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# Impacts of a pesticide on pollinator species richness at different spatial scales

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## Abstract

Pesticides are an important potential cause of biodiversity and pollinator decline. Little is known about the impacts of pesticides on wild pollinators in the field. Insect pollinators were sampled in an agricultural system in Italy with the aim of detecting the impacts of pesticide use. The insecticide fenitrothion was over 150 times greater in toxicity than other pesticides used in the area, so sampling was set up around its application. Species richness of wild bees, bumblebees and butterflies were sampled at three spatial scales to assess responses to pesticide application: (i) the 'field' scale along pesticide drift gradients; (ii) the 'landscape' scale sampling in different crops within the area and (iii) the 'regional' scale comparing two river basins with contrasting agricultural intensity. At the field scale, the interaction between the application regime of the insecticide and the point in the season was important for species richness. Wild bee species richness appeared to be unaffected by one insecticide application, but declined after two and three applications. At the landscape scale, the species richness of wild bees declined in vine fields where the insecticide was applied, but did not decline in maize or uncultivated fields. At the regional scale, lower bumblebee and butterfly species richness was found in the more intensively farmed basin with higher pesticide loads. Our results suggest that wild bees are an insect pollinator group at particular risk from pesticide use. Further investigation is needed on how the type, quantity and timing of pesticide application impacts pollinators.


## Zusammenfassung

Pestizide stellen einen möglichen Grund für die Diversitäts- und Bestäuberabnahme dar. Es ist jedoch wenig über die Wirkung von Pestiziden auf wildlebende Bestäuber im Freiland bekannt. Mit dem Ziel die Auswirkungen von Pestizideinsätzen festzustellen wurden Bestäuberinsekten in einem landwirtschaflichen Systemen in Italien gesammelt. Das Insektizid Fenitrothion ist etwa 150 mal toxischer als die anderen Pestizide, die in der Gegend genutzt werden, und so wurde die Untersuchung rund um seine Nutzung angelegt. Um die Reaktionen auf die Pestizidanwendung abzuschätzen wurde der Artenreichtum der Wildbienen, Hummeln und Schmetterlinge auf drei räumlichen Skalen untersucht: (i) auf der Feldskala entlang von Gradienten der Pestiziddrift, (ii) auf der Landschaftsskala indem verschiedene Feldfrüchte in dem Gebiet beprobt wurden und (iii) auf der regionalen Skala indem zwei Flusstäler mit

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unterschiedlicher landwirtschaftlicher Intensität verglichen wurden. Auf der Feldskala war die Interaktion zwischen dem Anwendungsregime des Insektizids und dem Zeitpunkt der Saison für den Artenreichtum wichtig. Der Artenreichtum der Wildbienen schien von einer Insektizidanwendung unbeeinflusst, nahm aber nach zwei- oder dreifacher Anwendung ab. Auf der Landschaftsskala nahm der Artenreichtum der Wildbienen in Weinbergen ab in denen die Insektizide angewendet wurden, aber nicht auf Maisfeldern oder auf nichtkultivierten Flächen. Auf der regionalen Skala wurden geringere Hummel- und Schmetterlingsartenzahlen in dem intensiver bewirtschafteten Flusstal mit den höheren Pestizidbelastungen gefunden. Unsere Ergebnisse zeigen, dass Wildbienen zu einer Bestäuberinsektengruppe gehören, die dem Risiko der Pestizidbelastung besonders ausgesetzt ist. Es sind weitere Untersuchungen darüber notwendig, wie der Typ, die Menge und der Zeitrahmen der Pestizidanwendung die Bestäuber beeinflusst.


***Keywords:*** Agriculture; Agro-chemicals; Bees; Butterflies; Fenitrothion; Insecticide

## Introduction

Pollinators are an important component of biodiversity that provide a key ecosystem service through wildflower and crop pollination (Klein, Vaissière, Cane, Steffan-Dewenter, Cunningham et al., 2007; Spira, 2001). They have been proposed as indicators of ecosystem health for assessing the impacts of a pressure such as pesticides (Kevan, 1999). Pollinators increase plant seed set (Morandin & Winston, 2006), fruit set (Klein, Steffan-Dewenter, & Tscharntke, 2003) and fruit quality (Roldan Serrano & Guerra-Sanz, 2006) and their value to agriculture in the European Union is estimated at €14.2 billion per year (Gallai, Salles, Settele, & Vaissière, 2008). There is growing concern and discussion relating to declines found in pollinators around the world (Kluser, & Peduzzi, 2007). A decline in wild bee species richness has been found in the UK and the Netherlands (Biesmeijer, Roberts, Reemer, Ohlemüller, Edwards et al., 2006) and the Committee on the Status of Pollinators in North America (National Research Council, 2007) found downward trends in the abundance of *Apis mellifera* (L.) and a small number of wild pollinators for which they had sufficient data. Though uncertainty remains as to the global extent of this phenomenon, further investigation needs to be undertaken into the scale, magnitude and causes of the decline, and the effects on pollination services (Roubik, 2001).

Agriculture is the primary land use in Europe, so its management has profound consequences for the environment and for biodiversity (Benton, Vickery & Wilson, 2003). Agricultural intensification is widely accepted as a cause of biodiversity decline (Robinson & Sutherland, 2002). Intensification is, however, a broad concept encompassing many factors, such as the loss of semi-natural habitat, fragmentation and increased pesticide input (Tilman, Fargione, Wolff, D'Antonio, Dobson et al., 2001). To understand the causes of biodiversity decline it is important to disentangle the effects of individual components of agricultural intensification. This study focused on pesticides as a driver. Pesticides have been shown to cause declines in non-target beetles (Lee, Menalled, & Landis, 2001), bees (Alston, Tepedino, Bradley, Toler, Griswold et al., 2007), birds (Hart, Milsom, Fisher, Wilkins, Moreby et al., 2006) and aquatic invertebrates (Fairchild & Eidt, 1993). The area to which agro-chemicals are applied in Great Britain has increased since the 1970s, with agricultural intensification (Robinson & Sutherland, 2002) and global pesticide production predicted to continue increasing in the future (Tilman et al., 2001).

This study aimed to isolate the impact of an insecticide on insect pollinators in the field. Most evidence of the impact of pesticides on pollinators comes from laboratory-based toxicity tests, determining LD50 values for honeybees (*A. mellifera*). Negative effects from sub-lethal doses of insecticide have also been demonstrated (El Hassani, Dacher, Gauthier, & Armengaud, 2005), but field assessments are needed to understand how laboratory-derived toxicity levels relate to real effects observed in pollinator communities (Stark, Jepson, & Mayer, 1995). Information is needed on the impacts of pesticides on the wider pollinator community, such as *Bombus* spp. and butterflies, not just honeybees. Some field- and semi-field-based studies have been undertaken (Gels, Held, & Potter, 2002; Koch & Weisser, 1997). However, most of the field-based studies in this area have been conducted at the field scale. Given that most systems have many chemical inputs, with varying levels of toxicity to invertebrates and that pollinators are a relatively mobile group, larger scale approaches may be more appropriate and could provide greater insight into the effects of pesticides. This investigation considered the effect of pesticide pressure at different spatial scales on pollinators, using detailed information on pesticide application over an area of 28 $km^2$.

As different pollinator taxa have different mobility, life history and feeding strategies, they were expected to interact and respond to pesticide pressure at different scales. Steffan-Dewenter, Münzenberg, Bürger, Thies, &