad structure, via an effect on vegetation type, proportional cover, density and height of plants, field size, margin types, etc. The latter deals with farming practices, such as treatments (fertilizers, pesticides), ploughing, mowing, pruning, machinery use, crop protection.

Agricultural intensification and land abandonment

One of the main threats to many species and avian communities of different farming systems is the still ongoing loss of heterogeneity (Benton *et al*. 2003, Vickery & Arlettaz 2012), which occurs at different spatial levels, and which is caused by both agricultural intensification and land abandonment. Even if they are two opposite processes (and hence two separate challenges), the intensification of cultivated areas and/or of agricultural practices, and the abandonment of rural regions, result in a comparable loss of habitat heterogeneity. Moreover, they are driven by the same search for maximum production and profit, which leads to intensification in most profitable areas and to abandonment in marginal or less remunerative ones. Intensification is dramatically impacting in lowland areas, whereas land abandonment is affecting huge extents of traditional, low-intensity farming systems in mountain areas, which are often less fertile and, especially, less accessible and suitable for mechanization. The loss of heterogeneity that these processes determine actually implies a loss of key habitats and microhabitats for several species: nesting sites provided by shrubs or hedgerows, foraging sites such as short grassland sward, sources of preys like unmanaged grassland patches. From a management point of view, intensification of agricultural practices (e.g. increasing the number and extent of cuts in grasslands or number of treatments in orchards and vineyards) often results in deteriorating habitat quality, even when habitat structure apparently remains largely unchanged (e.g. Assandri *et al*. 2017c).

At the landscape scale, intensification in lowland and valley floors and abandonment in hilly and mountain areas, have resulted in a dramatic decline of suitable habitats for a lot of species. Significant effects of land abandonment on bird communities have been reported, with negative or positive outcomes depending on the species considered in the Alps (Laiolo *et al*. 2004), and with negative impacts on Corn Bunting, Yellowhammer and Red-backed Shrike in Abruzzo (Scozzafava & De Sanctis 2006). Several species and communities have been severely affected by intensification, which had been suggested among the main causes of the nation-wide decline of lark species (Massa & La Mantia 2010), and impacts on species occupying very different agricultural systems, such as Corn Bunting in arable land and grassland in northern Apennines (Brambilla *et al*. 2009b), several common species breeding in vineyards (Assandri *et al*. 2017a, 2016), orchards (Brambilla *et al*. 2015, 2013c) and grassland in Trentino (Assandri *et al*. 2019), or Woodchat and Lesser Grey Shrike in pseudosteppe and other 'traditional' systems in southern Italy (Brambilla *et al*. 2017a, Chiatante *et al*. 2014).

Several other species, which depend on the occurrence of habitat mosaics (hence on landscape heterogeneity), are particularly subjected to the negative impact of both intensification and abandonment, which reduce the availability of key traits as hedgerows, shrubs, small grassland, untilled margins. Negative impacts have been reported or suggested for Red-backed Shrike in several different Italian regions (e.g. Brambilla *et al*. 2009a, Ceresa *et al*. 2012), for Moltoni's Warbler in northern Apennines (Brambilla *et al*. 2007a), and for Cirl and Black-headed Bunting in the Apennines (Brambilla 2015, Brambilla *et al*. 2008).

The disappearance of grassland-like habitats and crops, which are converted or abandoned, and of shrubs and hedges, which are removed or overgrown by encroachment, is particularly concerning, as it could impact on habitat extent, habitat suitability, and also density/population size. In Barn Swallows in Lombardy, the colony size is affected by hayfield extent in the surrounding landscape (Sicurella *et al*. 2014), and the cessation of livestock farming is associated with steeper declines of colony size (Ambrosini *et al*. 2012). For several species, the disappearance of grassland and marginal features means the loss of key components of mosaic habitats (Brambilla *et al*. 2012, 2008, Morelli 2013). The species depending on a combination of drastically depleted habitat characteristics, like the Woodchat Shrike that is tied to remaining steppe-like habitats and woody vegetation among fields, are particularly threatened (Brambilla *et al*. 2017a, Chiatante *et al*.

Table 1. Conservation status (according to the traffic light approach; according to Gustin et al. 2016), short-term (mostly 2000-2012) and long-term (from 1980/1990 to 2012) population trend (legend: +: increasing; - : declining; s: stable; f: fluctuating; ?: unknown) according to Nardelli et al. (2015) for farmland birds living in different agricultural systems and related environments in Italy.

Species	range	population	habitat	overall	short-term trend	long-term trend
ARABLE LAND						
Skylark *Alauda arvensis*	inadequate	bad	bad	bad	-	-
Barn Owl *Tyto alba*	inadequate	bad	inadequate	bad	-	-
Quail *Coturnix coturnix*	favourable	bad	inadequate	bad	+	?
Grey Partridge *Perdix perdix*	bad	bad	inadequate	bad	?	-
Little Owl *Athene noctua*	favourable	inadequate	favourable	favourable	-	?
Yellow Wagtail *Motacilla flava*	favourable	bad	inadequate	bad	-	-
Corn Bunting *Emberiza calandra*	inadequate	favourable	inadequate	inadequate	+	+
Crested Lark *Galerida cristata*	inadequate	inadequate	unknown	inadequate	s	-
White Wagtail *Motacilla alba*	inadequate	inadequate	inadequate	inadequate	s	s
Lapwing *Vanellus vanellus*	favourable	favourable	inadequate	inadequate	?	+
GRASSLAND						
Red-backed Shrike *Lanius collurio*	inadequate	bad	bad	bad	-	-
Lesser Grey Shrike *Lanius minor*	bad	bad	bad	bad	-	-
Woodchat Shrike *Lanius senator*	bad	bad	bad	bad	-	-
Corncrake *Crex crex*	inadequate	bad	bad	bad	-	?
Tawny Pipit *Anthus campestris*	inadequate	bad	inadequate	bad	?	-
Stonechat *Saxicola torquatus*	favourable	bad	inadequate	bad	-	-
Linnet *Linaria cannabina*	favourable	inadequate	inadequate	inadequate	-	-
Red-footed Falcon *Falco vespertinus*	inadequate	bad	inadequate	bad	f	f
MONTANE GRASSLAND, PASTURES						
Winchat *Saxicola rubetra*	inadequate	bad	inadequate	bad	-	-
Northern Wheatear *Oenanthe oenanthe*	favourable	inadequate	inadequate	inadequate	+	+
Yellowhammer *Emberiza citrinella*	inadequate	bad	bad	bad	s	-
Rock Sparrow *Petronia petronia*	inadequate	bad	inadequate	bad	?	-
Water Pipit *Anthus spinoletta*	inadequate	inadequate	inadequate	inadequate	s	s
Tree Pipit *Anthus trivialis*	favourable	inadequate	inadequate	inadequate	s	s
Chough *Pyrrhocorax pyrrhocorax*	bad	bad	inadequate	bad	-	-
Black-eared Wheatear *Oenanthe hispanica*	inadequate	bad	inadequate	bad	-	-
PSEUDOSTEPPE						
Little Bustard *Tetrax tetrax*	bad	bad	bad	bad	-	-
Stone Curlew *Burhinus oedicnemus*	inadequate	favourable	inadequate	inadequate	-	-
Calandra Lark *Melanocorypha calandra*	bad	bad	bad	bad	-	-
Short-toed Lark *Calandrella brachydactyla*	bad	bad	bad	bad	-	-
Lesser Kestrel *Falco naumanni*	favourable	favourable	bad	bad	+	+
Montagu's Harrier *Circus pygargus*	favourable	bad	inadequate	bad	?	+
Black-headed Bunting *Emberiza melanocephala*	unknown	unknown	unknown	unknown	?	-
SHRUBLAND						
Barred Warbler *Sylvia nisoria*	bad	bad	inadequate	bad	-	-
Woodlark *Lullula arborea*	inadequate	inadequate	inadequate	inadequate	+	+

continued

Species	range	population	habitat	overall	short-term trend	long-term trend
Orphean Warbler *Sylvia hortensis*	bad	bad	inadequate	bad	?	-
Withethroat *Sylvia communis*	inadequate	inadequate	inadequate	inadequate	-	-
Cirl Bunting *Emberiza cirlus*	favourable	favourable	inadequate	inadequate	+	+
MOSAICS						
Ortolan Bunting *Emberiza hortulana*	bad	unknown	bad	bad	?	?
Greenfinch *Carduelis chloris*	favourable	inadequate	favourable	inadequate	-	-
Wryneck *Jynx torquilla*	inadequate	bad	inadequate	bad	-	-
Fieldfare *Turdus pilaris*	inadequate	bad	favourable	bad	-	-
Red Partridge *Alectoris rufa*	inadequate	bad	inadequate	bad	?	?
Roller *Coracias garrulus*	inadequate	inadequate	unknown	inadequate	?	?
Hoopoe *Upupa epops*	favourable	unknown	unknown	unknown	?	?
GENERALISTS						
Italian Sparrow *Passer italiae*	favourable	bad	inadequate	bad	-	-
Tree Sparrow *Passer montanus*	favourable	bad	inadequate	bad	-	-
Swallow *Hirundo rustica*	favourable	bad	inadequate	bad	s	-
Starling *Sturnus vulgaris*	favourable	favourable	favourable	favourable	+	+
Kestrel *Falco tinnunculus*	favourable	favourable	favourable	favourable	+	+
Zitting Cisticola *Cisticola juncidis*	favourable	inadequate	favourable	inadequate	+	+
Magpie *Pica pica*	favourable	favourable	favourable	favourable	+	+
Hooded Crow *Corvus cornix*	favourable	favourable	favourable	favourable	+	+
Carrion Crow *Corvus corone*	favourable	favourable	favourable	favourable	s	?
Spotless Starling *Sturnus unicolor*	favourable	unknown	favourable	favourable	?	?
Goldfinch *Carduelis carduelis*	favourable	inadequate	favourable	inadequate	-	-
White Stork *Ciconia ciconia*	favourable	inadequate	favourable	inadequate	+	+
House Sparrow *Passer domesticus*	favourable	unknown	unknown	unknown	?	?
Spanish Sparrow *Passer hispaniolensis*	unknown	unknown	inadequate	unknown	?	?

2014). In addition to species-specific examples, deep impacts on bird communities by the above processes have been recently demonstrated. Grassland conversion resulted in a shift from assemblages rich in specialists to communities dominated by generalist species (Assandri *et al*. 2019). Similarly, intensive and early mown meadows have lower species richness and fewer meadow specialists, respectively. Low-elevation and high-inputs meadows thus offer the worst conditions to birds (Assandri *et al*. 2019) and biodiversity in general.

The Ortolan Bunting, a species dramatically declining in Europe (Vickery *et al*. 2014), provides a clear example of how strong the impact of such processes can be. This species in northern Apennines prefers areas with grassland, shrubland, patches of bare soil, and gentle sloping sites, whereas it avoids forest and urban areas (Brambilla *et al*. 2017b). Within such open or semi-open landscapes, at the territory scale it is associated with bare ground patches, hedgerows, shrubs and small lucerne fields (Brambilla *et al*. 2016a). All these characteristics depend on a non-intensive agricultural use, which unfortunately had dramatically reduced in this geographical context (Brambilla *et al*. 2010), to the point that between 1954 and 2012 the extent of suitable habitat for Ortolan Bunting had declined by 75%, due to abandonment and reforestation, intensification, and urbanization (Brambilla *et al*. 2017b).

The same effects of intensification and abandonment have been reported for Red-backed Shrikes in Lombardy (Brambilla *et al*. 2010, 2009a) and Emilia-Romagna (Brambilla *et al*. 2007b).

At the management level, intensification implies an increase in chemical inputs (fertilizers, pesticides), an increase in number of cut in hay meadows, a higher number of treatments, a shift to smaller/denser trees in or-

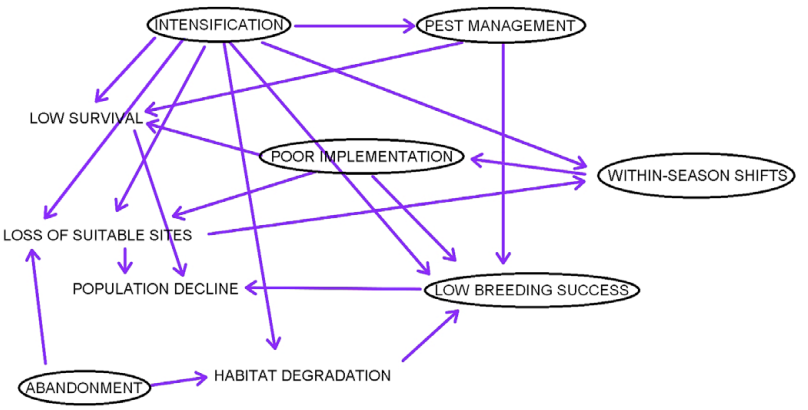

Figure 1. An attempt to graphically show the multi-faceted relationships between the six challenges (highlighted by ovals) and between them and some ultimate drivers of population decline in farmland bids.

chards and to a more mechanizable arrangement of crops, the use of artificial structures to protect or secure crops, an often extreme management of ground and non-crop vegetation in general. These changes often result in a deteriorating habitat quality, even when habitat structure apparently remains largely unchanged. Birds in permanent crops in Trentino are affected (also) by management traits due to intensification: the occurrence of anti-hail nets and the removal of ground vegetation have negative effects on Song Thrush and Chaffinch (Brambilla *et al*. 2015, 2013c), the low and small apple trees increasingly widespread are much less suitable for several species (Brambilla *et al*. 2015), and even the wine arrangement (trellising system) in vineyards matters, as most species prefer the traditional pergola and are negatively impacted by the increasingly widespread modern spalliera (Assandri *et al*. 2017a).

Abandonment at the management level implies underutilization or lack of management of vegetation, with potential negative effects on several species. Grazing is crucial for many species, including the endangered (Peronace *et al*. 2012) Black-eared Wheatear in southern Italy, which is tied to the occurrence of sheep or goat grazing (Brambilla *et al*. 2013a). The lack of ground vegetation control results in the grassland sward becoming unsuitable for insectivorous species, such as Redstart (Assandri *et al.* 2017b). In the pre-Alps, lack of grazing is associated with a decrease in species richness and in the density of Tree Pipit, whereas the lack of mowing results in a decrease of Skylark density (Bazzi *et al*. 2015).

Pest management

Pest management is likely a key pressure, especially in crops such as vineyards and, especially, fruit orchards. Impacts may be of several types: from disturbance effects and indirect interference (e.g. via a dramatic reduction of prey species), to potential direct toxic and carry over effects exerted by pesticides, which largely have to be assessed (in several cases, not only in Italy but in general). Differences in avian communities or species occurrence associated with different management regimes (e.g. conventional vs. organic) have been reported, but with contrasting evidence to the point that no generalization is possible.

At the landscape level, in organic and integrated fruit orchards, insectivorous species are more frequent and bird diversity is greater than in conventional ones in Emilia-Romagna (Genghini *et al*. 2006). In vineyards, only minor differences on bird community and common species abundance in Trento province are associated to pest management (and organic regime has often negative effects), as other factors are much more important (Assandri *et al*. 2016, 2017a).

A the management level, in Piedmont conventional vineyards offer fewer feeding resources than organic ones to Great Tits, and this difference has consequences on nestling growth (Caprio & Rolando, 2017).

A literature-based assessment of the potential sensitivity of Italian breeding birds to pesticides, carried out by Lipu/BirdLife Italia and based on habitat, diet (adult and nestlings), nest-site habitat, suggested that the species tied to fruit orchards and those nesting in open cups or on the ground, could be among the most sensitive to pesticide use in farmed environments. High exposure values could be hypothesized for Wryneck and Hopooe, and medium exposure for several species including threatened or declining ones as Turtle Dove, Calandra Lark, Greenfinch, Goldfinch, Sparrows, Ortolan Bunting (Rete Rurale Nazionale & Lipu, 2015b).

In studies carried out in other countries, positive ef-

fects of organic farming (usually mediated by landscape; Hole *et al*. 2005) have been largely attributed to the lower toxicity of organic treatments. However, such effects are more common in arable and other grassland-like crops (Bengtsson *et al*. 2005), whereas they have been rarely reported in e.g. vineyards. It is out of doubt that further studies are needed, especially in non-vineyard crops, and considering both the direct eco-toxicological effects and the indirect effects on prey availability.

Low breeding success in farmed areas

A serious problem for many populations of farmland birds (in other European countries too) is the low breeding success that birds breeding in cultivated areas experience, largely because of farming practices impacting on nest survival (e.g. nest destruction due to grassland mowing). However, other factors may be also responsible for a low productivity, including degradation of breeding habitat, disturbance due to management, unfavourable conditions within nesting sites apparently suitable; the latter cause clearly recalls ecological traps, a phenomenon rather common in farmed landscapes.

Nest destruction have been reported or suggested for field-breeding Montagu's Harriers in the Marche region, where pairs nesting in cultivated areas have lower productivity than those nesting in other areas (Pandolfi *et al*. 1995), and for Quail, Skylark and Corn Bunting in lucerne fields in N Italy (Ferlini 2009), where they are ecologically trapped because of regular nest destruction. In particular, subsequent cuts are too close in hay meadows and lucerne fields, resulting in unsuccessful breeding of Skylarks (Ferlini 2006). Other types of potential ecological traps may be determined by suitable foraging habitats associated with apparently suitable nesting sites, which in the end turn out to be highly unsuitable, as pipe holes (made available by supports used in vineyards) are for Wryneck in Trento province. In landscapes dominated by intensive vineyards, Wrynecks may find suitable conditions for hunting preys, but potential nest sites are extremely scarce; they thus seek for the occurrence of pipe holes, but all nesting attempts occurring in this kind of holes, fail during deposition or incubation. Nesting attempts in nest-boxes in the same areas show instead a breeding success in line with values usually reported for the species (Assandri *et al*. 2018a).

More subtle mechanisms may be involved in determining low breeding success in farmed areas. In Red-backed Shrikes, the degradation of breeding habitat (at the landscape level) due to intensive farming concurs to the lower number of fledged juveniles and the higher territory size for pairs breeding in less suitable sites (Brambilla & Ficetola, 2012). The level of disturbance due to farmer's entrance in the fields (for treatments, management, etc.) is the main predictor of the proportion of abandoned nests in vineyards, where nest failure is also affected by trellising system and farming (Assandri *et al*. 2017c).

Within-season shift in distribution and habitat by breeding species

The occurrence of within-season shift in distribution and habitat selection by birds breeding in farmed habitats is still an understudied topic with potentially important implications for conservation, e.g. in term of setting boundaries of protected areas, or sites and periods for the implementation of conservation measures. Until now, Corncrake and some passerine species have been reported to perform such a shift; this poses additional complications to the implementation of conservation measures for those species and further highlights the importance of preserving large-scale heterogeneity.

At the landscape level, birds may shift to higher elevation for the second brood and, in general, they may move from lowland fields or grassland to upland semi-natural grassland and pastures. This kind of pattern had been reported or hypothesized on the basis of replicated counts for some different species. The number of calling Corncrakes males in Trento province showed an elevation-related variation in the relative abundance between early and late counts, with abundance decreasing from the early to late periods in sites below 1000 m asl, and increasing at higher elevation (~1200 m asl) sites (Brambilla & Pedrini, 2011).

Woodlark in northern Apennines also showed an altitude increase in breeding densities from periods corresponding to first and second broods, respectively (Brambilla & Rubolini, 2009). Somewhat weaker but similar patterns have been suggested by changes in habitat suitability during the season for Skylark and Corn Bunting (Brambilla *et al*. 2012). Such shifts may have implications also for the correct estimation of population trend, as exemplified by Corncrakes in north-eastern Italy (Brambilla & Pedrini 2013, Pedrini *et al*. 2016, 2012). At the management level, Woodlarks (breeding outside vineyards) may largely shift from arable land and fodder fields, used for the first brood, to lucerne fields and semi-natural habitats, occupied to raise a second or later brood (Brambilla & Rubolini, 2009). All these within-season changes determine dynamic patterns, which should be taken into account in conservation planning. Different crop types and/or different sites within a given area may have varying importance during the breeding season for a given species (Gilroy *et al*. 2010), with potentially important implications for conservation, in terms of management prescriptions, site conservation, etc. (Brambilla & Rubolini, 2009).

Practical implementation of conservation measures

A critical issue in science-driven conservation biology is the frequently reported research-implementation gap (Arlettaz *et al*. 2010). Looking at the national context, the increasing amount of knowledge on farmland bird requirements still has to lead to widespread, scientifically based implementation of conservation measures. The potential outcomes of agri-environmental schemes for birds have been rarely evaluated, and quantitative assessments are particularly scarce (Calvi *et al*. 2018); sometimes they revealed negative impacts of non-targeted 'conservation measures' on declining breeding birds such as the corncrake (Brambilla & Pedrini, 2013), or mixed effects depending on species' ecology and regional trend (Campedelli *et al*. 2016).

Some positive examples are found especially at the local and regional scale. In some regions and provinces, action plans specifically targeted at farmland birds (e.g. species tied to grassland in Trento province, Brambilla & Pedrini, 2014; Red-backed Shrike in Lombardy, Casale & Brambilla, 2009) have been adopted by local governments and considered in the definition of agri-environmental schemes of the relative Rural Development Programme (RDP). The lobby work carried out by NGOs (especially by Lipu in the Alpine regions) has led to some important advancements in regional RDPs, or at least to challenge measures unsuitable for farmland birds, highlighting their potential weaknesses and counter-indications.

Recently, some local projects involving both conservationists and farmers are opening new scenarios for incorporating conservation measures into management protocols, potentially spreading the adoption of such measures. In particular, promising approaches are under development in vineyards, in different regions (e.g. Lombardy: https://vignetienatura.net/; Trentino: http://webgis.muse.it:8080/wordpress/). Within such projects, the integration of different competences allows to simultaneously consider biodiversity conservation and economic profitability, thanks to iterative processes of revisions and implementation of the management recommendations formulated thanks to dedicated field studies, aimed at the identification of key determinants of species occurrence and abundance within vineyards. These projects also highlighted how sometimes 'bad' management practices performed by farmers are just due to ignorance of the negative impacts they could have on biodiversity: some highly detrimental operations are due to 'business-as-usual' behaviour but are not justified by real needs, and informed farmers may be happy to change their approach, with immediate benefits for birds and biodiversity in general.

New opportunities may arise when looking at the potential synergy between bird conservation and the delivery of ecosystem services in cultivated areas. In fact, birds can be themselves providers of ecosystem services, such as pest control in case of outbreaks (Barbaro *et al*. 2017, García *et al*. 2018), or could be used as indicators for other ecosystem services, including cultural ones (Assandri *et al*. 2018b). Bird conservation and ecosystem services delivery may be favoured by integrated strategies, which can maximize the overall benefits for the broader environment (Brambilla *et al*. 2017c).

CONCLUSION AND OUTLOOK

I acknowledge that this work could not provide an exhaustive review of all studies on farmland birds in Italy, and that the six challenges I identified and used as a tool to address the main impacts of farming on birds, could fit well some of such impacts, whereas other ones could be less clearly related to one of the six categories. Nevertheless, I hope to have summarised the main knowledge and impacts concerning farmland birds in Italy, and I also hope that this work could be used as a starting point for the development of both conservation strategies and new, further research.

In tropical regions, land sparing has been usually reported as the best option for biodiversity conservation (Edwards *et al*. 2014, Phalan *et al*. 2011). In Europe, the millenarian agricultural history resulted in approximately half of the species being somewhat dependent on farming - especially in the Mediterranean region, and therefore applying a complete separation between agricultural and natural areas cannot be an effective conservation strategy. The overwhelming importance of farmed habitats for several species (including species of global conservation concern, or with unfavourable status and concentrated in Europe) makes land sparing an unfeasible conservation approach for the old continent. On the other side, a sort of 'small-scale sparing' - e.g. preserving marginal habitats untouched by farming practices - can be extremely important to guarantee the persistence of a minimum level of heterogeneity and, especially, of key resources such as feeding or nesting habitats. This approach could be particularly important, considering the high rate of intensification and abandonment, which are currently the most impacting factors for the largest part of farmland birds breeding in Italy, and which are threatening several other species and ecosystems elsewhere in the Mediterranean region (Beaufoy *et al*. 1994, Tucker & Evans 1997, Mikulić *et al*. 2014, Zakkak *et al*. 2015).

Even if the study of farmland birds' ecology in Italy has made important achievements in the last decades,

some (potentially critical) topics and issues yet need to be investigated. In particular, we still lack key knowledge on topics like demographic consequences of landscape characteristics and management practices for several species. We also need a better understanding of different pest management options, including indirect or hidden impacts (Boatman *et al*. 2004, Gibbons *et al*. 2015), and new data on shifts within and across season(s), as well as a more general link with the non-breeding periods (e.g. Chiatante & Meriggi 2016, Goodenough *et al*. 2017). Tables 2 and 3 show at the two scales, respectively, the overall level of knowledge about each challenge, its likely impact under current and future prospects for farmland birds, and the main gaps to be filled.

From a conservation point-of-view, several studies demonstrated the importance of the following crucial points:

1) to plan measures at the right scales;
2) to conserve, restore and recreate grassland (and correctly manage them to avoid ecological traps);
3) to conserve and enhance 'marginal' features, as well as heterogeneity;
4) to correctly manage ground vegetation in perennial crops, which is likely to have a crucial impact on invertebrate abundance and accessibility (Schaub *et al*. 2010);
5) to face the 'nest crisis', e.g. by using nest-boxes when and where there are clear evidence that the availability of nesting sites is the limiting factor for a species (e.g. Arlettaz *et al*. 2010), and by reducing disturbance during the nesting period;
6) to consider the different temporal suitability, and the connectivity among patches;
7) to consider the economic outcomes and the broader benefits of different conservation strategies, either species-specific or multi-target.

In general, the practical implementation of conservation measures for farmland birds requires multi-faceted efforts, targeted at different stakeholders (e.g. public authorities for RDPs, farmers for broader adoption of measures) and a focus also on the ecosystem services and other benefits arising from a biodiversity-friendly management of agricultural land to gain a broader support for conservation initiatives.

Now it is time to work in cooperation with practitioners (farmers at first) to translate into management protocols and appealing agri-environmental schemes the conservation implications defined by the detailed researches recently carried out. For several specific objectives, it could be better to work (more) with farmers and (than) with institutions: although lobby work with institutions is essential, especially to prevent broad-scale implementation of 'bad' measures (e.g. within RDPs), it is often short-carrying in terms of concrete applications on the field.

Future decades will be both crucial and highly dynamic for the fate of farmland birds in Italy (and beyond). Some species are on the verge of extinction, or close to it (e.g. woodchat shrike, orphean warbler; Peronace *et al*. 2012, Nardelli *et al*. 2015), and some global issues (namely climate change, and maybe crop demand for energy production) probably have yet to display their real impact on both cultivations and wild species. The shift toward hotter and drier summer, the more frequent occurrence of extreme events will definitely impact on crop type and on farming practices, with consequences on birds which could be potentially much heavier than the effect of climate change *per se*. Adaptation of human activities to climate change indeed could have deep influence on biodiversity (Chapman *et al.* 2014, Watson 2014) and it is essential to consider its implications for nature conservation (Brambilla *et al*. 2016b). Farmland birds have been already impacted by the different speed at which their phenology and the timing of agricultural practices advanced in response to cli-

Table 2. Level of knowledge, current and likely future impacts and main aspects requiring further research for the six challenges at the landscape level. A four-level score system (low – medium – high – unknown) is used for each column.

Challenge	Knowledge level	Current impact	Future impact	Main research needs for conservation
intensification	Good	high	high	demographic consequences
abandonment	Good	high	unknown (high?)	pros and cons of rewilding and re-farming
pest management	Low	high?	high?	demographic consequences
breeding success	Medium	high	high	links with large-scale distribution of suitable habitats
within-season shift	Low	unknown	unknown	1. general assessment of shifts 2. connectivity between temporarily suitable sites
implementation	Medium	high	high	farm-scale and landscape-scale strategies for conservation

Table 3. Level of knowledge, current and likely future impacts and main aspects requiring further research for the six challenges at the management level. A four-level score system (low – medium – high – unknown) is used for each column.

Challenge	Knowledge level	Current impact	Future impact	Main research needs for conservation
intensification	medium	high	high	strategies to preserve critical habitat features.
abandonment	medium	medium?	likely high	how to compensate the loss of suitable microhabitats.
pest management	low	likely high	likely high	how to minimize impacts on biodiversity: products, time, treatments.
breeding success	medium	high	likely high	1. full understanding of management impacts on productivity; 2. ecological traps and how to avoid them; 3. how to reduce the 'nest-crisis'.
within-season shift	low	unknown	unknown	links between management and intra-seasonal suitability.
implementation	medium	high	high	development of field-level practices promoting bird occurrence and breeding success.

mate change (Santangeli *et al*. 2018), and other important changes could be expected.

Some remunerative but potentially impacting crops are already increasing their cover: vineyards are expanding especially at higher elevation (as well as latitude at a global scale), thanks to milder climates (Hannah *et al*. 2013); new crops may establish or increase their share as climate becomes less suitable for 'typical' productions: in these circumstances, it is essential to investigate the biodiversity implications of new cultivations (new species and/or new techniques) since their early establishment, to harmonize production with conservation.

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