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Little field evidence of direct acute and short-term effects of current pesticides on the grey partridge

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ABSTRACT

Direct lethal and sublethal effects of pesticides on farmland birds' populations are recurring questions and largely debated. In this context, we conducted an innovative study combining radiotelemetry, farmer surveys, residue analyses on carcasses and modelling to assess the unintentional effects of pesticides on terrestrial birds. We chose the grey partridge *Perdix perdix* as a case study because this typical bird of European cereal ecosystems is highly exposed to pesticides. In this paper we focused on acute and short-term impacts of pesticides on adult mortality during spring and summer in a one-substance approach (multiple exposure were not studied here) but for a large variety of active substances (a.s.) actually used in cultivated farmland of Northern France.

The fate and the location of 529 partridges were monitored twice a day from early March to late August 2010 and 2011 on 12 sites (14,500 ha). Their daily potential exposure to 183 a.s. was determined by overlapping birds' habitat use and daily pesticide application data. Based on this procedure, we calculated mortality rates within 10 days following a potential exposure for 157 different a.s.. 5 a.s. were associated with a "10-day mortality rate" higher than 10% but a single one (thiacloprid) is reported to be highly toxic to birds. We recorded 261 mortalities among which 94 carcasses were in suitable condition for residue analyses. We detected at least one a.s in 39.4% of carcasses. However, only 2 mortality cases were attributed to poisoning (carbofuran). Furthermore, modelling results showed that these lethal pesticide-related poisonings decreased the population growth rate by less than 1%.

In conclusion, we did not point out important direct acute and short-term effects of pesticides currently used by farmers during the breeding season on the grey partridge. This is discussed with regards to the complexity of potential effects in operational conditions.

1. Introduction

Many farmland bird species have been experiencing a dramatic population decline in Europe since World War II (e.g., Siriwardena et al., 1998; Voříšek et al., 2010). Both correlative and causal evidence suggest that overall agricultural intensification has caused the widespread decline of farmland biodiversity through effects on habitat and food resources (e.g., Benton et al., 2002; Chamberlain et al., 2000; Newton, 2004). This intensification resulted in a suit of changes in farmland practices among which the increased use of pesticides. However, the extent to which pesticides have contributed to the population declines is often discussed.

Pesticides may affect farmland birds either directly, through lethal or sublethal poisoning, or indirectly, especially by reducing food resource.

For the last fifteen years, major concern has been focused on indirect effects of pesticides (Köhler and Triebskorn, 2013). Indeed pesticide use may reduce weeds (Wilson et al., 1999) and invertebrate (e.g., Morris et al., 2005; Rands, 1985) that are important food resource for granivorous and insectivorous farmland birds and thus may affect productivity (Rands, 1985; Hart et al., 2006) and/or adult survival. However, although indirect effects of pesticides are strongly suspected of having an impact on the population of several bird species (Boatman et al., 2004; Bright et al., 2008; Campbell et al., 1997), unequivocal evidences are only available for the grey partridge (*Perdix perdix* L.) (Potts, 1986). These indirect effects may theoretically be reversed or at least limited at a local scale through agri-environmental measures such as wildlife cover that provide insect- or seed-rich cover (Baker et al., 2012; Parish and Sotherton, 2004) or management of

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farming practices such as conservation headlands (Rands, 1985; Sotherton et al., 1993). However, the positive effects of these management measures have not always been detected at a wider scale (see Davey et al., 2010; Stevens and Bradbury, 2006).

Since the withdrawal of organochlorine and some organophosphate pesticides, there is now little evidence of significant population impacts arising from direct lethal or sublethal effects of pesticides (Bright et al., 2008; Burn, 2000; Newton, 2004). However, evidences of direct lethal effects on individual from field observations are common. Indeed, in many countries wildlife poisoning surveillance programmes have regularly reported casualties attributed to pesticide poisonings on an array of birds. (e.g., Antoniou et al., 1997; Berny, 2007; Berny and Gaillet, 2008; de Snoo, 1999; Fleischli et al., 2004; Guitart et al., 1999; Kwon et al., 2004; Lelièvre et al., 2001; Mineau et al., 1999; Motas-Guzmán et al., 2003). Some of these wildlife surveillance networks as SAGIR (it is not an acronym rather a motto "Surveiller pour AGIR") in France (see Lamarque et al., 2000) and The Wildlife Incident Investigation Scheme (WIIS) in UK (see Fletcher and Grave, 1992) are integral parts of the post-marketing monitoring of the Ministry of Agriculture. Such surveillance surveys have already detected problems with some newly marketed pesticides, leading to the implementation of mitigation measures or usage restrictions (Burn, 2000; Greig-Smith, 1994; Lelièvre et al., 2001). However, they are more effective at detecting massive lethal intoxication due to highly toxic and rapid-acting compounds (Berny, 2007). Moreover, they are based on the opportunistic collection of dead animals which are subject to imperfect detection and reporting (Berny, 2007; de Snoo, 1999). Consequently, these available incidental observations do not permit the estimation of population-level effects. It is therefore necessary to supplement these surveillance schemes with targeted studies.

Field studies have therefore been conducted to investigate direct lethal and/or sub-lethal effects of pesticides on bird (e.g., Prosser et al., 2006; Tank et al., 1993; Wilson et al., 2001; Wolf et al., 2010). Most documented pesticides are highly acutely toxic organophosphate and carbamate insecticides (i.e., anticholinesterase insecticide) because they are the most reported in incident registration systems (Berny, 2007; Fleischli et al., 2004). Yet, in Europe since the entering into force of regulatory programmes to limit the use of pesticides with high risks to the environment in the early 1990s (Council Directive 91/414/EEC remplaced by the Regulation 2009/11074/EC), many highly acutely toxic pesticide has been pulled from markets. Consequently, potential impacts on bird of this kind of pesticide have been further reduced during recent decades and acute poisoning events have declined over the last 20 years (Köhler and Triebskorn, 2013).

In view of the above, both direct and indirect effects of pesticides on farmland birds should have declined over the last years. Yet, in Europe, the intensive and extensive field study of Geiger et al. (2010) suggests that despite decades of European policy to ban harmful pesticides, negative effects on farmland birds still occur. However, how pesticides still adversely affect farmland bird is not clearly explained. Not all pesticides (e.g., insecticides and fungicides, or organophosphates and neonicotinoids insecticides) actually used are likely to have the same effect on farmland bird population. For example, the intensive radiotracking study of Wolf et al. (2010) did not demonstrate any negative effect of the hazardous organophosphate insecticide chlorpyrifos on farmland bird mortality and dispersal. Conversely, Hallmann et al. (2014) showed that birds have declined faster in places with more neonicotinoid pollution. Their results suggest that imidacloprid has a negative effect on insectivorous bird populations, via its adverse effects on invertebrate food resource. Other recent correlation studies (Hill et al., 2014; Mineau and Whiteside, 2013) found inconsistent outcomes about the role and the importance of insecticide and their acute toxicity as factor in grassland bird declines in North America. These kind of correlation studies from large data sets are very useful to assess, compare, and rank different hypotheses but they need to be supplemented by other approaches to directly test the role of pesticide.

Further researches are thus needed to disentangle all possible effects of different used pesticides. This need are especially necessary because pesticides are not going away anytime soon. For instance, in France, the main aim of the "Ecophyto 2018" programme was to reduce by fifty percent the number of used dose of pesticide by 2018. However, a recent mid-point review found no decrease of the pesticide use over the period 2008–2012 (Boiffin, 2014). Consequently, this aim has been reported by 2025.

In this context, we carried out a large-scale auto-ecological study on the grey partridge (Bro et al., 2013), with a focus on non intentional effects of pesticide use on mortality (this work) and reproduction (Bro et al., in press). The grey partridge is an omnivorous farmland bird (Aebischer and Kavanagh, 1997) highly exposed to pesticides (Bro et al., 2004, 2010; Decors et al. 2011). Furthermore, its biology and population dynamics are extensively known (e.g., Birkan and Jacob, 1988; Bro et al., 2013, 2001, 2000a, 2000b; Potts, 2012). The study was conducted in France, where agriculture is one of the most intensive in Europe, both in terms of yields and tonnages of pesticides used (FAOSTATS).

In this paper, we focused on acute and short-term effects of pesticides on adult mortality during spring and summer and their consequences on the population dynamic. Indeed, adult mortality during reproduction has large effects on population dynamics (Bro et al., 2000b).

For our purpose, we used an innovative methodological approach that combines:

(1) a radiotracking study,
(2) a farmer questionnaire to record plant protection products (PPPs) use,
(3) a spatio-temporal analysis using a GIS to cross-check bird habitat use and PPPs application at the field-day scale to identify the potential exposure of each bird to PPPs, and quantify associated mortality rates;
(4) necropsies and residue analyses on carcasses;
(5) modelling.

In this paper, we mainly present descriptive results. First, we report the variety of currently used active substance (a.s.) and their features (type of use, use rate, chemical family, acute toxicity, and acute risk). Second, we quantify partridge potential exposure (number of birds) to a.s.. Third, we examine whether some a.s. are associated with "concerning" mortality rate as well as the potential correlations between mortality rates and a.s. features. Forth, according to necropsies and residue analyses results we assess if fatalities may be attributed to pesticides poisoning. Finally, given the above results we assess by modelling the effects on the population dynamic of adult mortality due to pesticides. This work is based on a one-substance approach. Multi-exposure, cumulative, and chronic effects will be addressed in a further paper.

2. Material and methods

2.1. Selection of the focal species

The grey partridge is both as a cereal farmland bird (Aebischer and Kavanagh, 1997) and a representative focal species (Andrade et al., 2012; EFSA, 2009; Petersen et al., 2013). Grey partridge populations have dramatically declined during the XXth century (Kuijper et al., 2009). The Pan-European Common Birds