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European farmers' incentives to promote natural pest control service in arable fields

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ABSTRACT

Integrated pest management (IPM) is widely encouraged among the European Union (EU) member states. The successful adoption of IPM techniques requires strong farmer motivation and participation. However, few studies have explored EU farmers' incentives to promote natural enemies of crop pests in the fields, and none have addressed how this could be influenced by farmers' recognition of natural pest control service. Based on interviews among arable farmers involved in an EU funded agri-environmental project across seven member states, natural pest control was perceived to be a less important contributor to crop production than soil fertility and pollination. Preferences toward managing semi-natural habitats for natural enemies were also relatively low, while insecticides were commonly used among participants. Ordinal logistic regression indicates that farmers' decision to promote natural pest control was positively associated with the perceived importance of this ecosystem service for crop production. However, they expressed a relatively low confidence in the pest control efficacies of natural enemies compared with insecticides, especially under high pest damage levels. Farmers with greater income have more financial flexibility to adopt either pest control method. The environment surrounding a farm may also influence its owner's willingness to promote natural pest control.

1. Introduction

Since Stern et al. (1959) introduced the concept of integrated pest management (IPM) as 'applied pest control which combines and integrates biological and chemical control', this method has gradually gained recognition worldwide as a key element in more sustainable agricultural systems (Barzman et al., 2015; Birch et al., 2011). Although its definition varies among studies and organizations (Bajwa and Kogan, 2002), the key message is that IPM is a systemic approach which encourages the integration of multiple methods to control pests in a 'safe, cost-effective, and environmentally friendly manner' (Parsa et al., 2014).

IPM is also highly encouraged under the 'EU Pesticide Package', a suite of European Union legislation (European Union, 2009a,b,c,d). Member states are required to develop National Action Plans to support their professional pesticide users in following the eight general principles of IPM (European Union, 2009b,c). The first principle (prevention and suppression) stresses the importance of protecting and enhancing natural pest control in the fields (European Union, 2009b).

Indeed, natural pest control is an important ecosystem service in the agricultural sector, which could help suppress pest damage and, by reducing the unnecessary insecticide inputs, reduce incidence of pest resistance (Power, 2010). Its value towards crop protection has been characterised through field experiments (Safarzoda et al., 2014; Thies

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et al., 2011), ecological modelling (Jonsson et al., 2014) and economic evaluation (Naranjo et al., 2015; Zhang et al., 2018). In this study, 'pests' referred to are animal pests, and natural enemies as the related species that target these pests.

Natural pest control is negatively influenced by the on-going agricultural intensification (Crowder and Jabbour, 2014), either through a subsequent increase in pesticides (especially insecticides) (Geiger et al., 2010), or the loss of (semi-) natural habitats from cropland expansion (Zhao et al., 2015). To enhance the contribution of this ecosystem service to crop protection, the EU Framework Directive 2009/128/EC has provided guidelines on using insecticides strategically: e.g., monitoring pest populations in the fields and using action thresholds to determine applications (Hallett et al., 2014). Also, as an important tool to conserve biodiversity, the agri-environment schemes (AES) have provided EU farmers options to establish/manage semi-natural habitats on their farmland (Batáry et al., 2015). This has shown positive effects on promoting natural pest control (Holland et al., 2016): e.g., hedgerows (Stutz and Entling, 2011), beetle banks (Collins et al., 2002), and cover crops (Aguilar-Fenollosa et al., 2011).

Nonetheless, the successful adoption of these techniques requires strong farmer participation, which is also an important element in the IPM regime (Junge et al., 2009; Lefebvre et al., 2015). However, knowledge gaps remain in understanding EU farmers' incentives to apply related techniques to promote natural pest control in the fields (Lefebvre et al., 2015). Although numerous studies have shown natural pest control is valuable for sustainable agriculture (Letourneau et al., 2009), few have examined whether it is valuable from a farmer's perspective (Segura et al., 2004). To our knowledge, no studies have analysed the influence of farmers' perceptions of natural pest control on their decision-making in promoting this ecosystem service.

Based on an interview survey with arable farmers in seven EU countries, this study assesses the potential factors influencing farmers' decisions on whether to promote natural pest control in their fields. In particular, it focuses on how farmers' perceptions of natural pest control service influence their conservation actions. In parallel, the potential factors influencing farmers' decisions on using insecticides are analysed.

2. Methods

2.1. Interview area and process

To gather relevant information on farmer perception and management, 85 farmers participating in the EU funded LIBERATION (Linking farmland biodiversity to ecosystem services for effective eco-functional intensification, www.fp7liberation.eu) project across Germany (11 participants), Hungary (18), Italy (13), Netherlands (20), Poland (10), Sweden (5), and the UK (8) were face-to-face interviewed. Farmers were recruited from the farmer networks associated with the research institutes involved in the LIBERATION project in each country. The interviewees represented the farm businesses who provided field sites to support experimental work within this project, which aims to quantify the contribution of multiple ecosystem services (e.g., natural pest control) towards crop production, and to analyse the effectiveness of environmental management practices (e.g., hedgerows) for promoting these ecosystem services. The participants were a combination of farm owners (82%), managers (27%) and tenants (18%). They were primarily arable farmers, and grew mostly wheat (99%), maize (45%), sugar beet (42%), and oilseed rape (35%; Appendix A). The interviews were conducted in the autumn and winter of 2014, after field sites were selected and initial experimental works undertaken.

2.2. Interview contents

The questionnaire (Appendix B) elicited information on farmers' perspectives on three ecosystem services (natural pest control, pollination, and soil fertility) and disservices (pest, weed, and disease damage). For the scope of this paper, we focus on the following areas: (i) background information about the farms, (ii) preferences towards on-farm environmental management practices, (iii) perceptions of natural pest control service and pest damage.

The information about the farms included agricultural area (ha), average number of crops used in a rotation, average annual farm income (€, following a seven point scale from 1 = loss through to 7 = > €100,000, and included a 'Prefer not to say' option) for the last two financial years, years of farming, whether a farm is in a designated area of environmental interest (0 = 'No', 1 = 'Yes'; the following questions with the same structure also used this code), and whether a farm is involved in an agri-environment scheme (AES).

The farmers were then asked to indicate their attitudes towards 17 environmental management practices (Appendix C), covering those being implemented across the study sites and additional environmental options not implemented. This followed a three point scale: 1 = 'Dislike' to 3 = 'Like' (and also included an 'Unfamiliar' option).

Finally, the perceived importance of natural enemies and pest damage for crop production were captured by a four point scale, from 1 = 'Relatively unimportant' to 4 = 'Very important'. The number of perceived important natural enemy and pest species on-farm were also recorded. In terms of pest management, the number of methods used to promote natural pest control (Appendix E) and whether the farmers use chemicals to manage pests were recorded.

2.3. Statistical analyses

All analyses were done using R 3.2.5 (R Core Team, 2016), with significance levels set as 0.05. Mean values and standard deviations were used to summarize the data in the tables. If a data distribution is skewed, median values were also used to present the results to take into account outliers.

Information about farms and the perceptions of natural pest control service and pest damage were compared among seven countries using a Kruskal-Wallis one-way analysis of variance by ranks (R Core Team, 2016) and related post-hoc tests (Pohlert, 2014), to account for ordinal data characteristics and difference in data distribution.

For the environmental management practices provided in the survey, those that potentially provide semi-natural habitats with forage, shelter and reproductive opportunities for natural enemies were selected and grouped by the habitat management types reviewed from Holland et al. (2016) (Appendices C&D). For multiple management practices in the same group, the average preference